What is the Role of Enterprise Architects on a Firm's Digital Innovativeness?

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Preface

Dear reader,

I'm excited to present to you my thesis. This graduation project not only concludes my life as a graduate student and intern, but I am also saying goodbye to the years I spent at the TPM faculty with great pleasure. Obviously, the corona situation had a big impact on my life as a student, but I'm grateful for all the people that made this period an incredibly learning experience anyway, for all the people that I have met, and for the friendships that have started over the years. In the last 4 months I not only learned what Enterprise Architecture actually is, but also learned much more about how I can combine academic rigor with business focused practicality. There were a lot of people that helped me with various topics and therefore, before I tell you more about my research, I would like to express my gratitude to several people.

First, I would like to thank my main university supervisor Marijn for his guidance and support throughout my graduation journey. I especially appreciate his patience when I switched multiple times from topic before the summer holiday, his super fast responses when I send an email, and the quality of his feedback. Also his connections with a large number of enterprise architects were extremely valuable for my research.

Second, I would like to thank my second university supervisor Victor for his advice and insight on how to properly conduct a research project. When I started with my thesis, I had never done such a hypothesis-based research project before and his advice was immensely valuable to use the right method to arrive at the right results.

Third, I would like to thank my Deloitte supervisors Erik and Tim, who were incredibly supportive along the entire journey. Thank you Erik, for making Deloitte feel like an exceptionally pleasant employer to me, for all the guidance you gave me every week, and for all the constructive feedback. It really was a joy working with you!

Thank you Tim, for introducing me to the world of Enterprise Architecture, your guidance and highly relevant input. Your motivational, positive and constructive feedback was invaluable and made this journey a joy to go through.

Fourth, I would like to thank all the people that helped me with my thesis that work at Deloitte Consulting. I got especially from the TV&A team a tremendous amount of support, but also the support of everyone from the Customer Strategy & Applied Design offering was highly appreciated. Deloitte did not only teach me so much about the whole Enterprise Architecture discipline, but also gave me the motivation I needed to work hard on this project and the connections I needed to obtain the results.

Finally, I would like to thanks all my roommates, friends and family for the incredible time I had over the last few years. I really cherish all the conversations we had, coffee breaks, fun moments, unconditional support and holidays we had over the years. What could have been quite a boring period with all the lockdowns was actually a pretty cool period thanks to your support every day again.

Now that my time as a student has com to an end, I'd like to present with joy and pride my graduation report to you. I hope it makes an interesting read and brings you as much as it did for me.

Regards,

Joost Verbraeken
Delft, January 2022

Executive Summary

Innovating in the digital domain is almost essential for modern firms to be competitive. Anno 2021, seven of the ten largest companies worldwide belong to the digital sector compared to only one just twelve years ago. Digital technologies enable organizations to provide significant additional value that is incredibly scalable to many users, to streamline operations, and to help decision-makers gain valuable insights.

However, creating new and innovative digital technologies is challenging because the competition is intense. All digital systems within firms, including small experiments that might develop into successful digital innovations, are closely monitored by so-called enterprise architects. Enterprise architects stipulate the direction of the entire IT landscape, which makes the IT landscape significantly more manageable but perhaps also influences the development of new digital innovations. Surprisingly, the literature on the influence of enterprise architects on a firm's digital innovativeness is, to the best of the author's knowledge, literally non-existent.

Therefore, this research aims to provide insight into how enterprise architects influence their firm's ability to produce digital innovations. This is accomplished by measuring for more than 50 firms their digital innovativeness, the extent to which certain Enterprise Architecture (EA)-related factors apply, and the correlation between these data points. Additionally, the digital innovation readiness of each firm is measured by using several questionnaire items retrieved from prior research and is modeled as a moderating variable in the conceptual model.

The measure for digital innovativeness was found using a literature review and consists of 7 questionnaire items. The EA-related factors that might influence a firm's digital innovativeness (EA factors) were obtained from three different sources: scientific articles that contain previously identified EA factors, a Best Worst Method prioritization of the factors included in the DyAMM Enterprise Architecture maturity framework, and insights from EA experts. This approach resulted in the identification of 25 EA factors distributed among six categories: enterprise architecture design, alignment of the To-Be architecture with the business objectives, development of the proper architecture, usage of the architecture, implementation of the architecture, and enterprise architect behavior.

Ten statistically significant correlations were found. Hiring highly skilled enterprise architects is the highest-correlating factor I found that increases a firm's digital innovativeness. Other important influencing factors are whether the enterprise architects work in an agile manner, are aware of their role in the context of digital innovation, and actively identify external opportunities for innovation. Lesser important influencing factors are whether enterprise architects are involved in the strategic discussions, the existence of an open feedback culture, and the presence of a solid EA foundation on top of which it is easy for employees to innovate.

EA experts indicated that all the statistically significant correlations found are probably causal. Thus, whereas existing literature only hypothesizes that EA factors influence a firm's digital innovativeness, this study provides EA practitioners with the first empirically-grounded guidelines on how to do this. These findings are important considering the fact that digital innovativeness is often considered a key capability for firms to be competitive in the current rapidly changing markets.

This study empirically shows that an excellent enterprise architect is not only able to design and ensure compliance to an enterprise architecture, but also to behave in a way that stimulates the emergence and development of valuable innovative ideas.

EA experts also indicated for many other EA factors that they would expect these factors to positively influence firms' digital innovativeness, but that more samples are needed to be sufficiently confident in these causal relationships. Along with several other recommendations for future research, this thesis hopes to also provide a solid starting point for other researchers.

List of Abbreviations

AVE	Average Variance Extracted
BWM	Best Worst Method
C-level	Chief-level
CB-SEM	Covariance-Based Structural Equation Modeling
DI	Digital Innovativeness
EA	Enterprise Architecture
EAMM	Enterprise Architecture Maturity Framework
GICS	Global Industry Classification Standard
IPMA	Importance-Performance Map Analysis
IRR	Inter-Rater Reliability
MCDM	Multi-Criteria Decision making Method
MECE	Mutually Exclusive, Collectively Exhaustive
PCA	Principal Component Analysis
PLS-SEM	Partial Least Squares Structural Equation Modeling
R^2	Coefficient of determination
RQ	Research Question
SEM	Structural Equation Modeling
TOGAF	The Open Group Architecture Framework
VIF	Variance Inflation Factor

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Writing Style

This thesis was written in the APA style as defined in the Publication Manual of the American Psychological Association, Seventh Edition (American Psychology Association, 2020). Several principles that are worth highlighting are:

- APA principle 4.12: The literature review, method, and result section are written in the past tense; the discussion and conclusion in the present tense.
- APA principle 4.13: The active voice is used as much as possible; the passive voice is only used when the actor really is irrelevant.
- APA principle 4.16: The thesis is written using the pronoun ”I” because I (the author of the thesis) do not have any coauthors, but only several supervisors.
- APA principle 4.30: The text matches the spelling and hyphenation used by the Merriam-Webster.com dictionary and the APA Dictionary of Psychology. In practice, this means that I use American English instead of British English.
- APA principle 6.22: Key terms are written *italicized* the first them they are used, and accompanied by a definition.
- APA principle 6.24: Abbreviations are defined upon their first use and an overview is given in Section .
- APA principle 7.17: Tables include a horizontal border at the top and bottom of the table, beneath column heading, and above column spanners, but vertical borders are not used.

I chose not to follow APA principle 2.27 to omit the ”Introduction” heading and instead repeat the paper title. Although for a paper this may be good advice, it reduces the clarity of the structure of a thesis in my opinion, illustrated by the fact that the APA manual (American Psychology Association, 2020) also does not follow this principle.

Reflection on MOT

This master thesis was written as part of the course ”MOT2910” for the master’s program ”Management of Technology” (MOT) offered by the TU Delft. This section explains the link of this thesis with MOT and how the knowledge and skills taught by this program are applied in this thesis.

To explain the link of this thesis with MOT, I compare this thesis with the official study goals as mentioned in the TU Delft Study Guide under the course code ”MOT2910” (TU Delft, 2022b).

The ”MOT criteria for graduation” including a reflection on these criteria, are as follows:

- ”The work contains an analytical component”
  - This work uses advanced and complex modeling techniques to assess the measurement and structural model (see Section 7 and Section 8 respectively) and thus contains a large analytical component.
- ”The work is multidisciplinary in nature”
  - This work combines two unrelated scientific disciplines (namely, EA and digital innovation) in a new and unexpected way (see Section 9). Both scientific disciplines are taught as part of the MOT program: EA is taught in the course ”SEN1611” and its digital-business-process aspect in the course ”MOT1531”, and digital innovation theory is taught in MOT courses such as ”TPM406A”, ”MOT1412”, or ”SPM9730”.
    Additionally, scientific methods to conduct research were taught in the ”MOT2312” course. I make several references to its reading materials in this thesis, but after a critical evaluation of the state-of-the-art research methods available in the context of my research topic, I ended up using a method that was not taught during this course, namely PLS-SEM. This method has not been used to study the relationship between EA factors and digital innovativeness before but appeared to be the most suitable choice based on my evaluation (see Section 2).
    To summarize, this thesis investigates the link between two unrelated scientific disciplines by using a method from a third unrelated discipline. Therefore, this work is multidisciplinary.
- ”The work focuses on a technical domain or application”
  - This work focuses on EA, which mostly relates to the management of Information Technology (IT) within firms. I investigated, for example, various technical components of EA and the development of software technology in an EA-context, among other things. Because enterprise architects always think about the usage of technology several years down the road, they are to a large degree focused on high-tech domains.
- ”Management of Technology graduates learn to explore and understand how firms can use technology to design and develop products and services that contribute to improving outcomes”
  - By writing this thesis, I learned to explore and understand how enterprise architects should manage a firm’s information technology to enable firms to be digitally innovative and thus increase their competitiveness. I did this not only by conducting a literature review and evaluating the research results, but also by having one-hour interviews with 22 enterprise architects and 30-minute interviews with 35 EA and innovation experts. These interviews significantly increased my understanding of the topic.

MOT was, in my opinion, an excellent program to understand how technology can be used to increase the competitiveness of firms, but there are a few things that can be improved. For example, breaking complex problems down into structured issue trees is, in my opinion, an essential skill for the students to learn that is not systematically taught. To illustrate this, I do not remember the well-known consultancy term ”MECE” to be mentioned even once in the program.

Additionally, as aspiring ”managers of technology”, the students should be given a significantly more extensive introduction to the practical value of emerging technologies such as AI, big data, IoT, 3d printing, etc.

Finally, and this applies to all master programs at the TU Delft, there should be more attention to soft skills because projects often fail not because of a lack of knowledge or money, but because of poor communication skills (PMI, 2015).

Contents

1
Introduction

In this section, I first describe a problem that firms face and how this problem can be addressed by hiring enterprise architects in Section 1.1.

Then, I describe why it is important for firms to be able to produce digital innovations in Section 1.2.

Subsequently, I explain why I think that enterprise architects influence their firm's digital innovativeness in Section 1.3.

Finally, I stipulate how this thesis investigates that claim in Section 1.4.

1.1. Need for Enterprise Architecture

We are living in an age of digital Darwinism. Companies face the challenge of either being disruptive or being disrupted. The strongest companies survive; the weakest companies fail. One particular factor that is of paramount importance to thrive in modern business environments, which are characterized by continuous change and ever-increasing customer expectations, is a well-established Information Technology (IT) system. IT enables the efficient storage, processing, and communication of information (Molloy & Schwenk, 1995) which makes IT an indispensable asset for modern firms to manage their operations. However, firms need to continuously change their operations to stay competitive and grow, and as a result, their IT systems need to evolve too.

Coordinating changes in IT systems is non-trivial since these systems are often distributed across business units (Peterson, 2004). Especially in large and geographically dispersed organizations, these sub-units often enjoy a considerable degree of autonomy in managing their IT infrastructure, which typically results in a proliferation of incompatible and duplicate IT systems (DeSanctis & Jackson, 1994; Weill & Broadbent, 1998), making it increasingly more complex to facilitate the communication with each other (John Benamati, 2001). This creates a significant challenge for the organization to adjust its operations efficiently to its new strategy when this strategy depends on integration across business units (Tanriverdi, 2005; Weill & Broadbent, 1998). Additionally, this uncoordinated set of IT systems makes it increasingly harder to understand the firm's current capabilities and subsequently formulate a strategy that considers the current capabilities.

1.1.1. Introducing and Defining Enterprise Architecture

To accommodate these challenges, around the early 1990s, the first Enterprise Architecture (EA) concepts were introduced (Richardson et al., 1990; J. A. Zachman, 1987).

There are many definitions of EA (Kotusev, 2016), which makes the term somewhat vague and hollow J. A. Zachman (2009), and therefore it is important to clearly define what is meant with EA in this thesis. The definition that I use is a summary of many other EA definitions and was formulated by Land et al.: "Enterprise architecture is a reference to structure and relationships combined with a reference to a set of governing principles that provide guidance and support for directions and decisions. Enterprise architecture focuses on shaping and governing the design of the future enterprise using principles to stipulate future direction and models to underpin and visualize future states." (2009, p. 34)

In accordance, in this thesis *Enterprise Architects* create, maintain, and enforce the usage of the enterprise architecture to help their organization. I will use for this thesis the formal definition of Gøtze:

”Enterprise architects are the persons that ensure that the artifacts created by the various process owners adhere to and contribute to an overall enterprise architecture effort” (2013, p. 2) where ”adherence” refers to ”the degree of fit and integration among business strategy, IT strategy, business infrastructure, and IT infrastructure” (Henderson & Venkatraman, 1992, p. 23).

1.2. Need for Innovation

Whereas the previous section elaborates upon EA, this section introduces another discipline, namely innovation. In the next section, I will relate these two disciplines and introduce the research topic.

In the 1940’s, Schumpeter noted that innovation destroys existing value in order to create new, superior value, a processed called ”creative destruction” (Schumpeter, 1942). Ever since Schumpeter’s research, considerable attention has been paid to investigate how innovation processes can be implemented to maximize a firm’s ability to innovate (Drejer, 2004; Koellinger, 2008). For example, innovation is considered as one of the main drivers of value creation and as a means to achieve a sustainable competitive advantage (Drazin & Schoonhoven, 1996), business success (Nonaka & Takeuchi, 1995), growth (Maurseth & Frank, 2009), and improved performance (Hult et al., 2004). As McKinsey puts it: ”The ability to develop, deliver, and scale new products, services, processes, and business models rapidly is a muscle that virtually every organization needs to strengthen” (2021). This ability to innovate more effectively and efficiently has only grown in recent years with increased global competition, rapid changes in business capabilities and available technology, increasingly sophisticated customer requirements, and the shortening of product life cycles (Lianto et al., 2018).

1.2.1. Need for Digital Innovation

One type of innovation that has had a particularly profound impact on our society in the recent decade is digital innovation. This is illustrated by the fact that 7 of the 10 largest companies worldwide by market size in 2021 now belong to the digital sector (Statista, 2021), whereas in 2009, it was only 1 of the 10.

Although many of the biggest companies are pioneers in digital solutions, adopting these technologies has significant benefits for practically every firm, regardless of its sector (Huang et al., 2017). This is with good reason because, after a single development investment, the resulting digital service is usually highly scalable without substantial additional costs when the demand for the service increases (Svensson & Taghavianfar, 2015; Yoo et al., 2012). Additionally, digital solutions can also streamline operations or automate manual tasks, thus improving - for example - the reliability, the costs, or the quality of the service (Chowdhury et al., 2019). Thirdly, digital solutions can help decision-makers gain valuable insights by gathering and processing information on a scale that would be unfeasible without digital technologies (Stuart et al., 2021).

There are many examples of how various firms create new digital products and services to gain a competitive edge. For example, the household items shop IKEA partnered with the freelancing platform TaskRabbit to provide its customers with a service to assemble the furniture in their house (against a small premium) (IKEA, 2022). The post-delivery firm DHL is using smart glasses that automatically read bar codes, deliver information, and give instructions for complex tasks to optimize manual processes within their warehouses (DHL, 2019). The heavy machinery producer Caterpillar uses sensor data to correct operator behaviors, improve decision-making, and predict the best moment for preventive maintenance, thus significantly decreasing downtime for the equipment owners (Caterpillar, 2022).

1.2.2. Sharpening the Definition of Digital Innovation

Clearly, digital innovations are important, but what is exactly a digital innovation?

The term ”innovation” is often confused with ”invention”, partially because the difference between the terms has slightly changed over time. Originally, Schumpeter divided in his Theory of Economic Development technological change into the phases invention (the first prototype of a technology), innovation (the commercial introduction of a technology), and diffusion (the wide-spread adoption of a technology) (J. Schumpeter, 1934). Modern literature uses slightly different definitions where an invention refers to the creation of a new idea and an innovation refers to the combination of an invention and exploitation of a new idea (where exploitation refers to the conversion of the invention into a useful application) (Khilji et al., 2006; Roberts, 1988). The invention of a product or service is thus a single step in the innovation process, while innovation encompasses also aspects such as the commercial development, design, production, and marketing of the newly devised product or service. This definition of *innovation* is neatly summarized by the Organization for Economic Co-operation and Development (OECD) as follows: ”the scientific, technological, commercial, financial and organizational steps which are intended to lead, or actually lead, to the implementation of technologically new or improved products and processes” (OECD, 2005, p. 10).

Then, the term ”*digital innovation*” simply refers to innovation in a digital context. For this thesis, I will use the definition formulated by Ciriello et al.: ”Innovating digitally means innovating products, processes, or business models using digital technology platforms as a means or end within and across organizations. ” (2018, p. 3).

1.3. EA Contribution to Digital Innovativeness

Innovating in the digital domain is clearly important for companies to be competitive (as described in Section 1.2.1), but recent research shows that many firms are unable to do so successfully (Kane et al., 2015). To formulate a solution for this problem, I had several informal interviews with EA experts because enterprise architects intuitively seem to be somewhat comparable to innovation managers. The role of enterprise architects and innovation managers are both typically geared towards long-term benefits, practitioners in both roles have interactions with usually almost all business departments, and the projects in both roles are often closely related to IT.

Interestingly, these EA experts indicated that they expected that enterprise architects could significantly impact a firm’s digital innovativeness. The intuition behind this idea is that enterprise architects have considerable influence on their firm’s digital landscape, which would have a threefold impact on their organization:

1. Enterprise architects are presumably uniquely positioned to recognize the potential and initiate new digital innovations.

2. Enterprise architects can presumably significantly hinder or stimulate the opportunities for employees to run small experiments to test new and innovative digital solutions.

3. Enterprise architects presumably play a significant role in the speed with which successful digital pilots can be scaled up, be it internally or externally.

1.4. Research Design

In this section, I first explain that there is a research gap related to the relationship between enterprise architects and their firm’s digital innovativeness, and then describe the research objective, scope, questions, and methodology used to address this research gap.

1.4.1. Problem Definition

As described in the previous sections, enterprise architects have a profound impact on a firm’s IT landscape and there is significant evidence for digital innovation being a key capability for firms to being able to effectively compete in modern markets. However, there are - surprisingly - only a few papers that mention the relationship between enterprise architects and innovation. These papers either hypothesize that EA can influence the ability of a firm to innovate (Bachoo, 2018a; Banaeianjahromi & Smolander, 2019; Bontinck & Viaene, 2016; Gong & Janssen, 2019; Lange & Mendling, 2011; Marth et al., 2020; Nardello et al., 2016), assume this without giving any reference (Harrison, 2018; Jonkers et al., 2006; Kamogawa & Okada, 2005), claim this by using a faulty reference (Rouhani et al., 2014), or focus on a very specific type of EA/innovation (van de Wetering, 2019).

The literature that empirically investigates the influence of enterprise architecture on a firm’s innovativeness is incredibly scarce, and the literature that investigates specifically the influence of enterprise architects on *digital* innovativeness seems to be non-existent (as further illustrated in Section 3). Even the official TOGAF manual (Dedić, 2020), known for its comprehensiveness, gives a large number of proven EA benefits such as more effective and efficient business operations, more effective and efficient digital transformation and IT operations, better ROI, reduced risk for future investment, and faster, simpler and cheaper procurement, but nothing related to (digital) innovation.

1.4.2. Research Objective

Summarizing, the problem is a lack of insight into the influence of enterprise architects on a firm's digital innovativeness. However, organizations require this insight to make decisions regarding their EA-related efforts. Therefore, the main objective of this thesis is to learn which EA-related factors influence a firm's digital innovativeness. More specifically, I intend to study these relationships empirically and formulate concrete guidelines for enterprise architects to be more effective in improving this important driver for growth.

1.4.3. Research Scope and Focus

The scope of this thesis comprises the relationships between EA-related factors (*EA factors*) and the firm's digital innovativeness.

I focus only on enterprise architects working in The Netherlands because the reach of the professional network of the author is limited to mostly The Netherlands.

I will also apply the definition of "enterprise architects" (see Section 1.1.1) very strictly and consider typical solution architects and technical architects out of scope: their focus is more on specific technical aspects rather than the overarching architecture.

Although enterprise architects are obviously highly involved in the development of the enterprise architecture, producing a detailed evaluation of the influence of the enterprise architecture (instead of the architects) itself is not within the scope of the research. Only several very high-level factors about the enterprise architecture might be included.

Although I identify for each firm several contextual factors such as the sector, the number of enterprise architects, and the number of employees, I do not restrict the scope based on these factors (such as only the "financial" sector): on the one hand, I might get too few questionnaire responses when I significantly restrict the scope due to the uncertainty in the goodwill of potential respondents to collaborate, and on the other hand, it might be interesting to use these contextual factors in the evaluation of the results.

1.4.4. Research Questions

There is currently no empirical research available about the relationship between EA-related factors and a firm's digital innovativeness, as mentioned in Section 1.4.1. Therefore, the main research question is phrased as follows:

How can enterprise architects improve their firm's digital innovativeness?

The research question is kept quite broad on purpose because the research is both exploratory, descriptive, and correlational (and to a smaller degree also explanatory) as illustrated in Section 1.4.5.

To answer the main research question, I split the question up into several MECE sub-Research Questions (RQs). *MECE* is short for Mutually Exclusive and Collectively Exhaustive: the sub-research questions are non-overlapping, but combined, they do answer the main research question. I chose these sub-research questions because they are not only MECE but can also be answered sequentially during the research.

1. How can a firm's digital innovativeness be measured?
2. What factors that Enterprise Architects influence (EA factors) can be distinguished that are likely to be related to a firm's digital innovativeness?
3. Which EA factors significantly influence a firm's digital innovativeness?

1.4.5. Research Methodology

The aforementioned research questions are answered using structural equation modeling (SEM). SEM is a statistical technique to analyze data points and differentiates between the so-called structural model and measurement model. The structural model explains how the constructs are related, while the measurement model explains how the constructs can be measured. Structural equation models are relatively complex to understand for beginners and are therefore explained in more detail in Section 2.

I specify the structural model before the measurement model and assess the measurement model before the structural model, following the proposal of Russo and Stol (2021) because of their rigorous and very recent literature review. This approach is visualized in Figure 1.1 (adapted from Figure 2 from (Russo & Stol, 2021)). However, I slightly deviate from their approach by using several pilot studies to iteratively improve the reliability and validity of the measurement model. Although broadly speaking, I specify the structural model before the measurement model, in practice I go back and forth a few times between specifying these models because new insights during the specification of the measurement model sometimes give reason to modify and improve the structural model.

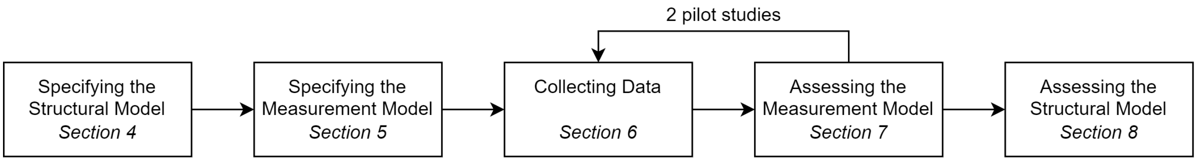

Figure 1.1: Flowchart of the structural equation model specification and assessment, adapted from Figure 2 from (Russo & Stol, 2021)

To be more confident in the results, I use *triangulation* for each step in the process (Hair et al., 2007) (where triangulation refers to the use of different methods that are supposed to lead to the same results to increase the confidence).

1. **Specifying the structural model** - Section 3 / Section 4

   To address the research gap, I need to hypothesize which EA factors influence a firm's digital innovativeness. These hypotheses are defined in the structural model, which presents the constructs and explains the hypothesized causal paths between these constructs (Freeze & Raschke, 2007; Gefen et al., 2011). To specify the constructs, I triangulate two methods, namely a literature review and subject matter expert interviews.

   - **Review literature to obtain an overview of previously identified EA factors and digital innovativeness measures** - Section 3

     I first conduct a literature review along the guidelines outlined by Xiao and Watson (2019) (as described in detail in Appendix B). This literature review results in:
     - Measures for a firm's digital innovativeness
     - EA factors that were identified by previous literature to be related to a firm's innovativeness
     - Enterprise Architecture Maturity Frameworks that contain EA factors that are not yet argued to be related to a firm's digital innovativeness

     The results are available in Section 3.
   - **Conduct interviews with EA experts to extend and prioritize the tentative set of EA factors with expert insights** - to answer RQ 2 (*exploratory research*), Section 4.1

     Because the literature found by the literature review might not cover all potential EA factors that are likely to be related to digital innovativeness, I extend the list of EA factors with insights offered by senior EA experts. Additionally, I ask the experts to rank all EA factors based on their likelihood to be related to digital innovativeness because the number of factors that can be evaluated with a survey, formulated in the next step, is limited. The results are elaborated upon in Section 4.1.3.
   - **Conduct interviews with innovation experts to choose the digital innovativeness measure** - to answer RQ 1 (*exploratory research*), Section 4.2

     Because not every digital innovativeness measure might be equally suitable for this research, I ask innovation experts to determine the most appropriate measure. The results are elaborated upon in Section 4.2.

   The hypotheses are formulated based on the results of the literature review and insights from experts, see Section 4.3. Subsequently, the first version of the structural model is presented in Section 4.4.

2. **Specifying the measurement model** - Section 5

   The structural model explains how EA factors are hypothesized to influence a firm's digital innovativeness, and to test these hypotheses I need to measure these constructs in the real world (i.e., *operationalizing* the constructs). This relation between unobservable constructs and observable indicators is explained by the measurement model (Freeze & Raschke, 2007; Gefen et al., 2011). The observable indicators will be, for this research, questionnaire item-pairs that are intended to be filled in by enterprise architects. The items that I formulate are validated by EA experts before I start collecting data. The first version of the measurement model is presented in Section 5.

3. **Collecting Data** - Section 6

   After formulating the measurement model, I can distribute the resulting questionnaire among EA practitioners working in The Netherlands. To obtain sufficient high-quality responses, I make use of several networks of architects and personal connections, as detailed in Section 6. These practitioners are asked to either fill in an electronic questionnaire or have an interview with me to share their insights. The results are obtained, stored, processed, and used in line with the procedures of the TPM ethics committee (TU Delft, 2022a)

4. **Assessing the measurement model** - Section 7

   After collecting the data, I first need to establish and (probably) improve the reliability and validity of the measurement model before I can verify the hypotheses of the structural model. This is done by conducting two pilot studies. More information about the assessment methodology can be found in Appendix F and the resulting measurement instrument can be found in Section 7.2

5. **Assessing the structural model** - to answer partially answer RQ 3 (*correlational research*), Section 8

   After establishing the reliability and validity of the measurement model, I can verify the hypotheses of the structural model and learn which EA factors correlate with a firm's digital innovativeness. First, I examine the quality of the structural model based on its multicollinearity. When the multicollinearity is acceptable, I assess the structural relationships of the endogenous constructs by using a series of regression equations to reject or accept the hypotheses. More specifically, I evaluate the strength and significance of the path coefficients, the model's explanatory power, and present an Importance-Performance Map Analysis of the results. The findings are explained in Section 8.

6. **Expert insights on the results** - to answer RQ 3 (*explanatory research*), Section 9

   To estimate the degree to which the previously found correlations are causal, as well as to formulate the most important limitations of this thesis and directions for future research, I conduct in-depth discussions with EA experts. Of course, using empirical data to validate the causality of the correlations would have been preferable, but that approach is, given the time constraints, infeasible. More information about these sessions can be found in Section 9.

7. **Synthesize the conclusions**

By combining a literature review, various kinds of interviews with EA and innovation experts, and specifying and assessing a structural equation model, I answer the research questions and give more insight into how enterprise architects can improve their firm's digital innovativeness.

2
Research Approach (SEM)

This section explains the research approach used for this research, namely PLS-SEM.

First, it explains what SEM is and why this research approach is used for this thesis in Section 2.1.

Then, it explains what type of SEM is used for this thesis (namely, PLS-SEM), what it is, and why it is used in Section 2.2.

2.1. About the Choice for SEM

To examine the influence of EA factors on a firm's digital innovativeness, I will formulate a large number of hypotheses that explain how unobservable factors (such as "a good implementation of the enterprise architect role" or "a strong focus on innovation by the enterprise architects") may influence an organization's digital innovativeness. To measure these unobservable factors, I relate them to a range of observable factors (such as asking the question "do you have enough time to execute your tasks properly?" to enterprise architects). Subsequently, I can evaluate the extent to which empirical data confirm the hypotheses.

There are many statistical tools to analyze data points, such as linear regression, LOGIT, ANOVA, MANOVA, ANCOVA, difference scores, McNemar's chi-square, marginal homogeneity tests, conditional logistic, and log-linear models (Little, 2013). However, for all of these older techniques, two unrelated analyses are required when the hypotheses depend on both observable and unobservable factors: (1) factor analysis: assessing how observable factors load on unobservable factors, and (2) path analysis: testing the hypothesized relationships between the unobservable factors (Gefen et al., 2000).

In contrast, SEM provides "a single, systematic and comprehensive analysis" (Gefen et al., 2011; Gefen et al., 2000) and can be thought of as a hybrid between factor analysis and path analysis (Weston & Gore Jr, 2006). The two main advantages of SEM over older statistical models are, according to Tarka (2018, p. 26), "(1) the fact that SEM allows to conduct a complex, multidimensional, and more precise analysis of empirical data, and (2) taking into account different aspects of the examined reality and abstract concepts or theoretical constructs." Additionally, it makes researchers "define their research problems more precisely regarding the examined phenomenon, makes them formulate clear targets and research hypotheses before starting the analyses, makes them provide precise definitions of the considered theoretical constructs and their further operationalization, and forces them to find the right, logic relationships between the constructs" (Tarka, 2018, p. 7).

As a result of these advantages, SEM has gained significant popularity in the last decades in many fields (Dragan & Topolšek, 2014; Fan et al., 2016; Ullma, 2006). For this research, I will use SEM because the model will be quite complex (see Section 5.3), and because it simplifies the analysis of the interaction between observable and latent factors.

More information about basic research- and SEM-specific terminology can be found in Appendix A.

2.2. About the Choice for PLS-SEM

Given the choice for SEM (see Section 2.1), there are two SEM methods available to choose from (Hair Jr, Matthews, et al., 2017): covariance-based SEM (*CB-SEM*; (K. A. Bollen & Long, 1993; Jöreskog,

1978)) and variance-based partial least squares SEM (*PLS-SEM*; (Kroonenberg, 1990; Wold, 1982)).
CB-SEM is based on a common factor model, which takes only the covariance between the variables into account.

In contrast, *PLS-SEM* is based on a composite model that takes all variance from the independent variables into account to predict the variance in the dependent variables. This approach can explain more of the variance in the dependent variables, albeit partly because error variance is also included when this helps to make the prediction.

To be able to decide which approach is most appropriate for this thesis, the two approaches are compared in Table 2.1 (which is quoted from (Hair Jr, Matthews, et al., 2017), a highly cited paper). From the table, it seems that PLS-SEM is a better choice than CB-SEM in many aspects. Many other papers confirm this. For example, McDonald (1996, p. 240) regards PLS-SEM as ”the most fully developed and general system” and Hair et al. (2011, p. 15) even calls it a ”silver bullet”. These positive judgments resulted in a very significant increase in articles using PLS-SEM relative to CB-SEM in the last decades (Hair et al., 2017). To choose between using PLS-SEM and CB-SEM for this research, I marked the statements that apply to this research in **bold**. Clearly, most statements point towards PLS-SEM as the recommended method, and therefore I will use PLS-SEM to conduct the research.

Types of analysis	Recommended method		
	PLS-SEM	CB-SEM	Both
Objective = prediction	X		
Objective = exploratory research or theory development	X		
Objective = explanation only		**X**	
Objective = explanation and prediction	X		
Measurement philosophy = total variance (composite-based)	**X**		
Measurement philosophy = common variance only (factor-based)		X	
Reflective measurement model specification			X
Formative measurement model specification	**X**		
Metric data			**X**
Non-metric data = ordinal and nominal	X		
Smaller sample sizes - N = <100	**X**		
Larger sample sizes – N = >100			X
Binary moderators			X
Continuous moderators	**X**		
Normally distributed data			X
Non-normally distributed data	**X**		
Secondary (archival) data	X		
Higher order constructs = two 1st order constructs	X		
Higher order constructs = three of more 1st order constructs			**X**
Latent variable scores needed for subsequent analysis	X		

Table 2.1: Comparison between the two SEM methods, namely PLS-SEM and CB-SEM. Statements that apply to this research are marked in **bold**. Table is cited from (Hair Jr, Matthews, et al., 2017)

3 Literature Review

To empirically investigate the relationships between the factors that enterprise architects influence or are influenced by (*EA factors*) and the firm's digital innovativeness (as explained in Section 1.4), I first conduct a literature review. This literature review enables me to formulate a large part of the structural model (see Section 4). In this section, I elaborate upon the relevant existing literature about the topic.

First, I make the goals of the literature review explicit in Section 3.1.

Then, I explain how the methodology used to reach those goals in Section 3.2. The details of this methodology are explained in more detail in Appendix B.

Finally, I present the synthesized results of the literature review that were obtained by following this methodology in Section 3.3 (for the results related to measuring digital innovativeness) and Section 3.4 (for the results related to EA-factors).

The literature is intended to only review the literature without interpreting its relevance to this research. The interpretation of the resulting literature can be found in Section 4.

The raw, intermediate results of the literature review are included in Appendix C.

3.1. Goals

The 4 sub-research questions, as stated in Section 1.4.4, are:

1. **How can a firm's digital innovativeness be measured?**
2. **What EA factors can be distinguished that are likely to be related to a firm's digital innovativeness?**
3. How do the EA factors correlate with the firm's digital innovativeness?
4. To which extent are (a subset of) these correlations causal?

RQ 1 and RQ 2 (highlighted in **bold** above) are (partially) answered by this literature review (as mentioned in Section 1.4.5). I refer in this literature review to these research questions as *goals* to prevent confusion about whether the term research question refers to the research questions formulated for this thesis or to the research questions formulated for this literature review.

For the literature review, I refine these two literature review goals as follows:

Goal 1. Finding measures for a firm's digital innovativeness

- What digital innovativeness measures for firms have been proposed by previous research?
- On what kind of data are these methods dependent?
- How is this data used to quantify a firm's digital innovativeness?

Goal 2. Finding EA factors that are likely to be related to a firm's digital innovativeness

- What EA factors are distinguished in previous research?
- To which extent are these factors presumed to be correlated with digital innovativeness, according to previous research?
- To which extent are these factors proven to be correlated with digital innovativeness, according to previous research?
- To which extent are these factors presumed to be causally correlated with digital innovativeness, according to previous research?
- To which extent are these factors proven to be causally correlated with digital innovativeness, according to previous research?
- To which extent are these factors presumed to be uncorrelated with digital innovativeness, according to previous research?
- To which extent are these factors proven to be uncorrelated with digital innovativeness, according to previous research?

For the first goal, I will create an overview of digital innovativeness measures, including their methodology and (dis)advantages.

For second goal, I will (1) create an overview of EA factors that were already identified to be related to a firm's digital innovativeness in previous work, and (2) an overview of generic EA factors that are not yet linked to digital innovativeness but might be worth including in the research.

For the first objective, I will plot the EA factors in Figure 3.1. This diagram visually illustrates the relationship between EA factors and their supposed or proven correlation/causality with innovativeness.

For the second objective, I search for extensive and scientifically validated *EA capability Maturity Frameworks* (EAMMs) that, by definition, should cover the most important aspects of the EA capability.

The results of the literature review are interpreted and used in Section 4.

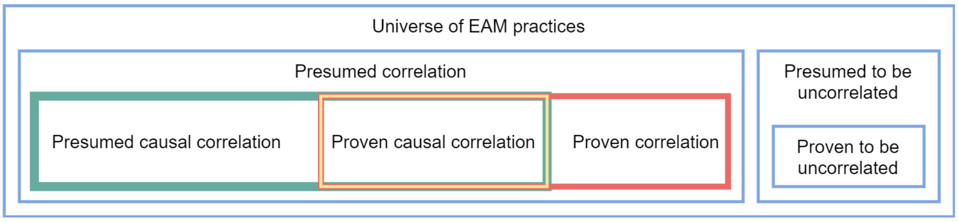

Figure 3.1: Visual illustration of the relationship between EA factors and their supposed or proven correlation / causality with innovativeness

3.2. Methodology

After establishing the two goals (research questions) that I aim to achieve with the literature review, I will explain the methodology used to achieve them. To answer the aforementioned research questions, I first develop the review scope and then conduct the actual literature review.

3.2.1. Developing the Review Scope

There are several factors to consider when conducting a literature review (Booth et al., 2016):

- Which literature review method is appropriate? *(methodological)*
- How much time, money and reviewer effort will the literature review take? *(logistical)*
- What are the inclusion/exclusion criteria? *(conceptual)*
- What are the keywords (including synonyms)? *(practical)*

These questions are answered by performing an informal scoping search (a brief search to gain a rough idea of what a scientific field looks like). The results are included as part of the review protocol in Section B.2.

3.2.2. Conducting the Literature Review

The method used to perform the literature review is described in a paper written by Xiao and Watson (2019) and elaborated upon in Appendix B. This paper is a recent, highly-cited literature review of literature review methodologies and combines all best practices in a single process. Because I want to structure the data extracted for both goals (namely, digital innovativeness measures and EA factors) based on certain characteristics, the literature review will be organized as a *textual narrative synthesis* (Xiao & Watson, 2019). This type of literature review clusters studies sharing similar characteristics into the same categories and then compares the similarities and differences based on the extracted data.

The structure of the literature review is shown in Figure 3.2. The first goal relates to the first phase, while the second goal relates to the latter two phases (see Section 3.1).

The review of phase 1 and 2 is exhaustive, which seems reasonable considering the relatively small amount of previous research on these topics, as identified during the scoping search. The review of phase 3 does not need be exhaustive, which would not only be infeasible consider the large amount of previous research, but also unnecessary because the EAMMs are only used as a source of inspiration for suitable EA factors.

The papers that I found at each step of the method are listed in Appendix C.

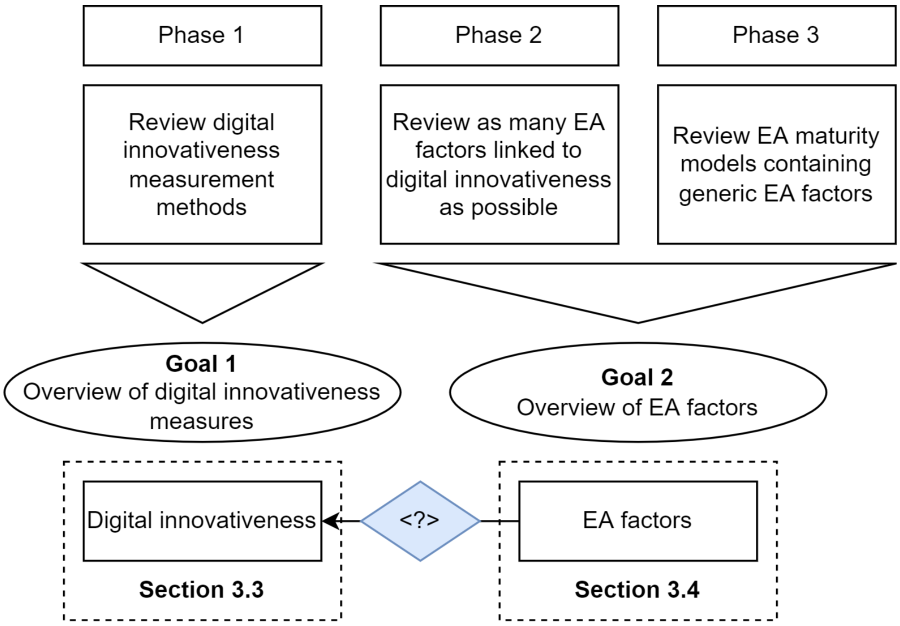

Figure 3.2: Literature review structure

3.3. Measuring a Firm's Digital Innovativeness

This section presents an overview of the literature on digital innovativeness measures that was collected as explained in Appendix B (under "Phase 1"). I found five scientifically validated measures for digital innovativeness, which seems like a low number. This is in line with the observation of Kohli and Melville (2019, p. 14) who note that "Despite its salience, exploration of digital innovation outcomes has received very little attention in the literature. Our literature review revealed a mere handful of studies, suggesting a significant opportunity for future research". Three of these measures are patent-based, and the other two are survey-based.

Because not all measures might be equally suitable to answer the research question, the next step is choosing the most suitable one by interviewing innovation experts, see Section 4.2.

3.3.1. Patent-based

Three measures are based on patents related to digital innovations (Firk et al., 2021; Kohli & Melville, 2019; Zwiers, 2021). These studies use data from the US patent and Trademark Office (USPTO) and associate a higher number of filed digital innovation-related patents with a higher degree of digital innovativeness.

- Firk et al. note that it is important to truncate the patents filed in recent years, given that the time gap between filing the patent and its publication can take many years, resulting in a truncation bias. To find only patents related to digital innovations, they restrict the applicable technological classes of the USPC scheme to those clearly associated with digital technologies.
- Kohli and Melville survey the state of the digital innovation literature and conclude that further research on developing proper digital innovation measures is needed. Nevertheless, they indicate that counting the number of relevant patents was, at the time of writing (2019), the most common one.
- Zwiers restricts the patents to certain classes, namely those that contain patents that intensively leverage combinations of information, communication, computing, and connectivity technologies.

3.3.2. Survey-based

The other two measures are based on conducting a survey (Arias-Pérez & Vélez-Jaramillo, 2022; Eirich, 2020):

- Eirich crafted 5 Likert-scale questions, based on the research by Kyrgidou and Spyropoulou (2013):
  - We always seek new digital market opportunities
  - One of our greatest strengths is identifying digital goods and services that people want
  - One of our greatest strengths is the ability to exploit high quality digital market opportunities
  - We have special alertness or sensitivity toward spotting digital market opportunities
  - We usually identify digital market opportunities better than professional researchers/analysts
- Arias-Pérez and Vélez-Jaramillo developed a digital innovation performance measure based on 7 Likert-scale questions:
  - The number of digital solutions introduced is superior compared to our competitors'
  - The number of successful digital solutions is superior compared to our competitors'
  - The time to market for digital solutions is superior compared to our competitors'
  - The quality of our digital solutions is superior compared to our competitors'
  - The features of our digital solutions are superior compared to our competitors'
  - The applications of our digital solutions are totally different from our competitors'
  - Some of our digital solutions are new to the market at the time of launching
  - Some of our digital solutions serve new markets and customers

3.4. EA Factors

The EA factors whose influence on digital innovativeness will be evaluated in this research are obtained from three different sources:

1. **EA factors that were found to be correlated with (digital) innovativeness in existing literature**
2. **EA maturity models containing a large number of EA factors that are not yet known to be correlated with digital innovativeness**
3. Expert insights on which EA factors are likely to be correlated with digital innovativeness

This section discusses only the first two points (marked in **bold**) because these can be answered through a literature review. Information about the third point, namely the expert insights, is discussed in Appendix D.

3.4.1. Related to Innovation

The research on EA factors that are known to influence a firm's digital innovativeness is - to the best of the author's knowledge - non-existent. However, there is some prior research about EA factors that influence a firm's *general* innovativeness that might be worth considering in the context of *digital* innovativeness. I found five somewhat relevant papers, four of which contain concepts that are directly useful for this research:

- Louw et al. (2017) map several sub-architectures within a generic enterprise to corresponding innovation capability requirements. Such an overview could have been an excellent starting point for this thesis, but because all of the capability requirements are factors outside the scope of the enterprise architects, they are also outside the scope of this thesis (see Section 1.4.3).

- Nardello et al. (2016) investigate for a single firm the extent to which the firm's enterprise architects are aware and contributing to innovations. They also mention a few ways the architects stimulate innovation: by documenting the planned innovations, proposing optimizations, and providing information blocks that employees can put together to innovate.

- Lange and Mendling (2011) mention that an EA expert hypothesizes that providing an easy, centralized way to access data increases innovation.

- van de Wetering (2019) focuses on dynamic Enterprise Architecture capabilities.

  Dynamic Enterprise Architecture capabilities are defined as "dynamic capabilities that help organizations identify and implement new business and IT initiatives to ensure that the organizations' assets and resources are current with the needs of the business" (van de Wetering, 2019, p. 3), where *dynamic capabilities* are defined as "the ability of organizations to integrate, build, and reconfigure internal and external competences to address rapidly changing environments" (Teece et al., 1997, p. 7).

  The study investigates the correlation between these dynamic EA capabilities and a firm's process innovation and IT-business alignment. This correlation is present, but the authors do not investigate which capabilities have the most influence, while I am especially interested in the influence of these distinct capabilities. Additionally, almost none of the dynamic capabilities evaluated in the study match my definition of EA factors, namely "the factors that enterprise architects influence or are influenced by" (see Section 1.4.3), but instead focus on how the employees use the architecture within the organization. The dynamic capabilities that do align with my definition of EA factors are (as cited from van de Wetering (2019)):

  – "We use our EA to identify new business opportunities or potential threats"
  – "We review our EA services regularly to ensure that they are in line with key stakeholders wishes"
  – "We adequately evaluate the effect of changes in the baseline and target EA on the organization"
  – "We devote sufficient time to enhance our EA to improve business processes"

- Bontinck and Viaene (2016) suggest many ways by which enterprise architects could contribute to innovation. I distilled the following factors from their paper:

  – The enterprise architects have articulated a clear innovation ambition
  – The enterprise architecture ensure the link between the organization's different innovation ambitions
  – The enterprise architects are involved in innovation strategy discussions
  – The enterprise architects analyze the impact of proposed optimizations of existing products on the organization's different departments
  – The enterprise architects continuously update an overview with the capabilities of the firm
  – The enterprise architects provide direction in redesigning existing organizational structures
  – The enterprise architects actively identify external opportunities for innovation
  – The enterprise architects analyze the desirability of new innovations

- The enterprise architects analyze the validity of new innovations
- The enterprise architects analyze the feasibility of new innovations

The factors identified in these papers are mapped in Figure 3.3.

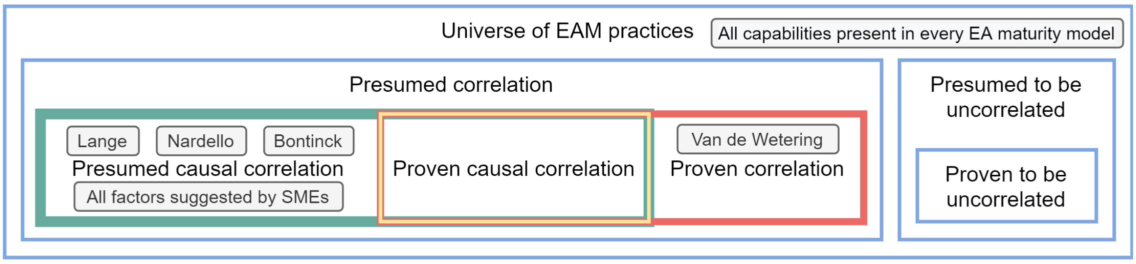

Figure 3.3: Previously identified EA factors linked to innovativeness mapped in a schematic scheme

In this figure, this thesis would fall in the category ”Presumed causal correlation” and ”Proven correlation.” However, this work differs from the existing works in these categories.

In contrast to the existing work in ”Presumed causal correlation”, I do extensive empirical research to prove the correlations. In contrast to the existing work in ”Proven correlation” (namely (van de Wetering, 2019)), I focus on digital innovation and a broad array of EA factors while van de Wetering focuses on a different type of innovation (namely process innovation) and a very specific type of EA factors (namely dynamic enterprise architecture capabilities). Additionally, I use expert interviews to gain insight into the causality of the correlations (see Section 9.3).

All of the EA factors mentioned above will be empirically investigated in correlation with a firm’s digital innovativeness. The mapping of these articles to constructs that are used within the structural model can be found in Section 4.1.1.

3.4.2. EA Maturity Models

The EA factors listed in Section 3.4.1 are interesting to evaluate, but there might also be other EA factors that were not identified by previous literature that also influence a firm’s digital innovativeness. To better understand what kind of other EA factors I could use for the research, I evaluate several EAMMs. These models measure the achieved level of competence of a firm’s EA capability (a.k.a., its maturity) based on a wide range of EA-related factors. These EA-related factors are designed to incorporate all important characteristics of an excellent EA department (Lagerström et al., 2009), which means that they can be an important source of inspiration for EA factors that are relevant to investigate for this research. The models found by the literature search are shown in Table 3.1.

I structure these models along several dimensions.

Firstly, I classify each EAMM as either a continuous, staged, or focus area model.

Continuous models assign to each dimension a certain maturity level.

Staged models assign to each maturity level a specific minimum performance per dimension.

Focus area models can be considered as a combination of continuous models and staged models with considerably more maturity levels. They juxtapose all dimensions (focus areas) to show a balanced, incremental development path towards a more mature practice (Van Steenbergen et al., 2008).

Secondly, I classify each EAMM as either product-based or process-based (or both) (van Zwienen et al., 2019).

Product-based models determine the maturity based on the availability and quality of the EA products used within the enterprise.

Process-based models determine the maturity based on the execution of the processes.

EA maturity model	Year	Reference	Type	# levels	Scoring method
Continuous model					
Enterprise Architecture Assessment Framework (EAAF)	2005	Office of Management and Budget	Product-based	5	KPIs with measurable artefacts
Enterprise Architecture Metrics in the Balanced Scorecard for IT	2008	Velitchkov	Process-based	-	Scorecard
EA Effectiveness Measurement Model	2010	der Raadt et al.	Process-based	-	Yes/no-questions
Comprehensive EA Benefit Realization Model	2012	Lange et al.	Process-based	-	High-level EA dimensions
Measurement Items for the Institutionalization of EAM	2012	Weiss and Winter	Process-based	-	Questionnaire
Enterprise Architecture Value Framework (EAVF)	2012	Plessius et al.	Product-based	4	Questionnaire
Enterprise Architecture Realization Scorecard (EARS)	2012	Pruijt, Slot, Plessius, et al.	Process-based	Scale of 0-30	Scorecard
Extended Enterprise Coherence-Governance Assessment (ϵECA)	2012	Wagter et al.	Product-based	5	20 open + 50 gradation questions
TOPAZ	2013	Sobczak	Process-based	-	250 control questions
Priority based EA Implementation Assessment Model (PEAIAM)	2017	Bakar et al.	Product- & Process-based	-	Ranking of factors
Staged model					
Capability Maturity Model Integration (CMMI)	2003	Chrissis et al.	Process-based	5	SCAMPI
Extended Enterprise Architecture Maturity Model	2003	Schekkerman	Process-based	5	?
Enterprise Architecture Maturity Model (NASCIO)	2003	Nascio	Product-based	5	Toolkit
Ross' Four Stages	2003	J. W. Ross	Product-based	4	?
Strategic Alignment Maturity Assessment Description	2011	Luftman	Product-based	5	High-level process descriptions
Ross' Five Stages	2006	J. W. Ross et al.	Product-based	5	?
IT Capability Maturity Framework (IT-CMF^{TM})	2008	Curley	Product- & Process-based	5	Questionnaire

Table 3.1 continued from previous page

EA maturity model	Year	Reference	Type	# levels	Scoring method
IT Architecture Capability Maturity Model (ACMM)	2007	U.S Department of Commerce	Product-based	5	Scorecard
Enterprise Architecture Management Maturity Framework (EAMMF)	2010	United States Government Accountability Office	Product-based	6	?
COBIT 2019	2018	Information Systems Audit and Control Association	Process-based	5	?
Maturity Model for Effective Enterprise Architecture	2018	Robertson et al.	Product-based	4	?
Focus area model					
Dynamic Architecture Maturity Matrix (DyAMM)	2008	Van Steenbergen et al.	Product- & Process-based	12	136 yes/no checkpoints

Table 3.1: Comparison of the EA maturity models found in the literature

3.5. Conclusion from the Literature Review

In this section, I briefly summarize the main conclusions of this literature review.

- There exist patent-based and survey-based methods to measure a firm's digital innovativeness. However, the number of papers published on this topic is very limited.
- There was no literature found specifically about EA factors that influence a firm's digital innovativeness.
- There are a few articles that mention EA factors that influence a firm's innovativeness in general. However, the number of papers related tot his topic is again very limited.
- There are many different Enterprise Architecture Maturity Frameworks (EAMMs) that measure the achieved level of competence of a firm's EA capability (a.k.a., its maturity) based on a wide range of EA-related factors. These EA-related factors are designed to incorporate all important characteristics of an excellent EA department, which means that they can be an important source of inspiration for EA factors that are relevant to investigate for this research.

This literature review resulted only the identification of relevant literature, but the aim of the thesis is to find EA factors that might influence a firm's digital innovativeness. Therefore, the most suitable measure for a firm's digital innovativeness is selected in Section 4.2, an overview of the previously identified EA factors is presented in Section 4.1.1, and the extraction of the most relevant EA factors from EAMMs is elaborated upon in Section 4.1.2.

4

SEM Step 1: Specifying the Structural Model

For this research, I chose to use PLS-SEM because it better aligns with the type of research conducted for this thesis than the other approaches (see Section 2.2). Given the choice for PLS-SEM, the structural equation model should be developed by first specifying the structural model and then specifying the measurement model (Russo & Stol, 2021). The structural model presents the constructs and explains the hypothesized causal paths between these constructs, while the measurement model explains how the constructs can be measured. (Freeze & Raschke, 2007; Gefen et al., 2011). The structural model is presented in this section and the measurement model is presented in Section 5.

This thesis aims to empirically evaluate the influence of several EA factors (the exogenous factors) on a firm's digital innovativeness (the endogenous factor), as explained in Section 1.4. Therefore, first, the exogenous constructs are presented in Section 4.1.

Then, the endogenous construct is presented in Section 4.2.

After specifying these exogenous / endogenous constructs, the hypothesises of how these constructs relate to each other are formulated in Section 4.3.

Finally, the pilot-ready version of the entire structural model is presented in Section 4.4.

4.1. Exogenous Constructs (EA Factors)

I use three different sources to obtain the final set of EA factors, namely EA factors that were found to be correlated with (digital) innovativeness in existing literature, EA factors obtained from EA maturity models, and EA factors suggested by EA experts (as mentioned in Section 3.4). Each of these sources has a dedicated subsection.

4.1.1. From Existing Literature

As part of the literature review, all literature that mentions EA factors that (presumably) correlate with a firm's innovativeness was mentioned in Section 3.4.1. These factors are shown in a systematic overview in Table 4.1.

EA factor	Questionnaire item	Source
Linkage different innovations	The architects document the planned innovations	(Nardello et al., 2016)
Active EA opportunity scouting	The architects propose optimizations	(Nardello et al., 2016)
Modular design	The architects provide information blocks that employees can put together to innovate	(Nardello et al., 2016)
Central data access point	All data can be accessed in an easy, centralized way	(Lange & Mendling, 2011)

Table 4.1 continued from previous page

EA factor	Questionnaire item	Source
Active EA opportunity scouting	We use our EA to identify new business opportunities or potential threats	(van de Wetering, 2019)
Feedback-driven EA design	We review our EA services regularly to ensure that they are in line with key stakeholders wishes	(van de Wetering, 2019)
Strategy consultation	We adequately evaluate the effect of changes in the baseline and target EA on the organization	(van de Wetering, 2019)
Continuous EA quality improvements	We devote sufficient time to enhance our EA to improve business processes	(van de Wetering, 2019)
Clear innovation ambition	The enterprise architects have articulated a clear innovation ambitions, either endogenous or exogenous	(Bontinck & Viaene, 2016)
Linkage different innovations	The enterprise architects ensure the link between the organization's different innovation ambitions	(Bontinck & Viaene, 2016)
EA involvement innovation	The enterprise architects are involved in innovation strategy discussions	(Bontinck & Viaene, 2016)
Innovation impact analysis	The enterprise architects are involved with analyzing the impact of proposed optimizations of existing products on the organization's different departments	(Bontinck & Viaene, 2016)
Not included - similar to DyAMM 5.A / 11 which was filtered out by the BWM method	The enterprise architects continuously update an overview with the capabilities of the firm	(Bontinck & Viaene, 2016)
Strategy consultation	The enterprise architects provide direction in redesigning existing organizational structures	(Bontinck & Viaene, 2016)
Active EA opportunity scouting	The enterprise architects actively identify external opportunities for innovation	(Bontinck & Viaene, 2016)
Innovation desirability analysis	The enterprise architects are involved with analyzing the desirability of new innovations	(Bontinck & Viaene, 2016)
Innovation validity analysis	The enterprise architects are involved with analyzing the validity of new innovations	(Bontinck & Viaene, 2016)
Innovation feasibility analysis	The enterprise architects are involved with analyzing the feasibility of new innovations	(Bontinck & Viaene, 2016)

Table 4.1: Overview of EA factors related to innovativeness as identified in existing literature

4.1.2. From EA Maturity Models

There exist many different EAMMs, as discussed in Section 3.4.2. I chose to use Dynamic Architecture Maturity Matrix (DyAMM) as a starting point for obtaining relevant EA factors because of its comprehensiveness (Lakhrouit & Baina, 2013), thorough scientific evaluation (Van Steenbergen et al., 2019; Van Steenbergen et al., 2010; Van Steenbergen et al., 2008), relatively recent update in 2019 (Van Steenbergen et al., 2019), application across different industries (Van Steenbergen et al., 2010), and its public availability. I already shortly introduced DyAMM in Section 3.4.2, but because I am going to use it as a starting point for evaluating the enterprise architecture, I will introduce the model in more detail in this section.

About DyAMM

DyAMM distinguishes 17 focus areas that EA practitioners should focus on to maximize the benefits of their EA. These focus areas are based on EA practitioners' practical experiences and comprise all important elements of the whole enterprise architecture capability. By evaluating for each focus area several checkpoints (yes/no questions), the practitioner can evaluate the maturity level for each of these focus areas. Although DyAMM also suggests which maturity levels should be prioritized and provides suggestions on how to improve in each focus area, I will only use it to learn what EA elements I should consider for the final set of EA factors.

EA factor extraction methodology

The total number of checkpoints (namely 137) is too high to evaluate in an interview or a survey. Therefore, I ask 7 EA experts to rank the factors based on how likely they deem these factors to be related to digital innovativeness (as explained in Appendix D). Subsequently, the factors that are - according to their intuition - most likely related to digital innovativeness are included in the structural model.

Assessing the relevance of various criteria (in this case, EA factors) can be done by using a so-called *Multi-Criteria Decision-making Method* (MCDM). There is a wide variety of MCDM methods available, and I suggest the reader to read the survey paper of Triantaphyllou (2000) or Munda (2005) for more information. I will use the *Best Worst Method* (BWM) (Rezaei, 2015, 2016), an MCDM method based on pairwise comparisons that has two main advantages: (1) it needs considerably less data than MCDM methods using a full pairwise comparison matrix, and (2) the results are more consistent than the results generated by most other MCDM methods (Rezaei, 2015). The method requires the user to choose the best and the worst criterion and rank all other criteria relative to only these two reference criteria on a scale of 1 to 9. More information about the BWM method can be found in Appendix D.

However, asking the experts to rank all 137 checkpoints of DyAMM would take too much time, even with the BWM method. Therefore, I create for each focus area a small number of statements that capture the essence of most checkpoints (see Section 5). Some statements correspond to multiple focus areas, and for certain focus areas, the levels are combined into a single concept when the differences are deemed too small. I group the resulting statements into four MECE categories shown in Figure 4.1. This clustering approach is based on the four categories used by Roest (2013), Bookholt (2014) and Lankhorst (2009), but specifies the categories more explicitly and shows the relationships between the categories. All factors found in DyAMM can be placed in one of these categories.

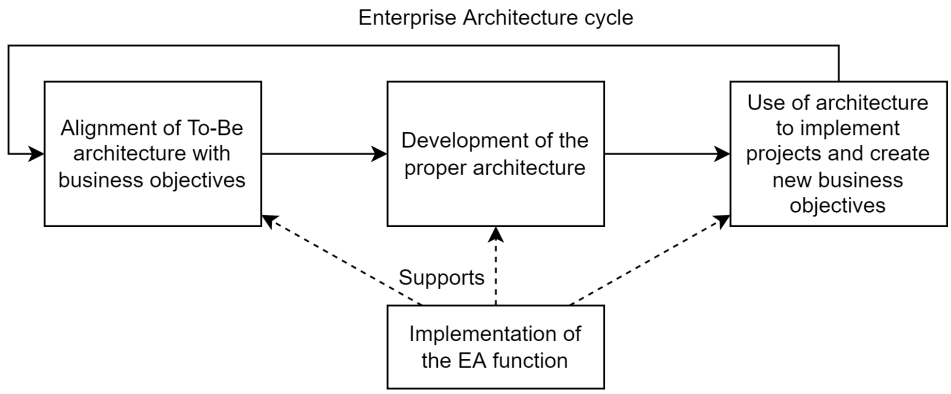

Figure 4.1: Segmentation of the enterprise architecture capability in four categories

DyAMM factors to be evaluated by experts

By using the methodology described above, the checkpoints are grouped into four categories with at most 9 EA factors, which is reasonable for experts to evaluate by using the BWM method. The resulting statements are shown in Table 4.2 and are evaluated by the experts. For the sake of brevity, the thesis does not include a detailed description of the meaning of each extracted concept. Instead, the reader can consult the DyAMM manual and look up the respective DyAMM focus area (van den Berg et al., 2019).

Abbreviation	**EA factor**
Alignment of To-Be architecture with business objectives	
Architectural documents are only drafted in there is someone in need of the result	1.A
All relevant parties are involved in the development of the architectural models (e.g., business managers, administrators, developers)	1.B / 15.B

Table 4.2 continued from previous page

Abbreviation	EA factor
The architecture is developed as a cohesive whole	1.C / 7.B / 16.C
The architecture is explicitly linked to the organization's business objectives, resulting in up-to-date To-Be diagrams	3.A
Development of the proper architecture	
The architects continuously update the As-Is architecture	5.A / 11
There is a roadmap showing the migration from As-Is to To-Be	5.B
The quality of the EA is continuously evaluated based on established quality requirements	9.A
The architectural process is continuously evaluated and improved	10.A
The architectural models are consistently developed and documented in the same modeling language	14.A / 16.A
The architectural method distinguishes a variety of perspectives for describing the architecture to different stakeholders	14.B
The architectural tools used are all integrated with one another	16.B
The staff carrying out projects offer feedback regarding the quality and applicability of the architecture	4.B
New architectural assignments are budgeted and planned based on historical data	17
Usage of the architecture to implement projects and adapt the business strategy	
he architecture is visible for the entire organization	2.A
The decision-makers consult enterprise architects or the architecture before starting a new project	2.B / 3.C / 7.C / 12.B
Staff carrying out projects consult enterprise architects or the architecture	7.A / 8
There are regular checks to verify that the staff carrying out projects work within the frameworks of the architecture	4.A / 7.B / 8 / 15.C
Implementation of the architect function	
A senior management member is ultimately responsible for the architecture	6.A / 12.C
There are sufficient resources allocated for the architectural process	12.A
The architects are sufficiently skilled to meet the demands of their job	13.A
The architects are supported with training programs, tools, and other methods to exchange best practices	13.B
The enterprise architects form a strong team by working closely together	15.A

Table 4.2: The DyAMM checkpoints grouped into four non-overlapping categories

Extracted DyAMM factors

The raw results of the BWM method applied to the statements shown in Table 4.2 are included in Appendix D. The final set of EA factors that were obtained by using the BWM method is listed in Table 4.3. The dimensions have been prefixed with ”*Innovation-focused*” to highlight that these constructs contain only those elements identified by EA experts to be probably related to digital innovativeness. In other words, these constructs are explicitly defined not to capture all aspects that would usually be associated with their original meaning anymore, but only those aspects that the interviewed EA experts hypothesize to correlate with digital innovativeness.

Abbreviation	EA factor (DyAMM concept)
Innovation-focused alignment of To-Be architecture with business objectives	
EA stakeholder collaboration	All relevant parties are involved in the development of the architectural models (e.g., business managers, administrators, developers)
EA cohesion	The architecture is developed as a cohesive whole
EA alignment with objectives	The architecture is explicitly linked to the organization's business objectives, resulting in up-to-date To-Be diagrams
Innovation-focused development of the proper architecture	
Roadmap	There is a roadmap showing the migration from As-Is to To-Be
Continuous EA quality improvements	The quality of the EA is continuously evaluated based on established quality requirements
Continuous EA process improvements	The architectural process is continuously evaluated and improved
Feedback-driven EA design	The staff carrying out projects offer feedback regarding the quality and applicability of the architecture
Innovation-focused usage of the architecture to implement projects and adapt the business strategy	
EA visibility	The architecture is visible for the entire organization
Strategy consultation	The decision-makers consult enterprise architects or the architecture before starting a new project
Program/project consultation	Staff carrying out projects consult enterprise architects or the architecture
Compliancy verification	There are regular checks to verify that the staff carrying out projects work within the frameworks of the architecture
Innovation-focused implementation of the enterprise architect role	
EA funding	There are sufficient resources allocated for the architectural process
Architect recruitment	The architects are sufficiently skilled to meet the demands of their job
Architect development	The architects are supported with training programs, tools, and other methods to exchange best practices
Architect bonding	The enterprise architects form a strong team by working closely together

Table 4.3: EA factors selected from the previously created groups after applying BWM

4.1.3. From EA Experts

The specification of the structural model is partly based on interviews with EA- and innovation-experts (as explained in Section 4.1). These interviews are needed because (1) the literature review might not cover all EA factors that are likely to be related to digital innovativeness, and (2) many of the EA factors present in the EA maturity models may be unlikely to correlate with digital innovativeness (and with a survey the number of factors that can be evaluated is limited). I interviewed 19 EA experts in total (as explained in Appendix D). They indicated that they would expect the following EA factors to influence a firm's digital innovativeness:

Abbreviation	EA factor	Rationale
Not included - similar to DyAMM 5.A / 11 which was filtered out by the BWM method	Degree to which the enterprise architects work from an ivory tower, degree of insight into the as-is state including the current limitations	Architects make better choices when their mental image of the firm is in line with reality
Support for pilots	Degree to which the enterprise architects support pilots or allow shadow IT systems	Supporting small-scale experiments and pilots are a prerequisite for bottom-up innovation
Modular design	The extent to which the architects configure the IT environment as loosely coupled, modular micro-services vs. a singular, monolithic system	A modular landscape makes it easier to find weak points and innovate specifically there, resulting in more targeted and efficient innovation
Cloud usage	The extent to which the cloud is used to run applications	The cloud gives the firm much more flexibility, agility, and scalability to try out new things
Central data access point	The amount of data that is stored in a single location for easy access	Easy access to data can make the organization more data-driven, opening up a myriad of ways to improve the value proposition
Low-code usage	The extent to which low-code applications such as Jupyter Notebook, Microsoft Power Apps, Salesforce Lightning, or similar applications are used to enable non-programmers to develop innovative solutions	Low-code enables non-programmers to realize small innovations in their own domain
EA stakeholder collaboration	Degree to which enterprise architects receive innovative ideas from bottom-up	Many employees in the organization may have innovative ideas that are relevant for the architects
Agile EA working method	Degree to which enterprise architects work in an agile way	Innovations are unpredictable and require a flexible, agile way of working
EA visibility	Degree of transparency within the organization of the projects that the enterprise architects are working on	The innovation efforts of employees are more focused when these are in line with the enterprise architecture
Strategy consultation	Degree to which the enterprise architects communicate with C-level executives to influence the strategic decisions	Innovative ideas of enterprise architects might depend on support from the C-level executives and vice versa
Compliancy verification	Mandate/empowerment of enterprise architects to set boundaries in between which projects must be executed	Stringent compliance measures might restrict employees in their innovation efforts
Escalation/exception handling	Degree to which the enterprise architects have an adequate process for granting exceptions with regards to following the rules set by the enterprise architecture	When the architects readily grant exceptions for innovative projects not in line with the architecture, these innovative projects might suffer less from EA-related delays

Table 4.4 continued from previous page

Abbreviation	EA factor	Rationale
EA involvement innovation	The extent to which enterprise architects are involved in the innovation strategy, for example, by closely working together with the innovation department	Architects might be able to reflect on the feasibility of innovative ideas devised in the innovation department

Table 4.4: Overview of EA factors related to digital innovativeness mentioned by EA experts

4.1.4. Combining all EA factors

All EA factors listed in the previous sections are shown together in Table 4.5. EA factors introduced multiple times, for example, both by the literature review and by EA experts, are combined in this overview in a single factor.

ID	EA factor	Source
Innovation-focused Enterprise Architecture design		
1.1	Support for pilots	EA expert
1.2	Modular design	EA expert
1.3	Cloud usage	(Nardello et al., 2016), EA expert
1.4	Central data access point	EA expert
1.5	Low-code usage	(Lange & Mendling, 2011), EA expert
Innovation-focused alignment of To-Be architecture with business objectives		
2.1	EA stakeholder collaboration	(van de Wetering, 2019; Van Steenbergen et al., 2019), EA expert
2.2	EA cohesion	(Van Steenbergen et al., 2019)
2.3	EA alignment with objectives	(Van Steenbergen et al., 2019)
Innovation-focused development of the proper architecture		
3.1	Roadmap	(Van Steenbergen et al., 2019)
3.2	Continuous EA quality improvement	(Van Steenbergen et al., 2019)
3.3	Continuous EA process improvement	(Van Steenbergen et al., 2019)
3.4	Feedback-driven EA design	(van de Wetering, 2019; Van Steenbergen et al., 2019)
3.5	Agile EA working method	EA expert
Innovation-focused usage of the architecture		
4.1	EA visibility	(Van Steenbergen et al., 2019), EA expert
4.2	Strategy consultation	(van de Wetering, 2019; Van Steenbergen et al., 2019)
4.3	Program / project consultation	(Van Steenbergen et al., 2019), EA expert
4.4	Compliancy verification	(Van Steenbergen et al., 2019), EA expert
4.5	Escalation / exception handling	(Van Steenbergen et al., 2019), EA expert
Innovation-focused implementation of the enterprise architect role		
5.1	EA funding	(Van Steenbergen et al., 2019)

Table 4.5 continued from previous page

ID	EA factor	Source
5.2	Architect recruitment	(Van Steenbergen et al., 2019)
5.3	Architect development	(Van Steenbergen et al., 2019)
5.4	Architect bonding	(Van Steenbergen et al., 2019)
	Innovation-focused enterprise architect behavior	
6.1	Clear innovation ambition	(Bontinck & Viaene, 2016)
6.2	Linkage different innovations	(Bontinck & Viaene, 2016)
6.3	EA involvement innovation	(Bontinck & Viaene, 2016)
6.4	Innovation impact analysis	(Bontinck & Viaene, 2016)
6.5	Active EA opportunity scouting	(Bontinck & Viaene, 2016; Nardello et al., 2016; van de Wetering, 2019), EA expert
6.6	Innovation desirability analysis	(Bontinck & Viaene, 2016)
6.7	Innovation validity analysis	(Bontinck & Viaene, 2016)
6.8	Innovation feasibility analysis	(Bontinck & Viaene, 2016)
6.9	Innovation-driven To-Be architecture	(Bontinck & Viaene, 2016)

Table 4.5: Overview of all EA factors

4.2. Endogenous Construct (Digital Innovativeness)

An overview of all digital innovativeness measures identified during the literature review was presented in Section 3.3. Three of these measures are patents-based and two questionnaire-based. I interviewed six innovation experts to determine the best measure for the research (see Appendix D).

The experts indicated that patent-based innovativeness measures (Firk et al., 2021; Kohli & Melville, 2019; Zwiers, 2021) are unsuitable for the research. On the one hand, many organizations - especially the smaller ones - do not have any patents even though they regularly produce innovations, significantly reducing the reliability of using a patent-based measure. On the other hand, digital innovations are often hard to patent because the patent application often takes longer than the software's useful lifespan and is difficult to prove as novel and non-obvious.

The two survey-based innovation measures seem to be better choices (Arias-Pérez & Vélez-Jaramillo, 2022; Eirich, 2020). The measure of Eirich (2020) purports to measure "digital innovation performance", but its elements seem to be focused on measuring the effort with which the enterprise looks for new digital market opportunities rather than the actual digital innovation output.

The measure of (Arias-Pérez & Vélez-Jaramillo, 2022) aligns best with the objective of this research: it uses 7 Likert-scale statements that are all related to a particular dimension of a firm's digital innovativeness. The authors assessed the reliability, convergent, and discriminant validity for the measurement instrument, all of which were excellent. Therefore, I will use this measure in the remainder of the thesis.

4.3. Hypotheses

This section first presents several high-level hypotheses and subsequently presents numerous more fine-grained hypotheses. Both high-level and low-level hypotheses can provide valuable insights into the influence of EA factors on a firm's digital innovativeness.

High-level hypotheses

The three sources used to gather EA factors to evaluate resulted in three different "types" of factors.

- The existing literature resulted mostly in factors that relate to the attitude of enterprise architects with regard to digital innovation (see Section 4.1.1 => From existing literature).

- The EAMM DyAMM contains only factors that relate to the maturity of the EA capability and not directly to innovation (see Section 4.1.2 => From EA maturity models).
- The EA experts mentioned mostly factors that relate to the design of the enterprise architecture with regard to digital innovation (see Section 4.1.3 => From EA experts).

Based on these three types of EA factors, I hypothesize that there are three ways in which Enterprise Architects influence a firm's digital innovativeness, namely by:

- Designing the architecture as a solid foundation on top of which it is easy for employees to test new ideas (*the EA design perspective*)
- By having a mature Enterprise Architecture capability that enables or inhibits innovative ideas to grow and realize impact in line with the business objectives (*the EA capability perspective*)
- By managing these bottom-up innovations with a top-down EA perspective to keep them in line with each other, with the internal business strategy, and with external industry trends (*the EA innovation perspective*)

Because analyzing the influence of a firm's EA capability maturity on its digital innovativeness seems to be too generic (EA capability maturity is a broad concept), I will analyze the influence of each of its four MECE categories on a firm's digital innovativeness, namely the categories that were shown earlier in Figure 4.1.

In addition, I hypothesize that the influence of the aforementioned constructs on a firm's digital innovativeness is moderated by how well the firm is positioned to produce digital innovations, a.k.a. its *digital innovation readiness* (Lokuge et al., 2019). The degree of digital innovation readiness essentially addresses the key question: "Is the firm able and willing to innovate?" (Holt & Daspit, 2015). The idea behind this hypothesis is that, no matter how mature the Enterprise Architecture and no matter how innovation-focused the Enterprise Architecture and enterprise architects are, when the firm does not have the resources, partnerships, motivation, or other digital innovation readiness aspects that are crucial to innovate, the firm will not be able to produce digital innovations.

These trains of thought result in the hypotheses shown in Table 4.6.

ID	EA factor	Hypothesized correlation with digital innovativeness
	EA Design Perspective	
1.	Innovation-focused Enterprise Architecture design	+
	EA Capability Perspective	
2.	Innovation-focused alignment of To-Be architecture with business objectives	+
3.	Innovation-focused development of the proper architecture	+
4.	Innovation-focused usage of the architecture	+
5.	Innovation-focused implementation of the enterprise architect role	+
	EA Innovation Perspective	
6.	Innovation-focused enterprise architect behavior	+
	Moderation	
X.	Digital innovation readiness	+/- for all main construct => digital innovation relationships

Table 4.6: Hypothesis map

Fine-grained hypotheses

Several papers mention that EA has a positive influence on innovation (see Section 1.4.1), but none of them specifies what specific elements of EA are important in this regard, nor what type of innovation is improved by EA. Because I want to formulate concrete guidelines for architects on improving their organization's digital innovativeness, I investigate for each EA factor mentioned in Section 4.1.4 its impact to evaluate if there are any significant correlations. This results in the hypotheses listed in Table 4.7. All of these are positive, except for hypotheses 2.1, 4.4, and 4.5 based on feedback from EA experts. These factors likely influence a firm's digital innovativeness, but the direction is unclear.

These hypotheses are tentative and updated after assessing the measurement model, as explained in Section 8.1.

ID	EA factor	Hypothesized correlation with digital innovativeness
1.	**Innovation-focused Enterprise Architecture design**	+
1.1	Support for pilots	+
1.2	Modular design	+
1.3	Cloud usage	+
1.4	Central data access point	+
1.5	Low-code usage	+
2.	**Innovation-focused alignment of To-Be architecture with business objectives**	+
2.1	EA stakeholder collaboration	+/-
2.2	EA cohesion	+
2.3	EA alignment with objectives	+
3.	**Innovation-focused development of the proper architecture**	+
3.1	Roadmap	+
3.2	Continuous EA quality improvement	+
3.3	Continuous EA process improvement	+
3.4	Feedback-driven EA design	+
3.5	Agile EA working method	+
4.	**Innovation-focused usage of the architecture**	+
4.1	EA visibility	+
4.2	Strategy consultation	+
4.3	Program / project consultation	+
4.4	Compliancy verification	+/-
4.5	Escalation / exception handling	+/-
5.	**Innovation-focused implementation of the enterprise architect role**	+
5.1	EA funding	+
5.2	Architect recruitment	+
5.3	Architect development	+
5.4	Architect bonding	+

Table 4.7 continued from previous page

ID	EA factor	Hypothesized correlation with digital innovativeness
6.	**Innovation-focused enterprise architect behavior**	+
6.1	Clear innovation ambition	+
6.2	Linkage different innovations	+
6.3	EA involvement innovation	+
6.4	Innovation impact analysis	+
6.5	Active EA opportunity scouting	+
6.6	Innovation desirability analysis	+
6.7	Innovation validity analysis	+
6.8	Innovation feasibility analysis	+
6.9	Innovation-driven To-Be architecture	+

Table 4.7: Extended hypothesis map

4.4. Pilot-ready Version of the Structural Model

The exogenous constructs, endogenous constructs, and their relationships in-between (explained in the previous sections) constitute the structural model, which is visualized in Figure 4.2.

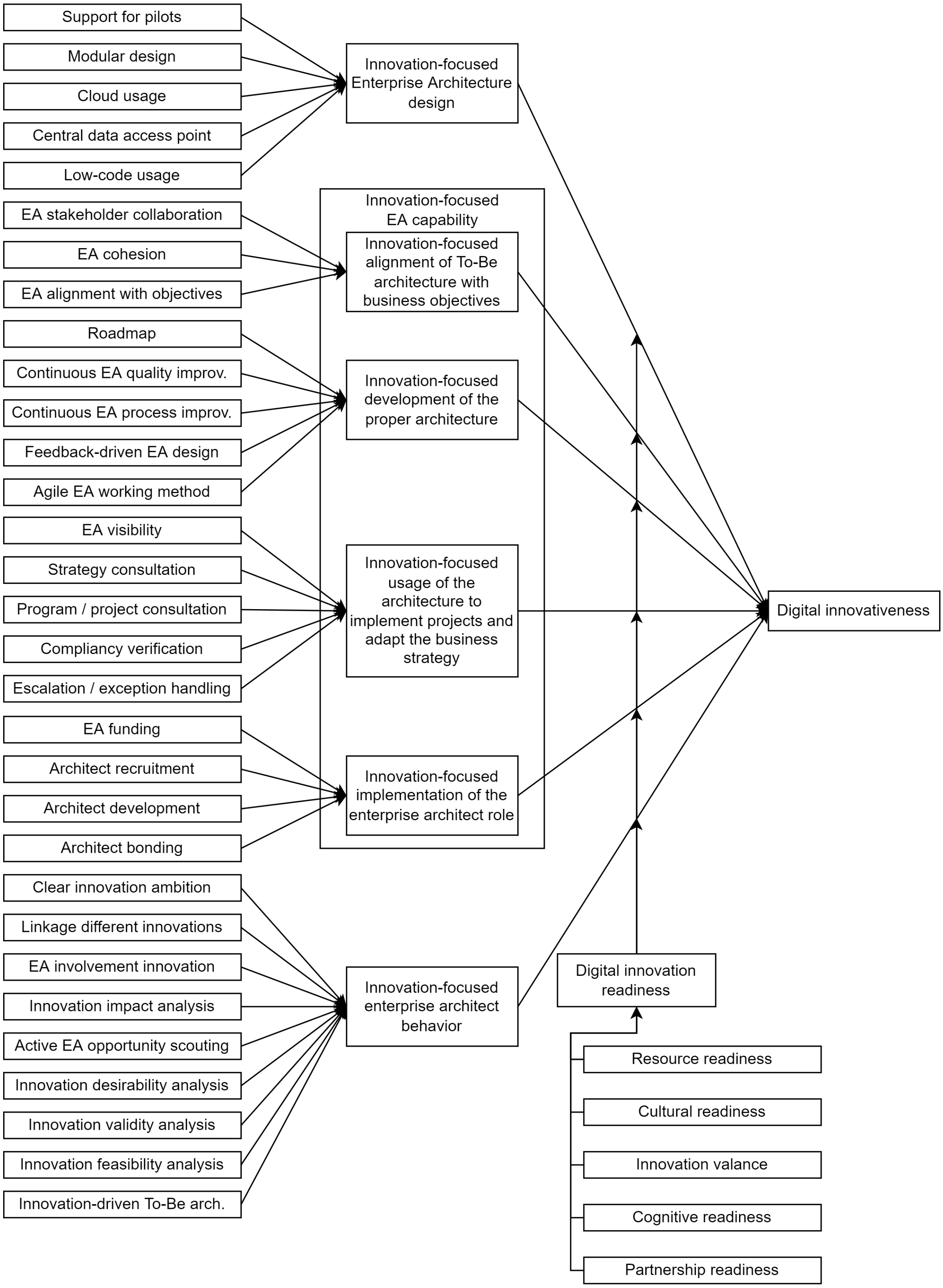

Figure 4.2: Pilot-ready version of the structural model

5

SEM Step 2: Specifying the Measurement Model

For this research, I chose to use PLS-SEM because it better aligns with the type of research conducted for this thesis than the other approaches (see Section 2.2). Given the choice for PLS-SEM, the structural equation model should be developed by first specifying the structural model and then specifying the measurement model (Russo & Stol, 2021). The structural model was presented in Section 4, and the measurement model is presented in this section.

The measurement model explains the relation between the observable indicators and unobservable constructs (i.e., the structural model) (Freeze & Raschke, 2007; Gefen et al., 2011). The measurement instrument is the method used to measure the observable indicators, such as an interview, an observational study, a questionnaire, etc.

This section first explains which type of measurement instrument is most suitable for the research in Section 5.1.

Based on this choice, I explain the methodology used for specifying the measurement model in Section 5.2.

Finally, I present the pilot-ready version of the measurement model that was formulated by using this methodology in Section 5.3.

This pilot-ready measurement model is assessed and improved by using two pilot studies in a later section, namely Section 7.

5.1. Choosing a Proper Measurement Instrument Type

Before choosing the most suitable measurement instrument, I define the target population. The target population consists of Dutch enterprise architects (see Section 1.4.3). These people are the most knowledgeable employees about their own role and the enterprise architecture used in the organization. They do not necessarily know much about their organization's innovation strategy, but in consultation with my supervisors, I chose to ask the enterprise architects also about their organization's innovativeness. On the one hand, enterprise architects are usually highly-skilled experts that operate on a relatively high level within the organization's hierarchy, making them likely to have a reasonably accurate idea of how their firm is performing. On the other hand, arranging interviews with innovation specialists for the same firms is not feasible given the time constraints of a thesis, which means that I would have to resort to methods that are not dependent on interviews (which are unsuitable as explained in Section 3.3).

To reach out to these individuals, I use, on the one hand, my personal connections and, on the other hand, two major Dutch networks for enterprise architects, namely the ”Nederlands Architectuur Forum” (commonly abbreviated as NAF) and the ”Chief Architecture Community” (a community created by Deloitte for chief enterprise architects working at their clients). The characteristics of these groups (such as their geographical dispersion) is important to keep in mind while choosing the type of measurement instrument.

Choosing for an electronic questionnaire and telephone interviews

There are three common types of measurement instruments used for business research - interviews, observation, and questionnaires -, all of which have their advantages and disadvantages as shown in Appendix J.

Because practically all of the constructs are based on subjective information that cannot be gathered from documents and is too cumbersome to observe for a large number of firms, I eliminated the observational studies option. Because of the geographical dispersion, I also eliminated the face-to-face interviews and personally administered questionnaires option. This leaves me with an **electronic questionnaire** and **telephone interviews**, both of which seem to be appropriate measurement instruments and will be used to gather data for this research.

Electronic questionnaires are suitable because they make it possible to (potentially) gather data from many architects and because the constructs within the structural model can relatively easily be mapped to corresponding indicators. Additionally, using this method is an established approach that has been found to lead to reliable results (Wall et al., 2004). However, I learned from the coordinator of the Chief Architect Community - who is also involved in the NAF - that the members of both networks are very busy and have developed a ”survey fatigue” in recent years.

Therefore, telephone interviews are also a suitable choice to gather data. Firstly, the aforementioned coordinator mentioned that architects are more likely to agree to participate in an interview than fill in a questionnaire due to this ”survey fatigue”. Secondly, telephone interviews still make it possible to call a relatively high number of architects per day and essentially ask them to fill in the questionnaire during the interview. Thirdly, these interviews let me get valuable feedback on the questionnaire and get additional insights into the nuances and underlying rationale behind the responses. To build rapport with the interviewees and observe non-verbal clues, I will aim to conduct most interviews by video rather than voice only.

Choosing for structured interviews

Interviews can be either unstructured, semi-structured, or structured (Owen & Noonan, 2013). Each of these interview methodologies has its own advantages and disadvantages (outlined in Appendix K)

Unstructured interviews are interviews without a planned sequence of questions to be asked. They are exploratory and often used to bring some preliminary issues to the surface that can be investigated in further research.

Semi-structured interviews are loosely structured where the researcher has several questions for which he/she wants an answer, but there is also considerable room to diverge to related topics based on what the interviewee says.

Structured interviews are used when the researcher knows what information is exactly needed in advance. The questions are clearly formulated and the same for everyone, which gives the researcher fine-grained insight into the differences between the respondents.

Because the exploratory part of this research was already conducted using a literature review and expert interviews (see Section 1.4.5), I already know exactly what information is required from the respondents (namely the information to verify the hypotheses formulated in Section 4.3). Therefore, the interviews will be **structured**, although I will ask the interviewees to briefly elaborate on certain choices every few minutes to gain additional insights, validate the measurement instrument, and keep the interview engaging.

5.2. Formulation of the Measurement Model

The structural model presented in Section 4.4 is operationalized to a measurement model by mapping each construct to a corresponding measure.

There are two types of measurement models, namely *reflective measurement models* (also known as scales and labeled as mode A) and *formative measurement models* (also known as indices and labeled as mode B) (Hair et al., 2011). More information about the difference between reflective and formative construct can be found in Table A.1. In this case, I formulate the measurement model reflectively because of two reasons:

On the one hand, the constructs that the indicators will measure are already quite specific because they are part of a larger, formative construct (one of the categories). The more specific the constructs, the harder it will be to split them into indicators that are adequately grounded in theory, properly measure the construct, and not overlap.

On the other hand, there is no proof that many of the questionnaire items are interpreted as intended. By formulating the measurement reflectively, I can compare the results of different wordings to evaluate if the items are interpreted correctly.

The measurement model is developed along three guidelines:

- To increase the validity, I adopt items from existing scales whenever possible.
- If there were no existing scales from which I can adopt the measures, I adapt existing scales.
- If there are no existing scales suitable to adapt either, I formulate new items based on the language and jargon used in existing literature (all respondents are EA experts).

Adopting existing items

Two constructs can be adopted from articles published in peer-reviewed journals, namely ”Digital innovation readiness” (Lokuge et al., 2019) and ”Digital innovativeness” (Arias-Pérez & Vélez-Jaramillo, 2022).

The ”Digital innovation readiness” construct consists of five formative dimensions, namely:

- Resource readiness - is the organization flexible in allocating adequate financial, human, and IT resources for digital innovations?
- Cultural readiness - is thinking about digital innovations entrenched in the mindset of the employees?
- Innovation valance - are the employees motivated and empowered to facilitate digital innovations?
- Cognitive readiness - do the employees have the appropriate knowledge, skills, and adaptability to facilitate digital innovations?
- Partnership readiness - does the organization have good relationships with its IT vendors, management consultants, and customers to facilitate digital innovations?

The ”Digital innovativeness” construct consists of eight dimensions for which the respondent should compare their own firm’s performance to its competitors, namely:

- Number of digital solutions introduced
- Number of successful digital solutions introduced
- Time to market for new digital solutions
- Quality of new digital solutions
- Features of new digital solutions
- New applications of the digital solutions
- New to the market of the digital solutions
- New markets and customers served by the digital solutions

The formulation of the items of the ”Digital innovation readiness” and ”Digital innovativeness” construct can be found in Section 7.2.

Adapting existing items and formulating new items

Whereas I was able to adopt existing items to measure the ”Digital innnovation readiness” and ”Digital innovativeness” construct, for all of the other constructs I need to adapt items from the literature or formulate them myself. Because these items are not validated yet, they are assessed and improved by using two pilot tests (see Section F). For these constructs, I have to make a trade-off: on the one hand, I would like to measure the reflective constructs with a high number of items to improve their reliability, but on the other hand, the questionnaire should not become too long, causing respondents to drop out. By formulating for each reflective construct exactly two items (referred to as ”*item-pair*” in the remainder of the thesis), the measurement instrument takes approximately 15 minutes to be completed when administered as a questionnaire and approximately 60 minutes to administer during an interview. Both timespans are deemed long but still reasonable.

All items are formulated on a Likert scale, a 5-point scale ranging from ”Totally disagree” to ”Totally agree”. I choose a Likert scale because it increases the response rate and response quality relative to scales with fewer or more points (Babakus & Mangold, 1992; Sachdev & Verma, 2004), is relatively simple to use when administered as an interview (Dawes, 2008), and has been suggested to be more appropriate for European surveys (Prentice et al., 1998). Because the scale consists of 5 naturally ordered categories, it results in ordinal data. Ordinal data allows for less powerful and sensitive statistical analysis than parametric data (such as ratio and interval) (Vigderhous, 1977). However, 5-point Likert scales usually have sufficient detail to be regarded as interval data, according to Clason and Dormody (1994).

The timeframe is a notable challenge I have to overcome with the measurement instrument. Ideally, I want to either investigate the state of the enterprise architecture several years ago or the innovation output several years in the future because it takes considerable time to develop innovations.

The first option is unsuitable because asking people about events that happened a long time ago usually results in inaccurate responses (B. A. Kitchenham & Pfleeger, 2002).

The second option would require a longitudinal study, which is not feasible within the time constraints of a thesis.

Therefore, I ask the respondents to focus specifically on recent innovations, including those currently in the pipeline.

To validate the measurement and structural model, I subject the first version to a review by 5 EA experts as suggested by Straub et al. (2004). Subsequently, the EA experts’ input is integrated into the model by reformulating, removing, and adding items to create a pilot-ready version.

The resulting pilot-ready measurement model is not included in this section because it consumes a considerable amount of space but can be found in Appendix F.2.1.

5.3. Pilot-ready Version of the Structural Equation Model

The first pilot-ready version of the structural equation model combines the structural model and the measurement model specified above and is visualized in Figure 5.1. The items of the measurement model can be found in Appendix F.2.1

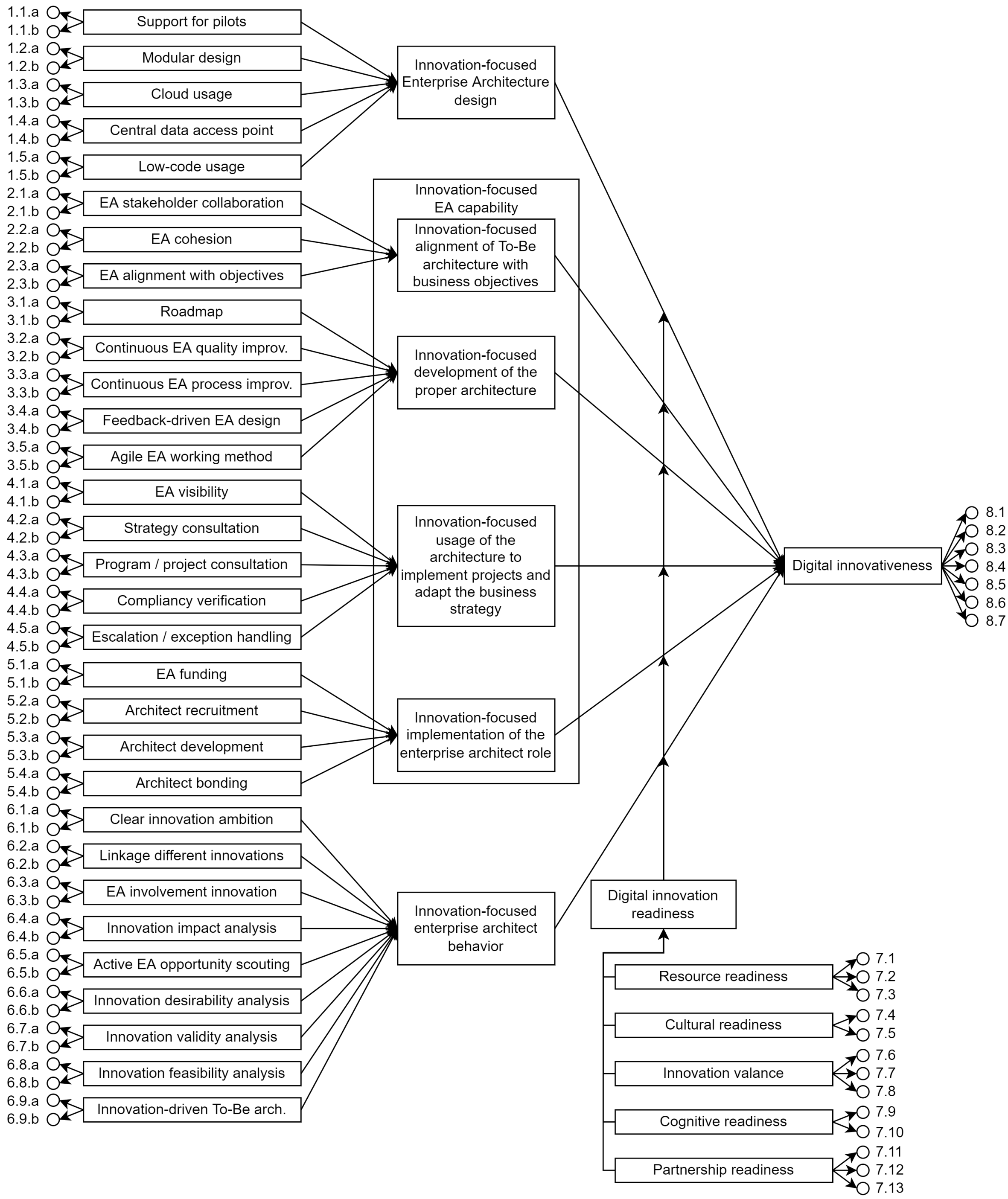

Figure 5.1: Pilot-ready version of the structural equation model

6
SEM Step 3: Collecting Data

After specifying the structural model (see Section 4) and the measurement model (see Section 5), the next step is to collect data to assess these models (as explained in Section 1.4.5).

In this section, I first explain the data collection methodology in Section 6.1.

Subsequently, I collect data based on this methodology and summarize several statistics about the results in Section 6.2.

More detailed results specific for assessing the measurement model are shown in Section 7 and results specific for assessing the structural model are shown in Section 8.

6.1. Data Collection Methodology

I use four ways to find enterprise architects to participate in the research:

- Personal connections from Prof. Dr. Ir. Marijn Janssen, the main supervisor of the author of this thesis
- Personal connections of Deloitte consultants
- Members of the Chief Architect Community, a small community of enterprise architect clients from Deloitte
- Members of the NAF (Nederlands Architectuur Forum)

For the pilot studies described in Section 7, I use personal connections of Deloitte consultants because this was a relatively easy and fast way to gather interviews.

Enterprise architects may have developed over the years survey fatigue, as mentioned in Section 5.1. Therefore, I use the following strategy to obtain sufficient responses in the first three groups:

- I ask the architects if I can arrange an interview instead of asking them to fill in a survey
- I refer to the architects as ”experts”, whose experience is needed for the research
- I send a separate (slightly customized) email directed towards each architect rather than sending a single message in a group
- I refer in the communication to each architect to a ”higher authority”. When architects are found via personal connections, I ask these personal connections to introduce me. When architects are members of the Chief Architect Community, I mention that Eric Onderdelinden is involved in the research (the community’s founder and a well-known EA expert). When the architects are members of the NAF, I mention that the NAF actively supports the research.
- I indicate that the clients get two valuable types of information in return:
  - The result of this thesis, namely insight into which EA factors strongly relate to digital innovativeness
  - Insight into how their responses compare with the benchmark (the average of the other responses)

- At the end of each interview, I ask the architects if they know some other enterprise architect(s) that I could interview

Because the interviews are highly structured, I do not need to transcribe the interviews, which reduces privacy concerns and the time needed per interview, making it possible to conduct more interviews.

Because the network of the NAF is quite large, I ask these members to fill in an equivalent survey instead. When the survey fatigue is less significant than initially expected, this might result in more responses than I could otherwise have obtained.

6.2. Result Statistics

This section contains several statistics about the final assessment results. These results are based on the final measurement model presented in Section 7.2. In total, I conducted 22 interviews and obtained 38 questionnaire responses, as illustrated in Table 6.1.

Statistic	Value
#interviews	22
#questionnaire responses	38
... of which complete	29
#interviews + complete questionnaire responses	51

Table 6.1: Overview of the number of responses

6.2.1. Segmentation by Industry

I segmented the firms by the sectors as defined by the *Global Industry Classification Standard* (GICS) (Barra, 2009), a popular classification system to assign firms to a specific sector that best defines its business operations. However, the GICS is intended for companies, so to make it more suitable for my research, I also added the category ”Government” to the categories. The result is shown in Figure 6.1.

The categories ”Real Estate” and ”Communication Services” have been omitted because no firms from those sectors accepted the invitation for an interview or responded to the questionnaire. Clearly, most firms that participated in the research are either active in the financial sector or part of the government. The implications of this are discussed in Section 9.5.

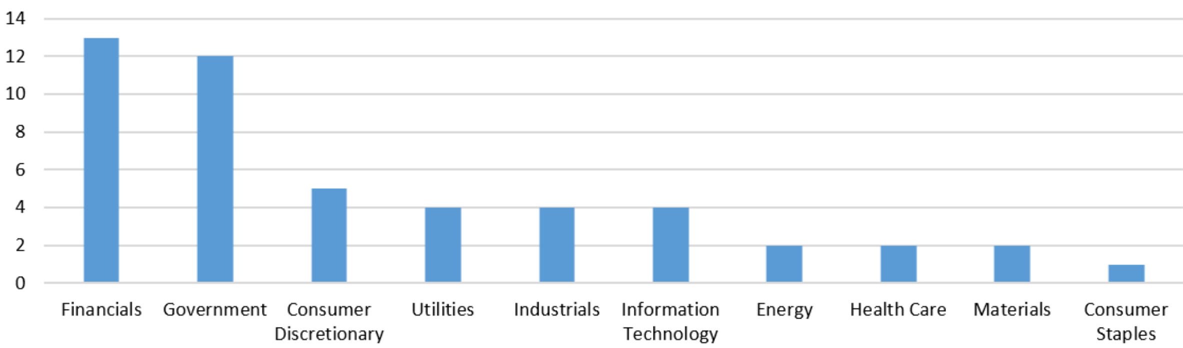

Figure 6.1: Segmentation of the results by industry

6.2.2. Segmentation by Role

To segment the respondents by their role, I clustered the respondents' official function titles into somewhat ”generic” roles by (a) removing the seniority level (such as ”junior” or ”senior”), (b) removing very specific specializations (such as ”strategy” or ”innovation”), (c) replacing ”information architect” with ”data architect”, and (d) replacing all leadership-related denotations with ”lead” (such as ”president”, ”principal”, and ”director”). The reason for applying these data simplifications is to protect the privacy of the respondents because the function titles of several respondents were so specific that it would be possible to trace them back to the respondent. The segmentation is shown in Figure 6.2.

Clearly, most of the respondents are either enterprise architects or lead enterprise architects, who are precisely the people I target for this research. However, it is important to note that the exact definition and implementation of the role of an ”enterprise architect” differs between firms, as discussed in Section 9.4.3.

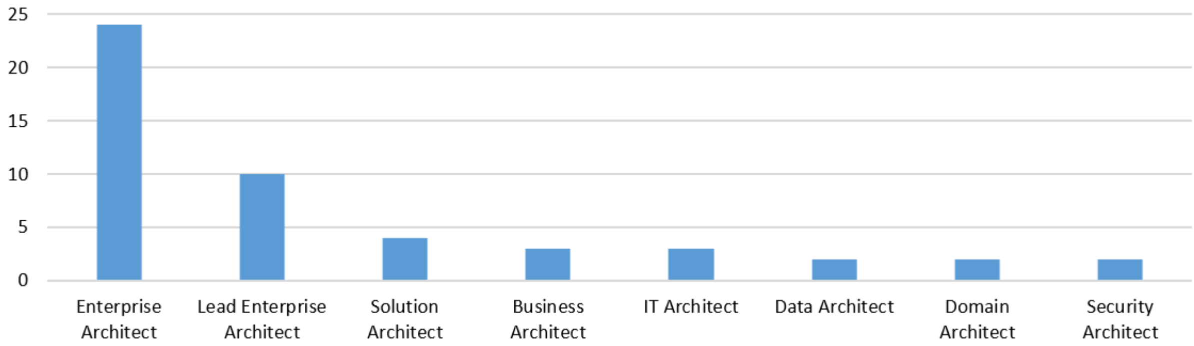

Figure 6.2: Segmentation of the results by role

6.2.3. Segmentation by Number of Enterprise Architects

I also segmented the responses based on the number of enterprise architects working for the organization, where enterprise architects are specifically defined as those employees satisfying the definition of ”enterprise architect” used in this thesis (see Section 1.1.1). This excludes employees who would regularly be considered solution architects or business architects.

The segmentation of the respondents by this number of enterprise architects is shown in Figure 6.3. Clearly, most firms that participated have between 5 and 25 enterprise architects. In conglomerates or very diversified corporations, the number of enterprise architects can be very large because each of the organization’s divisions may have a unique and distinct enterprise architecture.

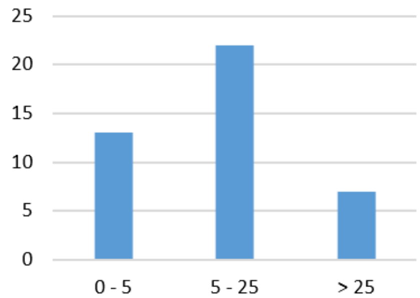

Figure 6.3: Segmentation of the results by number of enterprise architects

6.2.4. Segmentation by Number of Employees

Additionally, I segmented the responses by the total number of employees working for the organization. The segmentation of the respondents by the number of employees is shown in Figure 6.4.

Firms with 10.000 - 50.000 employees constitute a large part of the total number of respondents, which might be because hiring enterprise architects becomes more valuable when the size of the firm increases (Gong & Janssen, 2019). The reason why relatively few corporations with more than 50.000 employees participated is that there are not that many corporations with such a large number of employees of which their enterprise architects are employed in The Netherlands.

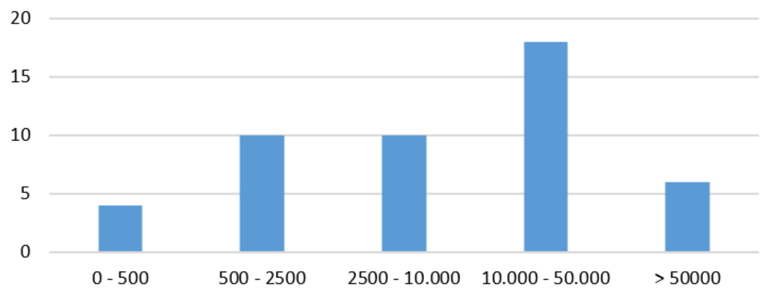

Figure 6.4: Segmentation of the results by total number of employees

6.2.5. General Statistics

A short summary of the construct and their dimensions is shown in Table 6.2. A more detailed assessment of the results including an explanation of the meaning of ”Cronbach’s alpha”, ”VIF”, and ”PCA factor loading” can be found in Section 7.

ID	EA factor	Mean	Std. Dev.	Cronbach’s Alpha	VIF	PCA factor loading
1.	**Innovation-focused Enterprise Architecture design**	3.32	0.69	N/A	2.09	
1.1	Support for pilots	4.14	0.92	N/A	1.64	0.57
1.2	Modular design	3.43	1.1	N/A	1.95	0.70
1.3	Cloud usage	3.6	0.94	0.62	2.27	0.72
1.4	Central data access point	2.98	1.04	0.59	2.4	0.81
1.5	Low-code usage	2.45	1.06	N/A	1.49	0.57
2.	**Innovation-focused alignment of To-Be architecture with business objectives**	3.58	0.81	0.88	3.94	
3.	**Innovation-focused development of the proper architecture**	3.37	0.78	N/A	3.80	
3.1	Roadmap	3.3	1.03	0.8	2.28	0.67
3.2	Feedback-driven EA design	3.25	1.11	N/A	3.09	0.77
3.3	Agile EA working method	3.55	0.87	0.63	2.25	0.81
4.	**Innovation-focused usage of the architecture**	3.46	0.82	N/A	3.43	
4.1	EA visibility	3.25	1.14	0.67	2.73	0.81
4.2	Strategy consultation	3.16	1.06	0.7	2.25	0.74
4.3	Program / project consultation	3.65	1.13	N/A	2.08	0.71
4.4	Compliancy verification	3.55	0.87	0.75	3.23	0.88
4.5	Escalation / exception handling	3.71	1.02	0.75	4.05	0.91
5.	**Innovation-focused implementation of the enterprise architect role**	3.63	0.60	N/A	2.84	
5.1	Architect recruitment	3.82	0.73	0.88	4.14	0.92
5.2	Architect development	3.83	0.88	0.83	2.58	0.85

Table 6.2 continued from previous page

ID	EA factor	Mean	Std. Dev.	Cronbach's Alpha	VIF	PCA factor loading
5.3	Architect time	3.29	0.9	0.85	1.32	0.38
5.4	Architect communication	3.59	0.78	0.88	3.1	0.85
6.	**Innovation-focused enterprise architect behavior**	3.31	0.82	N/A	3.71	
6.1	Clear innovation ambition	3.31	0.89	0.73	2.67	0.84
6.2	Linkage different innovations	3.2	1.1	N/A	4.72	0.91
6.3	EA involvement innovation	3.14	1.09	0.85	2.3	0.72
6.4	Innovation impact analysis	3.24	1.13	N/A	3.11	0.81
6.5	Active EA opportunity scouting	3.51	0.93	0.86	3.2	0.86
6.6	Innovation feasibility analysis	3.24	1.05	N/A	2.91	0.82
6.7	Innovation-driven To Be arch	3.57	0.84	0.68	3.1	0.91
7.	**Innovation readiness**	3.44	0.69	N/A	1.81	

Table 6.2: Overview of generic, reliability and validity statistics of the survey data

7

SEM Step 4: Assessing the Measurement Model

After the pilot-ready version of the measurement model was specified in Section 5.2, I will use two pilot studies to assess this measurement model and improve it (as explained in Section 1.4.5). This assessment is needed to ensure that the measurement model measures the constructs correctly.

First, I explain the methodology used for this assessment in Section 7.1.

Subsequently, I use this methodology to conduct two pilot studies to assess and improve the measurement model.

Finally, I present the final version of the measurement model in Section 7.2.

All intermediate results of the assessment and resulting improvements are included in Appendix F.

7.1. Assessment Methodology

The validity and reliability of the measurement model are assessed and improved by conducting two pilot studies among 15 enterprise architects. From now on, I use the term *measurement model* to refer to the items that operationalize the constructs of the structural model (see Section 5) and the term *questionnaire* to refer to the actual questionnaire containing not only the items of the measurement model but also secondary data (such as the size of the firm or if the respondent wants to receive a copy of the results). The questionnaire is the same for both the interviews and the electronically-distributed version.

After the first five interviews, I evaluate the responses to spot obvious errors in the questionnaire (”Pilot test #1”, see Section F.2). These insights are used to adapt the questionnaire. The subsequent ten interviews are used to get more reliable insight into which items should be entirely removed from the questionnaire (”Pilot test #2”, see Section F.3). After these interviews, the questionnaire is again adapted. The final measurement model can be found in Section 7.2.

Two constructs were already validated in previous work, published in peer-reviewed journals, namely ”digital innovation readiness” (Lokuge et al., 2019) and ”digital innovativeness” (Arias-Pérez & Vélez-Jaramillo, 2022) (see Section 3). Because these were already validated on significantly more and less biased data, I will not validate them again.

The scientific literature is surprisingly consistent on how to assess PLS-SEM models (Hair et al., 2011; Hair Jr, Matthews, et al., 2017; Petter et al., 2007; Russo & Stol, 2021). My approach to assessing the reliability and validity of the measurement model is similar to the method used by these articles and shown in Table 7.1. More information about all of these methods and the reasoning behind every threshold value can be found in Appendix E.

Type	Subtype	Test	Condition	Reference
To assess reflective constructs				
Reliability	Internal consistency	Cronbach's alpha	> 0.6 <= 0.95	(Cronbach, 1951)
Construct validity	Convergent validity	AVE	> 0.5	(Fornell & Larcker, 1981)
	Discriminant validity	Fornell-Larcker criterion		(Fornell & Larcker, 1981)
		HTMT	<= 0.85	(Henseler et al., 2015)
To assess formative constructs				
Reliability	Multicollinearity	Variance Inflation Factor (VIF)	< 5.0	(Becker et al., 2015)
Construct validity	Convergent validity	Omitted		(see Section E.0.2)
	Discriminant validity	PCA	> 0.5	(Hair Jr et al., 2020)
To assess reflective & formative constructs				
Content validity	N/A	• Structured Literature Review • EA expert review • Face validity assessment by respondents		(see Section E.0.2)
Criterion-related validity	N/A			(see Section E.0.2)

Table 7.1: Overview of the reliability and validity assessment methods used for the measurement model

7.2. Final Measurement Instrument

The measurement model presented in Section 5.2 was assessed and improved through an expert review and two pilot studies. More information about this assessment can be found in Appendix F. The final measurement instrument that is used to evaluate the structural model is shown in Table 7.2.

Item #	Items	Response format
Innovation-focused Enterprise Architecture design		
1.1	Pilots of new IT systems are allowed and supported by the enterprise architecture	Likert
1.2	The IT landscape within the firm is largely modular	Likert
1.3.a	Most IT systems run in the cloud	Likert
1.3.b	Cloud providers (such as Amazon or Microsoft) provide facilitating services such as the infrastructure, platforms, or applications	Likert
1.4.a	There is a data lake that provides easy access to most of the data available	Likert
1.4.b	The firm has a storage repository containing almost all data available at the firm	Likert

Table 7.2 continued from previous page

Item #	Items	Response format
1.5.a	The organization makes extensive use of low-code IT systems	Likert
	Enterprise Architecture Capability => Innovation-focused alignment of To-Be architecture with business objectives	
2.1.a	The architectural models are developed in collaboration with all relevant parties, such as the business managers, administrators, developers, and line staff	Likert
2.1.b	The interests of all stakeholders are addressed by the architecture	Likert
2.1.c	The enterprise architecture and project architectures are consistent with each other	Likert
2.1.d	The cohesion between the different architectural deliverables is effectively safeguarded during the development of the architecture	Likert
2.1.e	The relationship between the architectural choices and the organization's business objectives is clear	Likert
2.1.f	The architectural choices are in line with the business strategy and objectives	Likert
	Enterprise Architecture Capability => Innovation-focused development of the proper architecture	
3.1.a	There is a clear roadmap on how to proceed from the existing As-Is situation to the desired To-Be situation	Likert
3.1.b	The architecture offers guidelines in the area of migration (how to proceed from an existing to a desired situation)	Likert
3.2	The enterprise architecture is continuously adjusted based on suggestions from a wide range of employees (such as developers and administrators)	Likert
3.3.a	The architects develop the architecture in an agile way	Likert
3.3.b	The architects work iteratively, where they regularly get and incorporate feedback about the deliverables they're working on	Likert
	Enterprise Architecture Capability => Innovation-focused usage of the architecture	
4.1.a	The target architecture can be directly accessed by all relevant employees	Likert
4.1.b	Everyone in the firm who should know about the enterprise architecture knows where to find it	Likert
4.2.a	The architecture plays an integral role in the organization's decision-making process	Likert
4.2.b	If the business intends to change its strategic objectives, it automatically involves architects as a partner in the discussion	Likert
4.3.a	As soon as a project is started, architects are involved in the execution	Likert

Table 7.2 continued from previous page

Item #	Items	Response format
4.3.b	The architects help coordinate projects during the entire existence of these projects	Likert
4.4.a	Compliance with the requirements set by the target architecture is a standard feature of a project's execution	Likert
4.4.b	Actions are taken to ensure that projects satisfy the requirements of the target architecture (e.g., communication session or trainings)	Likert
4.5.a	If a project does not comply with the target architecture, there is a system in place to ensure compliance or make an exception	Likert
4.5.b	Deviations from the target architecture are actively managed (e.g., in an architecture board)	Likert
	Enterprise Architecture Capability => Innovation-focused implementation of the enterprise architect role	
5.1.a	The architects are generally sufficiently skilled to do their job well	Likert
5.1.b	The architects have the required knowledge and skills	Likert
5.2.a	The architects are stimulated to use seminars, trainings, consultants, and other opportunities to enhance their skill-set	Likert
5.2.b	The exchange of best practices with architects or EA experts from outside the firm is supported	Likert
5.3.a	The architects have sufficient time to do their assigned tasks well	Likert
5.3.b	The organization has hired enough architects to maintain and improve the architecture	Likert
5.4.a	The architects have good communication skills	Likert
5.4.b	Most architects have good listening skills and are effective in sharing their ideas	Likert
	Innovation-focused enterprise architect behavior	
6.1.a	The enterprise architects have articulated a clear ambition of how they want to contribute to the firm's innovation	Likert
6.1.b	The role and mandate of the architects is clear with regards to digital innovation	Likert
6.2	The enterprise architects ensure the link between the organization's different innovation ambitions	Likert
6.3.a	The enterprise architects are involved in innovation strategy discussions	Likert
6.3.b	Enterprise architects are part of the strategic discussions about the firm's innovation strategy	Likert
6.4	The enterprise architects are involved in analyzing the impact of proposed innovations on the organization's performance	Likert

Table 7.2 continued from previous page

Item #	Items	Response format
6.5.a	The enterprise architects actively identify external opportunities and trends, such as better software systems or new IT-related innovations	Likert
6.5.b	The architects proactively bring trends and developments in the market to the attention of business management	Likert
6.6	The architects assess whether the organization has the required capabilities of delivering the innovation	Likert
6.7.a	The architects adapt the target architecture (to-be architecture; envisioned architecture) based on new innovation projects taking place	Likert
6.7.b	The architects integrate new innovations in the enterprise architecture	Likert
	Company focus on digital innovation	
7.1	My organization is flexible in allocating adequate financial resources necessary to innovate in the digital domain	Likert
7.2	My organization is flexible in allocating adequate human resources necessary to innovate in the digital domain	Likert
7.3	My organization is flexible in allocating adequate IT infrastructure resources necessary to innovate in the digital domain	Likert
7.4	My organization has a well-established way of sharing ideas and thoughts about digital innovations	Likert
7.5	All business areas are engaged when making decisions about the IT portfolio	Likert
7.6	Our staff members have the right attitude to facilitate digital innovations	Likert
7.7	Our staff members are motivated to facilitate digital innovations	Likert
7.8	Our staff members are empowered to make decisions that facilitate digital innovations	Likert
7.9	Our staff members have the appropriate knowledge/skills (i.e., technical, business process, and organizational) to facilitate digital innovations	Likert
7.10	Our staff members have the appropriate adaptability to facilitate digital innovation	Likert
7.11	My organization has a good relationship with its IT vendors to facilitate digital innovations	Likert
7.12	My organization has a good relationship with management consultants to facilitate digital innovations	Likert
7.13	My organization has a good relationship with its customers to facilitate digital innovations	Likert
	Digital innovativeness	
8.1	The number of digital solutions introduced is superior compared to our competitors'	Likert

Table 7.2 continued from previous page

Item #	Items	Response format
8.2	The number of successful digital solutions is superior compared to our competitors'	Likert
8.3	The time to market for digital solutions is superior compared to our competitors'	Likert
8.4	The quality of our digital solutions is superior compared to our competitors'	Likert
8.5	The features of our digital solutions are superior compared to our competitors'	Likert
8.6	The applications of our digital solutions are totally different from our competitors'	Likert
8.7	Some of our digital solutions are new to the market at the time of launching	Likert
8.8	Some of our digital solutions serve new markets and customers	Likert
	General information	
9.1	Job title	Open
9.2	Industry	Open
9.3	Number of enterprise architects working for your organization	Number
9.4	Approximate number of employees working in your organization	Number
9.5	I would like to receive a copy of the final research results	Yes or no
9.6	I would like to receive a comparison of my responses with the other responses	Yes or no
9.7	I would like to participate in a round table session to discuss the results and gain more insight into this topic	Yes or no
9.8	Email (optional: only if you answered any of the questions above with ”yes”)	Open
9.9	Remarks	Open

Table 7.2: Final measurement instrument

8

SEM Step 5: Assessing the Structural Model

Based on my choice to use PLS-SEM (see Section 2.2), I first specified the structural model and the measurement model, and then assessed the measurement model (as explained in Section 1.4.5). Because the measurement model is reliable and valid (see Section 7), I can now assess the structural model and test the hypotheses formulated in Section 4.3.

Before assessing the structural model, I reformulate the structural model due to the changes in the measurement model, see Section 8.1.

After the structural model is again in line with the measurement model, I explain the methodology used to assess the structural model in Section 8.2.

Then, I assess the structural model by following this methodology, the results of which are presented in Section 8.3.

Finally, I show the most important results - the acceptance or rejection of the hypotheses - again in Section 8.4.

8.1. Reformulation of the Hypotheses

The hypotheses presented in Section 4.3 relate the exogenous EA factors and the digital innovation readiness factor to the endogenous digital innovativeness construct. However, the changes made to the measurement model in Section 7 resulted in the modification of several constructs, necessitating a reformulation of the hypotheses. As a result, I remove several hypotheses and add several hypotheses to bring the structural model in line with the new measurement model in consultation with EA experts. A copy of the former hypotheses presented in Section 4.3 is shown in Table 8.1 and the reformulated hypotheses are shown in Table 8.2. I also still hypothesize that the influence of the six main constructs on a firm's digital innovativeness is moderated by the firm's *digital innovation readiness*.

Copy of the former hypotheses

ID	EA factor	Hypothesized correlation with digital innovativeness
1.	**Innovation-focused Enterprise Architecture design**	+
1.1	Support for pilots	+
1.2	Modular design	+
1.3	Cloud usage	+
1.4	Data lake usage	+
1.5	Low-code usage	+

Table 8.1 continued from previous page

ID	EA factor	Hypothesized correlation with digital innovativeness
2	**Innovation-focused alignment of To-Be architecture with business objectives**	+
2.1	EA stakeholder collaboration	+/-
2.2	EA cohesion	+
2.3	EA alignment with objectives	+
3.	**Innovation-focused development of the proper architecture**	+
3.1	Roadmap	+
3.2	Continuous EA quality improvement	+
3.3	Continuous EA process improvement	+
3.4	Feedback-driven EA design	+
3.5	Agile EA working method	+
4.	**Innovation-focused usage of the architecture**	+
4.1	EA visibility	+
4.2	Strategy consultation	+
4.3	Program / project consultation	+
4.4	Compliancy verification	+/-
4.5	Escalation / exception handling	+/-
5.	**Innovation-focused implementation of the enterprise architect role**	+
5.1	EA funding	+
5.2	Architect recruitment	+
5.3	Architect development	+
5.4	Architect bonding	+
6.	**Innovation-focused enterprise architect behavior**	+
6.1	Clear innovation ambition	+
6.2	Linkage different innovations	+
6.3	EA involvement innovation	+
6.4	Innovation impact analysis	+
6.5	Active EA opportunity scouting	+
6.6	Innovation desirability analysis	+
6.7	Innovation validity analysis	+
6.8	Innovation feasibility analysis	+
6.9	Innovation-driven To-Be architecture	+
	Moderation	

Table 8.1 continued from previous page

ID	EA factor	Hypothesized correlation with digital innovativeness
X.	Digital innovation readiness	+/- for all main construct => digital innovation relationships

Table 8.1: Copy of the old hypothesis map (see Table 4.7)

Reformulated hypotheses

ID	EA factor	Hypothesized correlation with digital innovativeness
1.	**Innovation-focused Enterprise Architecture design**	+
1.1	Support for pilots	+
1.2	Modular design	+
1.3	Cloud usage	+
1.4	Data lake usage	+
1.5	Low-code usage	+
2	**Innovation-focused alignment of To-Be architecture with business objectives**	+
3.	**Innovation-focused development of the proper architecture**	+
3.1	Roadmap	+
3.2	Feedback-driven EA design	+
3.3	Agile EA working method	+
4.	**Innovation-focused usage of the architecture**	+
4.1	EA visibility	+
4.2	Strategy consultation	+
4.3	Program / project consultation	+
4.4	Compliancy verification	+/-
4.5	Escalation / exception handling	+/-
5.	**Innovation-focused implementation of the enterprise architect role**	+
5.1	Architect recruitment	+
5.2	Architect development	+
5.3	Architect time	+
5.4	Architect communication	+
6.	**Innovation-focused enterprise architect behavior**	+
6.1	Clear innovation ambition	+
6.2	Linkage different innovations	+
6.3	EA involvement innovation	+

Table 8.2 continued from previous page

ID	EA factor	Hypothesized correlation with digital innovativeness
6.4	Innovation impact analysis	+
6.5	Active EA opportunity scouting	+
6.6	Innovation feasibility analysis	+
6.7	Innovation-driven To-Be architecture	+
	Moderation	
X.	Digital innovation readiness	+/- for all main construct => digital innovation relationships

Table 8.2: Final, reformulated version of the hypothesis map

8.2. Assessment Methodology

After confirming that the measurement model is reliable and valid (see Section 7), the next step is to assess the structural model (Russo & Stol, 2021). This is done by evaluating the strength and significance of the relationships between the constructs. When these relationships are significant and have sufficient predictive power, the hypotheses can be accepted. The most common tools to assess these relationships are the VIF, the coefficient of determination (R^2), the path coefficients (β), and their statistical significance (t-value and p-value) (Hair et al., 2011; Petter et al., 2007; Russo & Stol, 2021). These tools are shown in Table 8.3. More information about all of these methods and the reasoning behind every threshold value can be found in Appendix G.

I use a few pre-processing steps to prepare the data for the assessment:

- All responses that are incomplete are removed
- Responses to open questions (such as the industry or number of employees) are clustered
- The data is standardized and normalized

Type	Test	Condition	Reference
Multicollinearity	Variance Inflation Factor (VIF)	< 5.00	(Miles, 2014)
Strength of path coefficients	Path coefficient (β)	N/A	(Hair Jr, Sarstedt, et al., 2017)
Statistical significance of path coefficients	• t-value • p-value	< 5%	(Fisher, 1992)
Practical significance of path coefficients	Expert review	N/A	(Kraemer et al., 2003)
Explanatory power	Coefficient of determination (R^2)	• >= 0.67 (substantial) • >= 0.33 (moderate) • >= 0.19 (weak)	(Hair et al., 2019)
Importance / performance analysis	Importance-performance map analysis (IPMA)	N/A	(Ringle & Sarstedt, 2016)

Table 8.3: Overview of the reliability and validity assessment methods used for the structural model

8.3. Assessment Results

This section presents all results of the structural model assessment without judgment or further interpretation. The implications of these results are discussed in detail in Section 9.3.

8.3.1. Multicollinearity

Main construct	VIF	Sub-construct	VIF
Innovation-focused Enterprise Architecture design	2.09	1.1 - Support for pilots	1.5
		1.2 - Modular design	1.31
		1.3 - Cloud usage	1.24
		1.4 - Data lake usage	1.55
		1.5 - Low-code usage	1.16
Innovation-focused alignment of To-Be architecture with business objectives	3.94		
Innovation-focused development of the proper architecture	3.8	3.1 - Roadmap	2.06
		3.2 - Feedback-driven EA design	1.72
		3.3 - Agile EA working method	1.66
Innovation-focused usage of the architecture	3.43	4.1 - EA visibility	1.87
		4.2 - Strategy consultation	2.62
		4.3 - Program / project consultation	1.33
		4.4 - Compliancy verification	2.01
		4.5 - Escalation / exception handling	1.77
Innovation-focused implementation of the enterprise architect role	2.84	5.1 - Architect recruitment	1.88
		5.2 - Architect development	1.91
		5.3 - Architect time	1.17
		5.4 - Architect communication	1.68
Innovation-focused enterprise architect behavior	3.71	6.1 - Clear innovation ambition	1.81
		6.2 - Linkage different innovations	2.22
		6.3 - EA involvement innovation	1.57
		6.4 - Innovation impact analysis	1.76
		6.5 - Active EA opportunity scouting	2.13
		6.6 - Innovation feasibility analysis	1.89
		6.7 - Innovation-driven To Be arch	3.34

Table 8.4: VIF values of the structural model relationships

Table 8.4 shows that the VIF of all main constructs and all of their dimensions is below the 5.0 threshold (see Section G.0.1), which indicates that multicollinearity is not significantly present for the structural model.

8.3.2. Path Coefficients

The path coefficients β of the EA factors without the moderating effect of digital innovation readiness are shown in Table 8.5. In total, 10 statistically significant correlations were found (where * $p < 0.05$; ** $p < 0.01$).

Main construct	β	Sub-construct	β
Innovation-focused Enterprise Architecture design	0.39*	1.1 - Support for pilots	0.03
		1.2 - Modular design	0.34
		1.3 - Cloud usage	0.34
		1.4 - Data lake usage	0.31
		1.5 - Low-code usage	0.26
Innovation-focused alignment of To-Be architecture with business objectives	0.28		
Innovation-focused development of the proper architecture	0.44*	3.1 - Roadmap	0.18
		3.2 - Feedback-driven EA design	0.5*
		3.3 - Agile EA working method	0.48*
Innovation-focused usage of the architecture	0.33	4.1 - EA visibility	0.35
		4.2 - Strategy consultation	0.46*
		4.3 - Program / project consultation	0.2
		4.4 - Compliancy verification	0.31
		4.5 - Escalation / exception handling	0.22
Innovation-focused implementation of the enterprise architect role	0.63**	5.1 - Architect recruitment	0.6**
		5.2 - Architect development	0.54*
		5.3 - Architect time	0.06
		5.4 - Architect communication	0.4*
Innovation-focused enterprise architect behavior	0.36*	6.1 - Clear innovation ambition	0.51*
		6.2 - Linkage different innovations	0.39
		6.3 - EA involvement innovation	0.14
		6.4 - Innovation impact analysis	0.27
		6.5 - Active EA opportunity scouting	0.5*
		6.6 - Innovation feasibility analysis	0.33
		6.7 - Innovation-driven To Be arch	0.37

Table 8.5: Path coefficient strength and statistical significance unmoderated by the digital innovation readiness factor; * $p < 0.05$, ** $p < 0.01$

The path coefficients β and β_X of the main construct moderated by digital innovation readiness are shown in Table 8.6. β_X denotes the weight of the respective EA construct $\times$ the moderating digital innovation readiness factor. There are no statistically significant correlations ($p < 0.05$). Therefore, the results of the moderated relationship are ignored.

The implications of these results are discussed in significantly more detail in Section 9.3.

Main construct	β	β_X
Innovation-focused Enterprise Architecture design	0.39	-0.81
Innovation-focused alignment of To-Be architecture with business objectives	1.22	-0.72
Innovation-focused development of the proper architecture	0.99	-0.64
Innovation-focused usage of the architecture	0.46	0.01
Innovation-focused implementation of the enterprise architect role	0.99	-0.67
Innovation-focused enterprise architect behavior	0.87	-0.45

Table 8.6: Path coefficient strength and statistical significance moderated by the digital innovation readiness factor; * p < 0.05, ** p < 0.01

Because I was curious if a firm's digital innovation readiness directly influences its digital innovativeness (instead of moderating other relationships), I conducted a simple regression analysis to find out. The results are shown in Table 8.7. The table shows that "Digital innovation readiness" and its dimensions "Cognitive readiness" and "Partnership readiness" statistically significantly correlate with digital innovativeness. These results are discussed in Section 9.3.

Construct #	β	Sub-construct	β
Digital innovation readiness	0.6*	Resource readiness	0.41
		Cultural readiness	0.38
		Innovation valance	0.45
		Cognitive readiness	0.55*
		Partnership readiness	0.62**

Table 8.7: Path coefficient strength and statistical significance of digital innovation readiness on digital innovativeness; * p < 0.05, ** p < 0.01

Until now, I evaluated in this section only the correlation between the EA factors and digital innovativeness. I also evaluated the correlation between the EA factors and each of the 8 components of digital innovativeness to get more fine-grained insight into the results. The table containing all these correlations is quite big and therefore included in an appendix, namely Appendix H. These results are discussed together with the other results in Section 9.3.

8.3.3. Explanatory Power

The explanatory power R^2 of the model is 0.532, which is "moderate" according to Chin (1998). Ideally, the R^2 should be compared with R^2 values from related studies or models of similar complexity (Hair et al., 2019). Although there are no other studies that are directly comparable to this research (see Section 1.4.1), there are many studies that investigate the influence of EA on a firm's performance. For example, Shanks et al. (2018) report an R^2 value of 0.632, Van Steenbergen et al. (2011) report an R^2 value of 0.595, and Foorthuis et al. (2016) report an R^2 value of 0.598. Thus, the explanatory model of my model of 0.532 is slightly below the values of these other models. This is not unreasonable given that I measured digital innovativeness by asking subjective questions, whereas organizational performance can be measured less subjectively, thus reducing the noise and increasing the R^2 value of the model.

8.3.4. Importance-Performance Map Analysis

The IPMA analyses are conducted along the method outlined in Section G.0.6. The importance-performance map of the statistically significant main hypotheses is shown in Figure 8.1. The full names of the abbreviations in the figure are shown in Table 8.8.

ID	EA factor
EA	**Innovation-focused Enterprise Architecture design**
Development	**Innovation-focused development of the proper architecture**
3.2	Feedback-driven EA design
3.3	Agile EA working method
	Innovation-focused usage of the architecture
4.2	Strategy consultation
Role	**Innovation-focused implementation of the enterprise architect role**
5.1	Architect recruitment
5.2	Architect development
5.4	Architect communication
Focus on innovation	**Innovation-focused enterprise architect behavior**
6.1	Clear innovation ambition
6.5	Active EA opportunity scouting

Table 8.8: Legend for Figure 8.1 and Figure 8.2

The most evident observation is that the ”Role” construct is considerably more important and performant than the other constructs. Additionally, there is a positive correlation between the importance and performance of the constructs.

The importance-performance map of the statistically significant detailed hypotheses gives more insight into the importance of the dimensions of the main constructs, see Figure 8.2. The importance of the ”Role” construct turns out to be mostly the result of the ”Architect recruitment” construct, and to a lesser degree, of the ”Architect development” and ”Architect communication” constructs. The ”Feedback-driven EA design” and ”Strategy consultation” constructs are relatively unimportant and unperformant. Again, there is a positive correlation between the importance and performance of the constructs.

A discussion of these results can be found in Section 9.6.

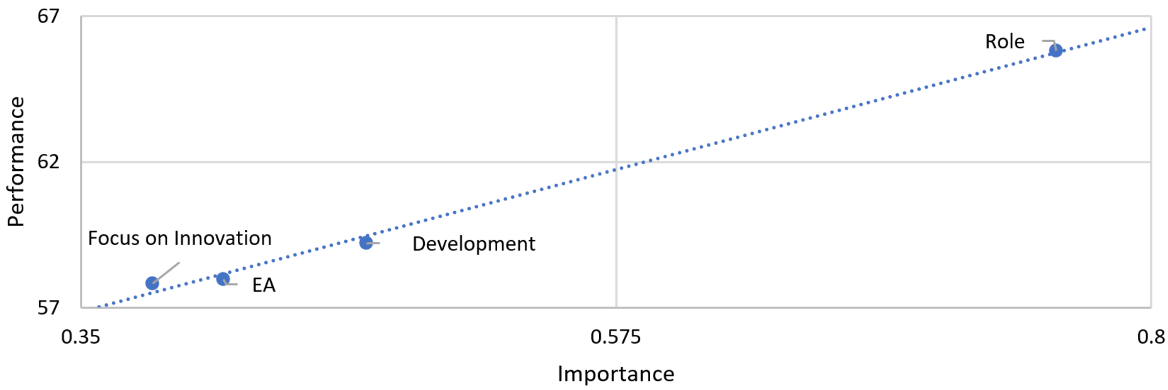

Figure 8.1: Importance-Performance Map Analysis of the main constructs

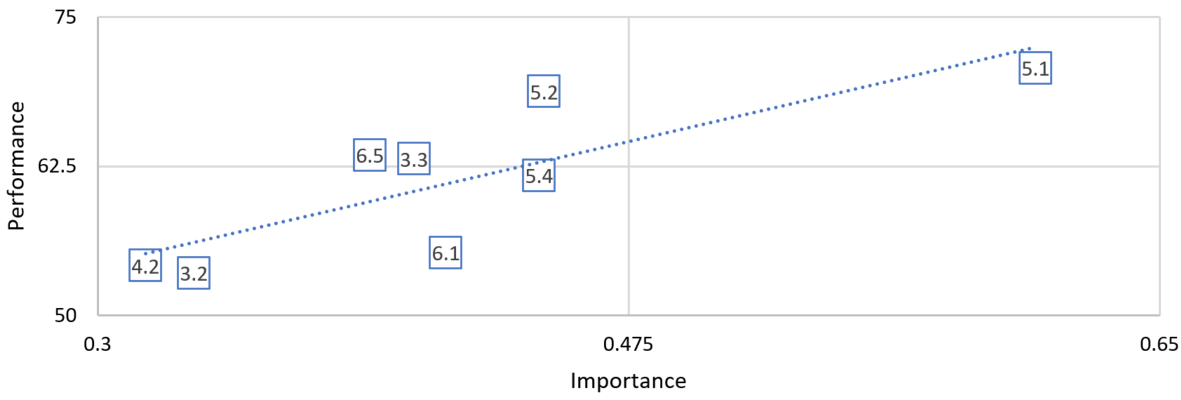

Figure 8.2: Importance-Performance Map Analysis of the main construct dimensions

8.4. Hypothesis overview

The hypotheses whose path coefficient is positive and statistically significant (see Section 8.3.2) can be accepted. An overview of the results is shown in Table 8.9.

ID	EA factor	Hypothesized correlation with digital innovativeness	Result
1.	**Innovation-focused Enterprise Architecture design**	+	Accepted
1.1	Support for pilots	+	Rejected
1.2	Modular design	+	Rejected
1.3	Cloud usage	+	Rejected
1.4	Data lake usage	+	Rejected
1.5	Low-code usage	+	Rejected
2	**Innovation-focused alignment of To-Be architecture with business objectives**	+	Rejected
3.	**Innovation-focused development of the proper architecture**	+	Accepted
3.1	Roadmap	+	Rejected
3.2	Feedback-driven EA design	+	Accepted
3.3	Agile EA working method	+	Accepted
4.	**Innovation-focused usage of the architecture**	+	Rejected
4.1	EA visibility	+	Rejected
4.2	Strategy consultation	+	Accepted
4.3	Program / project consultation	+	Rejected
4.4	Compliancy verification	+/-	Rejected
4.5	Escalation / exception handling	+/-	Rejected
5.	**Innovation-focused implementation of the enterprise architect role**	+	Accepted
5.1	Architect recruitment	+	Accepted
5.2	Architect development	+	Accepted

Table 8.9 continued from previous page

ID	EA factor	Hypothesized correlation with digital innovativeness	Result
5.3	Architect time	+	Rejected
5.4	Architect communication	+	Accepted
6.	**Innovation-focused enterprise architect behavior**	+	Accepted
6.1	Clear innovation ambition	+	Accepted
6.2	Linkage different innovations	+	Rejected
6.3	EA involvement innovation	+	Rejected
6.4	Innovation impact analysis	+	Rejected
6.5	Active EA opportunity scouting	+	Rejected
6.6	Innovation feasibility analysis	+	Rejected
6.7	Innovation-driven To-Be architecture	+	Rejected
	Moderation		
X.	Digital innovation readiness	+/- for all main construct => digital innovation relationships	Rejected for every relationship

Table 8.9: Extended hypothesis results

9 Reflection on the Research by using Expert Insights

To estimate the degree to which the previously found correlations are causal, as well as to formulate the most important limitations of this thesis and directions for future research, I conduct in-depth discussions with EA experts.

First, I discuss the results found for each sub-research question with the experts in Section 9.1 (RQ 1), Section 9.2 (RQ 2), and Section 9.3 (RQ 3).

Then, to give the reader more insight into the validity of these results, I discuss the study's limitations in Section 9.4.

Subsequently, I investigate the external validity of the research results to show how the results translate to other situations in Section 9.5.

Finally, based on all these insights I give the reader several recommendations for future research in Section 9.6.

The findings of the thesis are investigated by discussing them with senior EA experts (> 10 years of relevant work experience). I asked these experts five things:

1. Would you expect the EA factors that were found to have a statistically significant correlation with digital innovativeness to correlate indeed with digital innovativeness?
2. Would you expect these correlations to be causal, reverse-causal, or both? (where reverse-causal means that an increase in a firm's digital innovativeness is likely to cause an increase in a particular EA factor)
3. Would you expect the EA factors that do not have a statistically significant correlation with digital innovativeness to have no such correlation indeed?
4. Would you expect the results to be generalizable to other firms, despite the overrepresentation of financial and governmental organizations in this research?
5. What are the most important limitations of this research, in your opinion, and how can future research address these limitations?

The second question results from the difficulty of empirically establishing the correlations' causality because such research requires a longitudinal study (which was not feasible given the time constraints). Therefore, I chose to use these expert interviews as an alternative and use their expertise to estimate the causality of the statistically significant correlations. More information about these interviews can be found in Section I.

This section contains several expert quotes, recognizable by *"the italic text between the quotation marks"*. All of these quotes are translated from Dutch to English by the author of the thesis.

9.1. RQ 1: ”How can a firm’s digital innovativeness be measured?”

I measured the digital innovativeness of the participating firms by asking the enterprise architects how their firm compares to its competitors on several aspects by using the questionnaire presented by Arias-Pérez and Vélez-Jaramillo (2022). This seemed to be the best approach based on the literature review, as explained in Section 3.3. However, this approach has several limitations:

- Enterprise Architects are often not directly involved in the innovation strategy of their organization, which means that they often do not have a clear picture of how innovative their organization is. The reason why I chose to interview enterprise architects to this end anyway is explained in Section 5.1.
- Even when the enterprise architects are well aware of how innovative their organization is, they may be (unconsciously) biased because rating a firm’s innovativeness is quite subjective.
- Even when the enterprise architects have an accurate and unbiased view of their organization’s innovativeness, they might not be able to compare it to the innovativeness of competitors because the firm might not really have any direct competitors (for example, governmental organization or conglomerates that have a unique mix of subsidiaries)
- Even when the firm does have direct competitors, the enterprise architects may not be aware of how innovative these competitors are.
- Even when the architects can accurately compare the digital innovativeness of their own firm compared to its closest competitors, they still have to quantify this comparison which is a gray area: for example, there is no clear-cut line between what constitutes an incremental improvement and a true innovation, or what time horizon is reasonable, or how two smaller innovations should be rated compared to a single bigger innovation.
- Even when the architects are able to accurately compare the digital innovativeness of their own firm with its closest competitors in exactly the same way, the resulting innovation scores are relative to the firm. In other words, when firm A knows it is more innovative than its competitors B and C, and firm X knows it is less innovative than its competitors Y and Z, it is impossible to compare the innovativeness of firm A with firm X.

Clearly, there are numerous limitations related to using the digital innovativeness measure used for this research. However, I was unable to find a more suitable measure for digital innovativeness in the literature, which seems to be very limited on this topic as explained in Section 3.3. This is confirmed by Kohli and Melville who note that ”Despite its salience, exploration of digital innovation outcomes has received very little attention in the literature. Our literature review revealed a mere handful of studies, suggesting a significant opportunity for future research” 2019, p. 14.

Based on the aforementioned limitations and the observation that the literature on measuring digital innovativeness is very scarce, I suggest that more effort is put into developing a better digital innovativeness instrument.

9.2. RQ 2: ”What EA factors can be distinguished that are likely to be related to a firm’s digital innovativeness?”

The EA factors that are likely to be related to a firm’s digital innovativeness were obtained by interviewing EA experts, by reviewing the literature, and by having EA experts select the most suitable elements of the DyAMM enterprise architecture maturity model as explained in Section 4.1. This resulted in a reasonably large set of EA factors shown in Section 4.1.4.

Such a single, comprehensive set of EA-related factors that might influence a firm’s digital innovativeness did not exist yet in the scientific literature: the existing literature is very scarce but also fragmented on this topic (see Section 3.4.1). Therefore, for other researchers that want to investigate this relationship, this overview is a valuable starting point.

One way of how this overview could be extended is by using brainstorm techniques. After all, using professional brainstorm techniques often result in considerably more and better ideas than simply asking people to name a lot of ideas (in this case, EA factors that might influence a firm’s digital innovativeness) (Ritter & Mostert, 2018). Additionally, researchers can use the Delphi method to not only increase the number of ideas but also refine and prioritize them in a structured manner (Brown, 1968).

9.3. RQ 3: ”Which EA factors significantly influence a firm’s digital innovativeness?”

In this section, I discuss the path coefficients presented in Section 8.3.2 and Appendix H.

First, I will refer back to the initial high-level hypothesis made in Section 4.3, namely:

> ”There are three ways in which Enterprise Architects influence a firm’s digital innovativeness, namely:
>
> - By designing the architecture as a solid foundation on top of which it is easy for employees to test new ideas (*the EA design perspective*)
> - By having a mature Enterprise Architecture capability that enables or inhibits innovative ideas to grow and realize impact in line with the business objectives (*the EA capability perspective*)
> - By managing these bottom-up innovations with a top-down EA perspective to keep them in line with each other, with the internal business strategy, and with external industry trends (*the EA innovation perspective*).”

This hypothesis seems to be partially correct based on the results shown in Section 8.3 and can be rewritten to the following empirically supported claim (where the *X.X* refer back to the accepted hypotheses presented in Section 8.3):

> ”There are three ways in which enterprise architects probably increase a firm’s digital innovativeness, namely:
>
> - When they design the architecture as a solid foundation on top of which it is easy for employees to test new ideas (*1.X*) (*the EA design perspective*)
> - When they are highly skilled (*5.X*), involved in strategic discussions (*4.2*), and use a feedback-driven approach to guide their efforts (*3.2 / 3.3*) (*the EA capability perspective*)
> - When they pro-actively search for external innovation opportunities (*6.5*) as part of a well-defined EA innovation ambition (*6.1*) (*the EA innovation perspective*).”

In the remainder of this section, I discuss the more fine-grained hypotheses (presented in Section 8.1).

One of the articles from which I extracted EA factors is a paper written by van de Wetering (2019). This article had a different orientation than this thesis (namely process innovation instead of digital innovation) and did not provide insight into which of the factors studied were statistically significant. Interestingly, all EA factors that I extracted from this paper have a statistically significant correlation with the firm’s digital innovativeness. Considering the fact that process innovation and digital innovation are both types of innovation and thus relatively similar concepts, it is a good sign that the results of van de Wetering are comparable to my results.

I did not find other notable correlations between sources of EA factors and statistically significant results.

The results become more meaningful when I relate the EA factors to the 8 individual components of the ”digital innovativeness” measure, shown in Appendix H. Discussing all statistically significant correlations shown in this appendix would consume a lot of additional space and distract from the important conclusions. Therefore, I elaborate only upon the highly statistically significant results ($p < 0.01$) of these extra-detailed results that stand out, either because they confirm the thoughts of the experts, or reject them.

Innovation-focused Enterprise Architecture

ID	Hypothesis: EA factor correlates with digital innovativeness	Hypothesis accepted?
1.	**Innovation-focused Enterprise Architecture**	Accepted
1.1	Support for pilots	Rejected
1.2	Modular design	Rejected
1.3	Cloud usage	Rejected
1.4	Data lake usage	Rejected
1.5	Low-code usage	Rejected

Table 9.1: Results hypothesis 1

Interestingly, the correlation of the main construct ”Innovation-focused Enterprise Architecture” (which is the average of its sub-constructs) with digital innovativeness is statistically significant while that is not the case for each of its sub-constructs. The EA experts still expect all of these five hypotheses, and especially hypothesis 1.1, to be correct (for the reasons explained in Section 4.1.3) and recommend to gather more data to confirm this. They also mentioned several factors that they assume to moderate the relationships:

- The influencing effect of sandboxes (the technology to provide ”Support for pilots”) is moderated by whether the sandboxes include access to a wide array of convenient tools that are in line with the enterprise architecture. In the words of an expert (translated to English): *”The availability of such tools is necessary to make it as easy as possible for employees to innovate in line with the architecture.”*

- The influencing effect of cloud solutions is moderated by whether firms use cloud agnostic software (such as open-source packages) rather than cloud-native software. After all, when firms can easily switch to other software packages when valuable innovations come along, they can be more innovative.

- The influencing effect of low-code/no-code solutions is moderated by whether there is sufficient monitoring to ensure that no business-critical code is built using these tools. In the words of an expert (translated to English): *”When business-critical code is built using these tools, it can result in very risky and unscalable situations.”*

Limitations with regard to the scale.
In hindsight, many of these questions could have been formulated better, even after the improvements in their wording made during the two pilot studies. For example, a scale of ”Totally disagree” to ”Totally agree” is not entirely applicable because their implementation is not a linear scale: in one part of the organization, all five aspects could be a ”totally agree”, while in another part of the organization all aspects could be a ”totally disagree”. A better approach would be to score the aspects on a scale of ”Used not at all within the organization” to ”Used extensively in each department within the organization”.

To further complicate things, the experts indicated that they would recommend a customized approach for each part of the organization:

- In some areas a top-end dedicated test environment (*sandbox*) should be facilitated while in other areas such an environment is not worth the benefits

- A modular design should be used in those areas where agility is key while a cheaper monolithic design should be used in those areas where agility is not that important (often the case for ERP systems)

- An external (confidential) cloud should used for almost all purposes but not for solutions which are not suitable for the cloud, for example because of high-performance computing (HPC), extreme security, latency, or scalability demands

- Whereas firms should use a data lake (or mesh) to store many different types of data because subsequent analyses might result in important insights, firms should not use the data lake to store other types of data that are more expensive than their expected return (for example, due to the size of the data)
- Low-code should be used in those business areas that continuously need to adapt where it can significantly boost the employees’ productivity, but not in areas where the best practices are very consistent over the years and any changes are likely to do more bad than good

Because clearly the usage of all of these aspects should depend on their relevance to each business area, an even better approach would be to score the aspects on a scale of ”Not used at all within the departments that would benefit from the technology” to ”Used in all departments that would benefit from the technology”.

For an even better investigation, the researcher should also determine the quality of the implementation of the feature and define a metric that replaces the binary ”department benefits from a given technology” choice with an ordinal ”degree to which a department benefits from a given technology” scale.

Limitations with regard to the content validity.
Another point for improvement is the extent to which the statements are aligned with the current business practices.

- The ”Support for pilots” construct should establish the availability of the usage of sandboxes, because these provide the proper way in which enterprise architecture can provide support for pilots (Pizette et al., 2009)
- The ”Cloud usage” construct should also distinguish between the type of cloud that is used by the firm, such as an internal cloud, external cloud, federated cloud, leasing of a mainframe at another company, etc.
- The ”Data lake usage” construct should also capture the availability of a data mesh, since several respondents with a mature EA capability indicated that they were replacing their data lake with a data mesh
- The ”Low-code usage” construct should also include the usage of no-code solutions, because these are even more effective in enabling non-programmers to innovate (Krejci et al., 2021)

Innovation-focused Alignment of To-Be Architecture with Business Objectives

ID	Hypothesis: EA factor correlates with digital innovativeness	Hypothesis accepted?
2	**Innovation-focused alignment of To-Be architecture with business objectives**	Rejected

Table 9.2: Results hypothesis 2

The experts think that this hypothesis was rejected, because the impact of aligning the enterprise architecture in the context of digital innovativeness probably depends on a third factor that was not accounted for in the research. They mention that *”aligning the enterprise architecture with the business objectives only increases a firm’s digital innovativeness when the strategy is focused on digital innovations to begin with.”* Depending on the strategy, the role of enterprise architects in the context of digital innovations can be, on the one hand, more focused on providing a solid foundation on top of which employees are empowered to be creative and come up with new and innovative digital solutions or, on the other hand, more focused on developing an architecture that suits the digital innovations that are explicitly defined in the strategy. These roles are in line with the EA design and EA capability perspective discussed in Section 4.3.

They also expect that aligning the enterprise architecture with the business objectives is more effective when the architects can provide input for the business objectives based on their superior insights into the feasibility and complexity of new initiatives. This seems to be confirmed indeed by the accepted hypothesis 4.2.

Innovation-focused Development of the Proper Architecture

ID	Hypothesis: EA factor correlates with digital innovativeness	Hypothesis accepted?
3.	**Innovation-focused development of the proper architecture**	Accepted
3.1	Roadmap	Rejected
3.2	Feedback-driven EA design	Accepted
3.3	Agile EA working method	Accepted

Table 9.3: Results hypothesis 3

The experts think that, in hindsight, the ”Roadmap” hypothesis is incorrect for the same reason as why the ”Feedback-driven EA design” and ”Agile EA working method” hypotheses were accepted. The reason is that firms have to change continuously and rapidly to stay ahead of the competition. Although a roadmap might help in the development of very complex innovations with a long development time, it might also be undesirable when the firm has to be agile and continously change its way of working. In contrast, actively seeking feedback and promoting a culture where employees approach the enterprise architects with constructive comments is something that increases the flexibility of the firm. In the context of EA, it is also important that *”the feedback includes requests for new tools that enable innovation, apart from comments that relate to the applicability of existing architecture tools and guidelines”* according to an expert (translated to English). The enterprise architects can then provide the employees with all the tools and support that they need so that the employees can make the most effective use of their time. The feedback should not come only from employees, but also from competitors or market researchers.

It also seems reasonable that combining this feedback culture with an iterative way of working (i.e., agile) improves a firm’s digital innovativeness, because the future is to a certain extent unpredictable and therefore the architects continuously need to revise the architecture. Working in an agile manner thus aligns the product more closely with the customers’ demands and thus its perceived quality, which is confirmed by the detailed results in Appendix H.

Innovation-focused Usage of the Architecture

ID	Hypothesis: EA factor correlates with digital innovativeness	Hypothesis accepted?
4.	**Innovation-focused usage of the architecture**	Rejected
4.1	EA visibility	Rejected
4.2	Strategy consultation	Accepted
4.3	Program / project consultation	Rejected
4.4	Compliancy verification	Rejected
4.5	Escalation / exception handling	Rejected

Table 9.4: Results hypothesis 4

Respondents indicated in interviews that ensuring that everyone knows and follows the enterprise architecture is tricky. The hypothesis that ”EA visibility” influences an organization’s digital innovativeness is rejected, but the experts indicate that this does not mean that it is not important. They reason that when the development teams are well aware of the enterprise architecture, the enterprise architects less often need to intervene in projects to ensure compliance. In the words of an expert (translated to English): *”As an enterprise architect, intervening in projects is a last resort option: there is often quite some resistance from the project teams and intervening lowers the morale of the employees.”* Upon closer examination, the p-value of this correlation is 0.074, which means that with a relatively small amount of additional interviews the correlation might be significant and the hypothesis accepted.

The experts agree that the ”Strategy consultation” hypothesis is correct. However, the causality may be inversed: when the C-level executives do not use the superior insights of enterprise architects into the feasibility and complexity of new initiatives, the firm’s ability to innovate likely drops (or more specifically, the quality of the digital innovations, as implied by the detailed results in Appendix H). They also indicate that this factor is probably contingent on whether the EA capability is placed underneath the CEO, something that can be verified in further work. They think expect that when the EA capability is the responsibility of the CEO, the architects are more likely to be consulted for the business strategy. When the EA capability is the responsibility of another C-level executive such as the CTO, the architects are probably more likely to be expected to just adapt the enterprise architecture based on the strategy, without being able to give feedback about how appropriate the strategy is given the current enterprise architecture.

Considering ”Program / project consultation”, there was an interesting difference between the responses of the participating firms. In larger firms, enterprise architects usually only approve a project before it starts, after which the solution architects coordinate the projects (and escalate to the enterprise architects when the architecture needs to be changed). The enterprise architects meanwhile coordinate between the projects, which is in large firms often a full-time task considering the large number of projects being executed. In smaller firms, the enterprise architects also coordinate between the projects, but are also more involved in the execution of these projects by having regular check-ins. The experts agree that the extent to which enterprise architects approve every project or coordinate projects probably does not influence a firm’s digital innovativeness significantly.

Experts indicated that they would expect that the compliancy verification process significantly influences a firm’s digital innovativeness and that hypothesis 4.4 is probably rejected because of two reasons.

On the one hand, they indicate that the factor is contingent on whether there exists a sandbox in which employees can locally experiment with small pilots. After all, when all systems always comply with the enterprise architecture, piloting a new software system would be very challenging, unless the enterprise architecture includes a sandbox that can be used to this end.

On the other hand, they indicate that it depends on the flexibility of the enterprise architects when new technologies come along. In the words of an expert (translated to English): *”suppose that the employees know to find the enterprise architects right away and that the architects always adapt the architecture rapidly when an innovative idea comes along. In that case, a strong compliancy verification does not really reduce a firm’s digital innovativeness because the project can continue without much resistance from the architects.”* Especially when innovative ideas are proposed to be used outside a sandbox, enterprise architects have to balance between being a police force that prevents an unwieldy proliferation of software projects and at the same time give room to innovative initiatives that deserve their place in the IT landscape. In other words, although enterprise architects are typically mostly concerned with standardizing the IT landscape, they need to balance this standardization effort with providing sufficient flexibility for enabling innovation.

Innovation-focused Implementation of the Enterprise Architect Role

ID	Hypothesis: EA factor correlates with digital innovativeness	Hypothesis accepted?
5.	**Innovation-focused implementation of the enterprise architect role**	Accepted
5.1	Architect recruitment	Accepted
5.2	Architect development	Accepted
5.3	Architect time	Rejected
5.4	Architect communication	Accepted

Table 9.5: Results hypothesis 5

All five EA experts unanimously agreed with the results of these four hypotheses. A highly skilled enterprise architect is able to act as a "police agent" that keeps all systems in check and simultaneously enable the emergence and development of innovative concepts that challenge the status quo.

The experts also fully agree with the observation that enterprise architects need to stay up-to-date with important developments taking place. There are several ways in which enterprise architects can learn about these developments, for example by hiring consultants or attending trainings, conferences or seminars.

Many enterprise architects are highly intelligent, but their communication skills should not be underestimated as a key determinant of their ability to get things done. After all, when they are insufficiently able to explain the importance of their role to others, steer the enterprise architecture based on observations from others, or influence others to develop IT systems in a particular way, their effectiveness as enterprise architect is limited. This is illustrated by a quote from an enterprise architect (translated to English): *"It is important but also surprisingly hard to make all employees recognize and respect the role of enterprise architects."*

The experts don't expect firms where enterprise architects have loads of time to perform their tasks to be more or less digitally innovative. There might be a small causal link the other way around: highly innovative firms might result in busier enterprise architects, but this factor is expected to be significantly less important than the competence of the architects.

Although the implementation of the enterprise architect role seems to be very important for providing a smooth and successful roll-out of innovative software, it does not seem to significantly influence specifically the "newness" of innovations, as shown in Appendix H.

An interesting finding is that most firms support their architects in their professional development, but don't have a clear-cut career ladder for these architects. An important reason why enterprise architects do not often get a promotion is that there are generally not that many enterprise architects within a firm and thus the potential for promotions is quite limited. An important reason why solution architects are usually not promoted to enterprise architects is that they possess a very different skill-set: solution architects are much more knowledgeable about the actual implementation of software while enterprise architects are usually people with a business background and good communication skills. Because of this discrepancy in their skill-set, firms that have enough architects to regularly promote them provide a different career ladder for enterprise architects than for solution architects.

Many firms also often mentioned that it is incredibly hard to find good enterprise architects and vacancies often remain open for a long time.

Because the quality of the enterprise architects plays such a big role, I asked eight firms about the KPIs that they used to evaluate their enterprise architects. Because none of these firms used clear KPIs to this end, this provides an interesting opportunity for future research, explained in more detail in Section 9.6.

Innovation-focused Enterprise Architect Behavior

ID	Hypothesis: EA factor correlates with digital innovativeness	Hypothesis accepted?
6.	**Innovation-focused enterprise architect behavior**	Accepted
6.1	Clear innovation ambition	Accepted
6.2	Linkage different innovations	Rejected
6.3	EA involvement innovation	Rejected
6.4	Innovation impact analysis	Rejected
6.5	Active EA opportunity scouting	Accepted
6.6	Innovation feasibility analysis	Rejected
6.7	Innovation-driven To-Be architecture	Rejected

Table 9.6: Results hypothesis 6

These hypotheses were all derived from the paper of Bontinck and Viaene (2016) (see Section 4.1.1). The correlation of the main construct with digital innovativeness is statistically significant. This does not come as a surprise, because when enterprise architects explicitly focus more on innovation, one might logically expect the organization to become more innovative. More specifically, especially the quality of the digital solutions was affected by the focus of architects on innovation (see Appendix H).

However, only for two sub-hypotheses sufficient evidence was found, namely ”Clear innovation ambition” and ”Active EA opportunity scouting”. EA experts agree that these two factors are likely to be the most important ones to increase a firm’s digital innovativeness.

Having a clear innovation ambition that is recognized by the executives gives enterprise architects the mandate to voice their opinion about innovation efforts, and reminds the architects that they should keep the firm’s digital innovativeness in mind while performing their tasks. This is important because, in the words of an expert: *”enterprise architects are in a uniquely suitable position to have a high-level overview of all systems within the company and understand how these might benefit from innovations.”*

When the enterprise architects pro-actively scout external opportunities and trends by reading relevant articles, attending conferences or seminars, or by hiring external consultants, they might be able to take advantage of these opportunities. These EA-related external opportunities can be new digital technologies (e.g., blockchain or 5G), new use-cases of existing technologies (e.g., providing personalized shopping experiences, or adopting software packages that have recently become cost-effective), or existing use-cases of technologies that are projected to significantly increase in popularity (providing the product ”as a service” to customers, or distributing software peer-to-peer).

The experts also expect that when enough data is gathered, the other hypotheses will be confirmed, albeit with a lower correlation because most of these highly depend on the interaction of the enterprise architects with innovation managers.

Digital Innovation Readiness

Construct #	β	Sub-construct	β
Digital innovation readiness	0.6*	Resource readiness	0.41
		Cultural readiness	0.38
		Innovation valance	0.45
		Cognitive readiness	0.55*
		Partnership readiness	0.62**

Table 9.7: Copy of Table 8.7: path coefficient strength and statistical significance; * $p < 0.05$, ** $p < 0.01$

The moderating effect of the digital innovation readiness was not statistically significant for any relationship as mentioned in Section 8.3.2. Instead, I decided to investigate the correlation between a firm’s digital innovation readiness and its digital innovativeness, the results of which are shown in Table 9.7. Intuitively, these concepts are highly correlated, and indeed, the β value of the digital innovation readiness construct is not only statistically significant but also very high compared to the other path coefficients presented in Section 8.3.2.

Its cognitive readiness dimension is also statistically significant ($p < 0.05$) and measures if the employees have the appropriate knowledge, skills, and adaptability to facilitate digital innovations. The experts indicate that the correlation seems very logical: when the employees do not have the knowledge, skills, or adaptability to facilitate digital innovations, the firm will not be able to produce digital innovations.

The partnership readiness is even more statistically significant ($p < 0.01$) and measures if the organization has good relationships with its vendors, management consultants, and customers to facilitate digital innovations. Several architects mentioned the importance of these partnerships. Vendors, consultants, and customers can all provide a firm with many innovative ideas and help with their development. Especially IT vendors often play an important role in that regard because digital innovations are, according to the architects, often a matter of bringing together existing software in new and unexpected ways. To make the innovation successful, it has to meet the customer's demand for which a close collaboration is very valuable.

The resource readiness, cultural readiness, and innovation valance constructs do not correlate statistically significantly with digital innovativeness. The consultants I interviewed made clear that the partnership readiness was essential for their firm to be innovative (backed up by this empirical research), but the other factors seem to correlate less strongly with innovativeness. However, these factors might still be proven to be statistically significant when more data is gathered.

- Resource readiness - Is the organization flexible in allocating adequate financial, human, and IT resources for digital innovations?
- Cultural readiness - Is thinking about digital innovations entrenched in the mindset of the employees?
- Innovation valance - Are the employees motivated and empowered to facilitate digital innovations?
- Cognitive readiness - Do the employees have the appropriate knowledge, skills, and adaptability to facilitate digital innovations?
- Partnership readiness - Does the organization have good relationships with its IT vendors, management consultants and customers to facilitate digital innovations?

9.4. Limitations

Apart from the limitations that were specific to the digital innovativeness measurement (discussed in Section 9.1), the EA factors (discussed in Section 9.2), or certain correlations (discussed in Section 9.3), I discuss in this section several generic limitations, including a solution that other researchers may use for future work.

9.4.1. Number of Responses

For this research, I obtained in total 51 responses. This was enough to establish eight statistically significant correlations ($p < 0.05$) but insufficient to accept or refute the other hypotheses. Obtaining more responses is laborious and time-consuming.

The questionnaire was sent to more than 1500 Dutch enterprise architects (members of the NAF), followed by a reminder two weeks later, and was filled in by 38 architects (2.5%) (despite several measures that were taken to increase the response rate, see Section 6.1).

Planning interviews involves sending endless reminders and is time-consuming. However, when researchers are able to gather more responses for future work, they may be able to accept many more hypotheses.

9.4.2. Dependence on Historical Data

Because innovations usually take several years or more to be developed, it would be ideal to compare a firm's score on several EA factors at a given point in time with its digital innovativeness several years in the future (see Section 5.2). On the one hand, one might ask enterprise architects about EA factors from several years ago and compare this to their current innovativeness, but asking facts from a long time ago is likely to result in inaccurate responses (B. A. Kitchenham & Pfleeger, 2002). On the other hand, a longitudinal study of firms' EA factors today compared to their digital innovativeness several years from now would be preferable. For this thesis, this option was not feasible given the time constraints.

9.4.3. Inconsistent Definitions

The interviews were conducted with employees that called themselves "enterprise architects," and the questionnaire was sent to a network specifically meant for "enterprise architects" (namely, the NAF - see Section 6). However, the definition of an "enterprise architect" is not entirely consistent between organizations. It occurred to me that enterprise architects in large multinationals usually pay significant attention to business and strategic implications and rarely to the execution of single projects. Meanwhile, enterprise architects in smaller organizations are usually more IT-focused and involved in the execution of several projects. In other words, in practice, enterprise architects are, in many organizations, also domain architects or even solution architects (to a certain extent). For this research, I included almost everyone that had the function title ”enterprise architect”, because they satisfied my definition of ”enterprise architect” (see Section 1.1.1).

Additionally, I noticed that the degree of centralization of innovation systems differs significantly between firms. Whereas in some firms, there is a dedicated innovation (or R&D) department - which makes it easy for enterprise architects to work together with innovation managers -, in other firms, the innovations take place in a decentralized manner, namely in the distinct departments or even teams - which makes it hard for enterprise architects to stay up-to-date with all innovations taking place.

These two differences between firms might introduce a bias that was initially not accounted for. Therefore, in future work the researchers should determine for each respondent how they define the role of ”enterprise architect” and where the innovation within the firm takes place (at the most basic level by using a distinction between centralized, decentralized, or hybrid - but a more nuanced method might be well needed).

9.5. External Validity

Although some authors define *external validity* as the extent to which the model fits on another sample drawn from the same population (Sharma et al., 2019), I will use the definition that defines external validity as the extent to which the conclusions of the thesis apply outside the context of the study (Mitchell & Jolley, 2010). This definition is more suitable because readers will probably be interested in the applicability of the results for all organizations instead of only those based in The Netherlands.

All threats to external validity are unobserved statistical interactions (Lynch, 1982). Because it is almost impossible to account for every independent variable that might differ across populations and influence the results, establishing external validity is non-trivial.

A particularly important variant of external validity is *selection bias* (or sampling bias), which is created when the study is not representative of the intended population (Nielsen et al., 2017). Whereas investigating only Dutch firms was explicitly part of the research scope (see Section 1.4.3) and therefore a reasonable limitation, the fact that the majority of the participating firms is a financial or governmental organization (see Section 6.2.1) is an unintended bias in the study. Two very experienced EA experts (> 20 years of relevant work experience) indicated that this skewed segmentation reflects the enterprise architect population in The Netherlands. They mention that the reason for this skewed segmentation is that *”both financial organizations and the government are very data-driven. Therefore these organizations invest significantly into their EA capability to manage their data-driven processes.”*

The experts indicate that the bias unquestionably reduces the validity of the results but that the results are still useful: the current findings are largely in line with their expectations, while that would be unlikely to be the case when the bias would be too large. Although governmental organizations are usually not very concerned with innovation, the experts indicate that the opposite is true for financial organizations. They illustrate the importance of innovation for financial organizations by noting the proliferation of fintechs in recent decades, which illustrates that there is significant room for digital innovation, especially to improve internal processes. Consequently, the results of the thesis may be especially applicable for financial organizations.

The experts also indicate that enterprise architects operate relatively similarly across countries and therefore expect the findings to be relevant in most of the world.

9.6. Recommendations for Future Research

Apart from all minor suggestions for future research mentioned in Section 9.1, Section 9.2 and Section 9.3, and the suggestions mentioned to tackle the limitations described in Section 9.4, I will also give the reader several important recommendations for future research in this section. Because this thesis is the first empirical work investigating the influence of EA factors on firms’ digital innovativeness (see Section 10.3.2), there are ample directions for other researchers to confirm and extend the presented insights.

Development of a KPI that measures the performance of each enterprise architect as an individual

A particularly important direction for future research is the development of clear KPIs for the performance of each enterprise architect as an individual (see Section 9.3 => *Innovation-focused implementation of the enterprise architect role*). None of the firms that I asked about this KPI had one that was, in their own opinion, satisfactory. Instead, they evaluated their enterprise architects simply by measuring how they were perceived by the other architects and stakeholders within the company. There are many KPIs available to assess the EA function as a whole (such as (Bonnet, 2009; Günther, 2014; Jugel et al., 2015; Pruijt, Slot, & Plessius, 2012)). Additionally, there are many types of certificates to certify enterprise architects (such as (EACOE, 2022; Open Group, 2022; Zachman, 2022)). However, Besker and Olsson (2015) were - in 2015 - unable to find any set of measurable goals for the effectiveness of enterprise architects in their literature review and with their survey among architects. Seven years later, I am also unable to find such KPIs by doing a quick search on Google Scholar and asking several participating firms about it. Because the quality of the enterprise architects is the most important determinant of a firm's digital innovativeness, the discipline would benefit greatly from the development of a proper KPI measuring each individual's contribution. All EA experts agreed that a KPI that measures the degree of compliance of the systems with the enterprise architecture must also measure innovativeness-related aspects. Otherwise, the architects are incentivized to steer towards other KPIs that might result in reducing the inherently unpredictable and risky innovation projects going on.

Add "pressure to innovate" and "regulatory hurdles" as moderating factors

Two important moderating factors that could give significantly more insight into the research problem are "pressure to innovate" and "regulatory hurdles".

For example, even when a certain firm has an EA department perfect for enabling innovation, when this firm has little need to innovate because there is no innovation pressure from its competitive environment, the innovation output will likely be limited.

Additionally, when this firm faces significant regulatory hurdles to innovate (for example, in the financial or medical drugs sector), the innovation output will also likely be reduced.

Development of a better "digital innovativeness" measure

Based on the list of issues related to the digital innovativeness instrument included in Section 9.1, I would recommend researchers to develop an alternative instrument that addresses each of these issues. The Community Innovation Survey (CIS) (Arundel & Smith, 2013) could be an excellent starting point since it is well-validated and filled in by a large number of firms every two years. To access the raw data collected by the survey, researchers need to apply for micro-data access.

Empirical investigation of the causality of the correlations

Another important area for future research is to empirically establish the causality of the correlations by using a longitudinal study that measures firms' digital innovation output over time. Such a study was for this thesis not possible given the time constraints. I also lacked sufficient evidence to establish statistical significance for the majority of the EA factors. These remaining hypotheses may also be accepted with a more extensive sample set.

More diverse data collection

In future work, researchers may seek to gather data from all across the world and distribute the interviews/questionnaire equally over firms from different sectors. This thesis focused only on enterprise architects working in The Netherlands, whereby financial and governmental organizations are overrepresented. This reduces the external validity of the findings (see Section 9.5).

< no recommendations based on the IPMA >

The IPMA shown in Section 8.3.4 shows that the skills of the enterprise architects are the most important factor studied for predicting a firm's digital innovativeness, followed by whether they work in an agile manner, are aware of their role in the context of digital innovation, and actively identify external opportunities for innovation. These observations are in line with the results obtained by analyzing the path coefficients (see Section 9.3). What is interesting, however, is that in both importance-performance maps EA factors that are more important are usually also more performant. In other words, firms already score well on the most important factors and worse on the lesser important factors, which indicates that the current prioritization of EA-related digital innovativeness efforts is quite good on average for the participating firms. Because the IPMA analysis did not show any constructs that are important on which the participating firms perform poorly (the right-bottom corner of the graphs), I cannot give suggestions for research efforts that aim to address the reason behind such discrepancies.

10
Conclusion

Whereas previous section (Section 9) discussed the methodology and results of the thesis in detail from an expert point of view, this section recapitulates the study's most important findings and concludes this thesis.

First, it presents the answers to the sub-research questions (see Section 1.4.4) in Section 10.2. Then, it explains both the practical and scientific contribution of this thesis in Section 10.3.

10.1. Main Conclusion

But before diving into these details, I want to clearly answer the **main research question** of this thesis:

> How can enterprise architects improve their firm's digital innovativeness?

The answer to this question and the **main conclusion** of the thesis can be summarized as follows, as copied from Section 9.3: Based on empirical evidence from over 50 investigated firms in The Netherlands, ...

> ”... there are three ways in which enterprise architects can probably increase a firm's digital innovativeness, namely:
>
> 1. When they design the architecture as a solid foundation on top of which it is easy for employees to test new ideas (+) (*the EA design perspective*)
> 2. When they ... (*the EA capability perspective*)
>   - Ensure that they are highly skilled by hiring highly skilled enterprise architects (+++), especially those with excellent communication skills (++), and by providing them with sufficient professional development opportunities (++)
>   - Join strategic discussions to advise about, for example, the feasibility of innovations and the prioritization of resources (+)
>   - Use an agile working methodology (+) (where continuously seeking feedback to guide their efforts is an especially important factor (++))
> 3. When they pro-actively search for external innovation opportunities (++) as part of a well-defined EA innovation ambition (++) (*the EA innovation perspective*).”

A (+) denotes a weak (but positive) statistically significant correlation with a firm's digital innovativeness, a (++) denotes a moderate correlation, and a (+++) denotes a strong correlation.

These guidelines were obtained by answering the four sub-research questions recapitulated in this section and are discussed in considerably more detail in Section 9. This section summarizes the answer to each of these questions and concludes with a summary of the research implications.

10.2. Answering the Sub-research Questions

Measurement Digital Innovativeness

How can a firm's digital innovativeness be measured?

A firm's digital innovativeness can be measured by using either patent-based or survey-based approaches (see Section 3.3).

I measured for this research a firm's digital innovativeness by using the survey-based approach of Arias-Pérez and Vélez-Jaramillo (2022).

This method measures the digital innovation output that I intend to measure and does not assume that firms have patented their innovations, which many organizations do not regularly do (especially not for software innovations). This peer-reviewed method uses 7 Likert-scale statements related to particular dimensions of a firm's digital innovativeness.

EA Factors

What factors that Enterprise Architects influence or are influenced by (EA factors) can be distinguished that are likely to be related to a firm's digital innovativeness?

I compiled a list of 25 EA factors that are likely to be related to a firm's digital innovativeness by synthesizing three different sources, namely EA factors found in the literature, EA factors distilled from an Enterprise Architecture maturity framework (namely DyAMM) by using the Best Worst Method, and EA factors suggested by EA experts. These factors were grouped into 3 clusters: the EA design, EA capability, and EA innovation perspective. The EA capability perspective was split up into 4 MECE segments, thus resulting in 6 main categories.

The resulting segmentation and list of EA factors can be found in Section 4.1.

Influence EA factors on Digital Innovativeness

Which EA factors significantly influence a firm's digital innovativeness?

To empirically investigate which of the previously identified EA factors significantly influence a firm's digital innovativeness, I used PLS-SEM. The structural model consists of (1) the six main categories that are formatively composed of their corresponding EA factors, (2) a moderating digital innovation readiness factor, and (3) the endogenous digital innovation output. The EA factors are reflective measures with mainly two (sometimes one) questionnaire items constituting the measurement model. The measurement model was assessed and improved by conducting two pilot studies based on several reliability and validity measures. Afterward, the structural model was assessed for its multicollinearity and used to calculate, among other things, the strength/significance of the path coefficients.

Empirically establishing the causality of the structural paths is challenging and requires a longitudinal study (which was not feasible given the time constraints). Therefore, I chose to interview seven senior EA experts (> 10 years of relevant work experience) as an alternative and use their expertise to estimate the causalities. These EA experts indicated that they expected all of the statistically significant correlations to be causal. However, they also mentioned a lot of additional nuances, as discussed in Section 9.

Hiring highly skilled enterprise architects is the factor that was found to increase a firm's digital innovativeness most. Additionally, the digital innovativeness of firms is increased significantly when the enterprise architects work in an agile manner, are aware of their role in the context of digital innovation, and actively identify external opportunities for innovation. The results also identified several factors that increase a firm's digital innovativeness to a lesser degree, namely the involvement of enterprise architects in the strategic discussions, the existence of an open feedback culture, and the presence of a solid EA foundation on top of which it is easy for employees to innovate. These conclusions are discussed in detail in Section 9.

This research did not find evidence that any investigated EA factor negatively influences digital innovativeness. Instead, for most EA factors, insufficient evidence was found to correlate them with statistical significance ($p < 0.05$) to digital innovativeness. For some correlations, EA experts expected that these were moderated by an additional factor. For other correlations that were not statistically significant, the experts were quite confident that they influence a firm's digital innovativeness, but the research setup should be changed, or the collected number of samples increased to establish a statistically significant correlation. Therefore, I encourage other researchers to re-use my list of EA factors (adapted with the suggestions in Section 9) when investigating the correlation between EA factors and digital innovativeness with a larger number of samples.

10.3. Contribution

This section explains how this thesis contributes to the EA practice and related literature.

10.3.1. Contribution to Practice

Being digitally innovative is important for practically every firm, regardless of its sector (see Section 1.2.1). The rewards for being a strong digital innovator are manifold. For example, after a single development investment, the resulting digital service is usually highly scalable without substantial additional costs when the demand for the service increases (Svensson & Taghavianfar, 2015; Yoo et al., 2012). Additionally, digital solutions can streamline operations or automate manual tasks, thus improving - for example - the reliability, the costs, or the quality of the service (Chowdhury et al., 2019). Thirdly, digital solutions can help decision-makers gain valuable insights by gathering and processing information on a scale that would be unfeasible without digital technologies (Stuart et al., 2021).

Meanwhile, Enterprise architects have considerable influence on a firm's IT landscape and thus presumably also on the firm's ability to produce digital innovations. However, there are currently no empirically grounded guidelines available for enterprise architects to contribute to their firm's digital innovativeness despite all of the aforementioned reasons why it is important for firms to be a digital pioneer. Considering the notion of Kane et al. (2015) that many firms are unable to produce digital innovations successfully (2015), there is an urgent need for proper guidelines for enterprise architects on how they can contribute to their firm's digital innovativeness.

This thesis provides EA practitioners with the first empirically validated guidelines on how to contribute to their firm's digital innovativeness. It shows that hiring highly skilled enterprise architects is the most important thing (compared to all other factors studied) that a firm can do to increase its digital innovativeness. These architects must keep developing their skills, for example by joining trainings, attending conferences, or learning from consultants. Many architects may be highly intelligent, but their communication skills are also critical to adjust and realize their ideas about the enterprise architecture. Clearly, an excellent enterprise architect is not only able to design and ensure compliance to an enterprise architecture, but also to behave in a way that benefits the organization.

Additionally, this research shows that firms can maximize their innovation potential even more when these architects work in an agile manner, are aware of their role in the context of digital innovation, and actively identify external opportunities for innovation. Also, several other lesser important factors were identified: the importance of involving enterprise architects with the strategic discussions, creating an open feedback culture and creating a solid EA foundation on top of which it is easy for employees to innovate. Enterprise architects should not consider themselves to be ”police agents” that ensure compliance to the enterprise architecture, but rather as professionals that maximize the potential of the firm's systems by paying attention to (among other things) the emergence and development of valuable innovative ideas and the prevention of an unwieldy proliferation of organizational systems.

Considering the importance of digital innovativeness (as described in Section 1.2), I expect the insights from this study to be valuable for many enterprise architects. Interestingly, the results also indicate that the factors that were found to be most important are also the factors that many firms have already implemented very well. This makes the results all the more relevant for firms that score worse on these factors and are lagging behind.

10.3.2. Contribution to Theory

Scientific research that empirically demonstrates the influence of EA factors on a firm's digital innovativeness is - to the best of the author's knowledge - non-existent, as described in Section 3.4.1. Although some prior research exists about EA factors that influence a firm's general innovativeness, this research is also scarce.

This study contributes in several ways to the scientific field.

The main contribution is providing the first scientifically validated empirical evidence for the impact of many EA-related factors on a firm's digital innovativeness. Thus, this thesis is an important first step towards closing this research gap, but more research is needed to get a complete picture of the relationship between EA and digital innovativeness.

To this end, this research contributes an extensive overview of many other EA-related factors that are presumed to improve a firm's digital innovativeness that can be validated in future research when a larger sample of enterprise architects is available. These EA-related factors are accompanied by a large number of insights from EA experts (see Section 9.3) that are undoubtedly useful for further research.

Finally, this thesis contributes to the theory the identification of an important impediment towards the development of such empirically validated guidelines, namely the availability of an objective and unbiased measure for a firm's digital innovativeness that adequately captures all relevant aspects. By identifying this impediment, this research enables future research to take a goal-oriented approach by first addressing the main impediment: namely, the development of a better digital innovativeness measure, and afterward using this measure to develop additional empirical guidelines.

A

Research Approach (SEM) - Primer into the terminology

This appendix is a concise primer into basic research terminology, and terminology used for structural equation models.

Constructs are unobservable, latent concepts that exist only in the subject's mind (Bunge, 1974). A famous example of constructs is IQ (Intelligence-Quotient) which cannot be observed directly in the real world but is an imaginary concept that can be ”measured” by measuring and combining so-called indicators.

Indicators, also called measures, elements, indicator variables, or manifest variables, are empirical, quantitative variables obtained by observations in the real world. These indicators may be measured, for example, utilizing a questionnaire (in which case they are called ”*items*”), observations, interviews, self-reports, or other empirical means (Gefen et al., 2000).

SEM distinguishes between two types of indicators. On the one hand, there are *reflective indicators*, also called effect indicators, that measure an underlying construct (which is consequently called a *reflective construct*). Any change in a reflective construct will be ”reflected” (i.e., cause a change) in the value in each of its indicators.

On the other hand, there are *formative indicators*, also called causal indicators, that determine a construct (which is consequently called a *formative construct* or composite variable). Each of its indicators can vary independently from the others and influence or ”form” the value of the formative construct.

The same construct can be specified either formatively or reflectively. Consider, for example, the construct ”Customer satisfaction with a hotel”. To make this a reflective construct, the indicators could be questionnaire items such as ”I appreciate this hotel”, ”I am looking forward to staying in this hotel”, or ”I recommend this hotel to others”. To make it a formative construct, the indicators could be items such as ”The service is good”, ”The personnel is friendly”, or ”The rooms are clean”.

The difference between reflective and formative constructs is explained in more detail in Table A.1, which is cited from Jarvis et al. (2003) and adapted with information from Freeze and Raschke (2007).

The constructs that explain other constructs are independent, criterion, or *exogenous constructs*, and constructs that are being explained by other constructs are called dependent, predictor, or *endogenous constructs* (Hair Jr et al., 2021; Schreiber et al., 2006).

These constructs and indicators are the building blocks of structural equation models that show how all the constructs and indicators are interlinked. A structural equation model splits the analysis into a *measurement model* (or outer model) that explains the relation between the observable indicators and unobservable constructs, and a *structural model* (or inner model or nomological network) that explains the hypothesized causal paths between the constructs (Freeze & Raschke, 2007; Gefen et al., 2011).

The terminology is visualized in Figure A.1, following the notation style used by Petter et al. (2007).

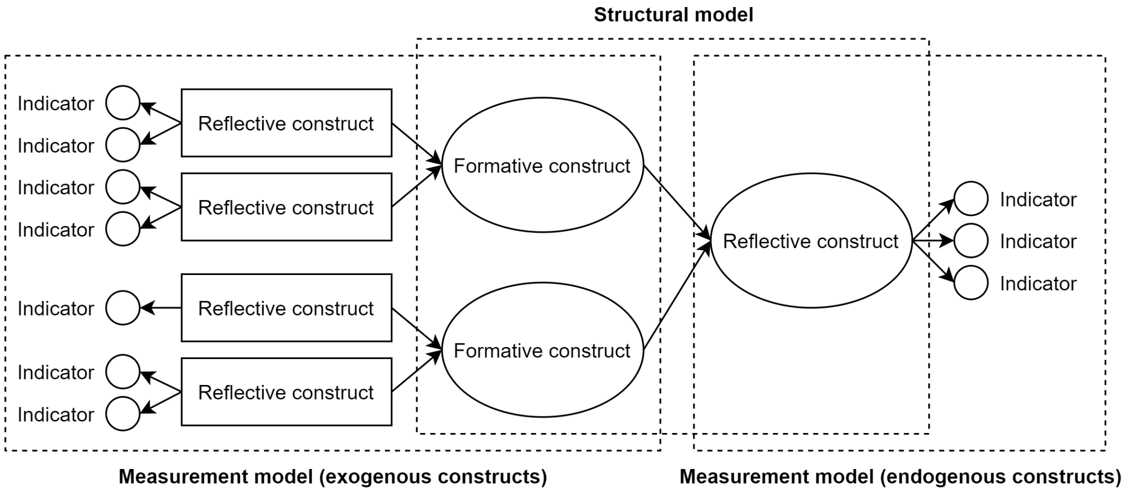

Figure A.1: Graphical illustration of a Structural Equation Model

Decision rule	Reflective construct	Formative construct
1. Direction of causality from construct to measure implied by the conceptual definition	Direction of causality is from construct to indicators	Direction of causality is from indicators to construct
Are the indicators (a) defining characteristics or (b) manifestations of the construct?	Indicators are manifestations of the construct	Indicators are defining characteristics of the construct
Would changes in the indicators cause changes in the construct or not?	Changes in the indicator should not cause changes in the construct	Changes in the indicators should cause changes in the construct
Would changes in the construct cause changes in the indicators?	Changes in the construct do cause changes in the indicators	Changes in the construct do not cause changes in the indicators
2. Interchangeability of the indicators	Indicators should be interchangeable	Indicators need not be interchangeable
Should the indicators have the same or similar content? Do the indicators share a common theme?	Indicators should have the same or similar content/indicators should share a common theme	Indicators need not have the same or similar content/indicators need not share a common theme
Would dropping one of the indicators alter the conceptual domain of the construct?	Dropping an indicator should not alter the conceptual domain of the construct	Dropping an indicator alters the conceptual domain of the construct
3. Covariation among the indicators	Indicators are expected to covary with each other	Not necessary for indicators to covary with each other
Should a change in one of the indicators be associated with changes in the other indicators?	Yes	Not necessarily
4. Nomological net of the construct indicators	Nomological net for the indicators should not differ	Nomological net for the indicators may differ
Are the indicators expected to have the same antecedents and consequences?	Indicators are required to have the same antecedents and consequences	Indicators are not required to have the same antecedents and consequences

Table A.1: Difference between reflective and formative constructs, mostly cited from Jarvis et al. (2003) and adapted with information from Freeze and Raschke (2007)

B

Literature Review - Methodology

This appendix details how the literature review method presented by Xiao and Watson (2019) was used to conduct and write the literature review. The steps of this method are shown in Figure B.1. Because the review protocol, developed in step 2 of the process, describes steps 3 until step 7, these steps are described as part of the review protocol.

First, I formulate the problems to be addressed by the literature review in Section B.1.

Then, I explain which review protocol is used to gain answers to these problems in Section B.2.

The results that are obtained from following this review protocol are presented in Section 3.

The papers found at each step of the process are listed in Appendix C.

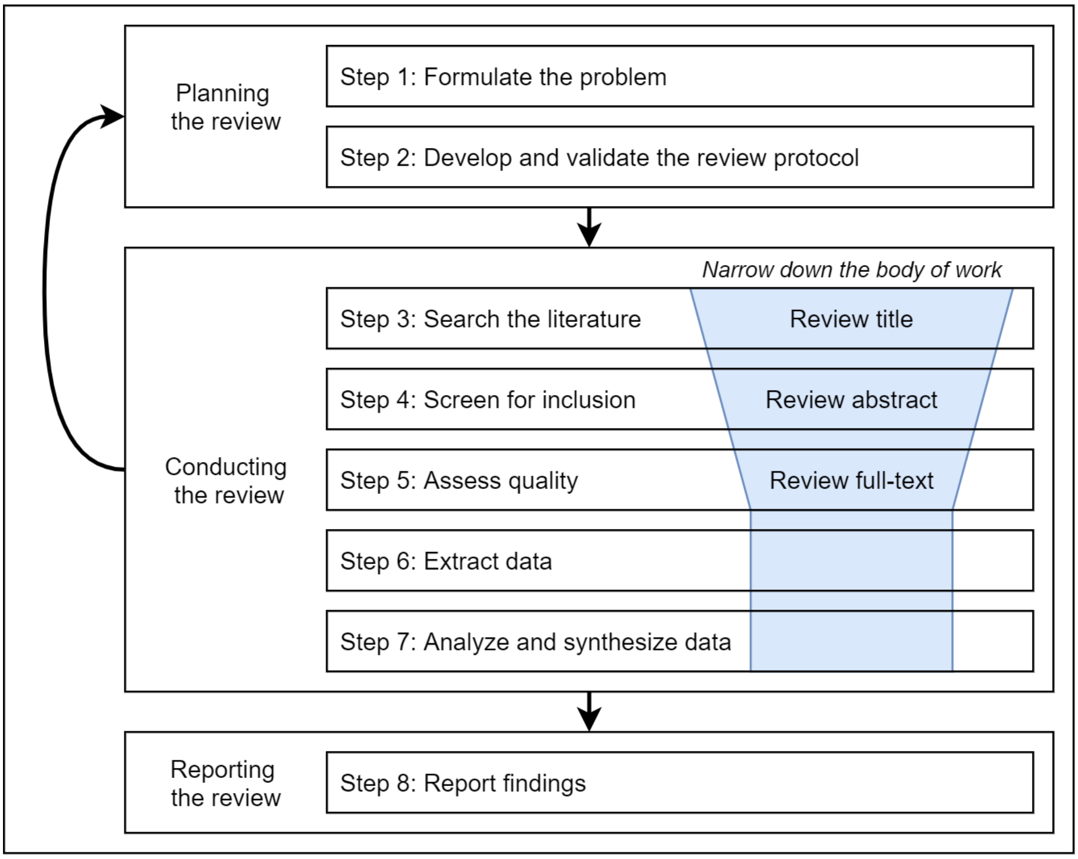

Figure B.1: Literature review process

B.1. Step 1: Formulate the Problem

The problem and corresponding research questions were formulated by talking to several EA experts and informally exploring the literature about EA. The research questions that are answered through the literature review are as follows (as copied from Section 3.1):

1. How can a firm's digital innovativeness be measured?
2. What EA factors can be distinguished that are likely to be related to a firm's digital innovativeness?

I answer the second research question by, on the one hand, collecting EA factors that were linked to innovativeness before by previous researchers, and, on the other hand, finding an EAMM that mentions important aspects of an EA capability (see Section 3.2.2). Therefore, I split the literature review into three phases, namely (1) reviewing digital innovation measurement methods, (2) reviewing EA factors linked to digital innovativeness, and (3) reviewing EAMMs.

B.2. Step 2: Develop the Review Protocol

A *review protocol* is a preset plan specifying the method used to conduct the literature review. There are several reasons why it is important to specify the review protocol before conducting the review:

- It lowers the risk of researcher bias in data collection and analysis (B. Kitchenham & Charters, 2007)
- It improves the review's credibility by allowing others to replicate the study for cross-checking and verification using the same procedure (Xiao & Watson, 2019)
- It can be evaluated and critiqued to increase the rigor of the study (B. Kitchenham & Charters, 2007)

This section presents the literature review protocol for this research, categorized per step.

B.2.1. Review Protocol - *Step 3: Search the Literature*

Because the quality of a literature review largely depends on the literature found, I take a systematic approach to search the literature.

Channels for Literature Search

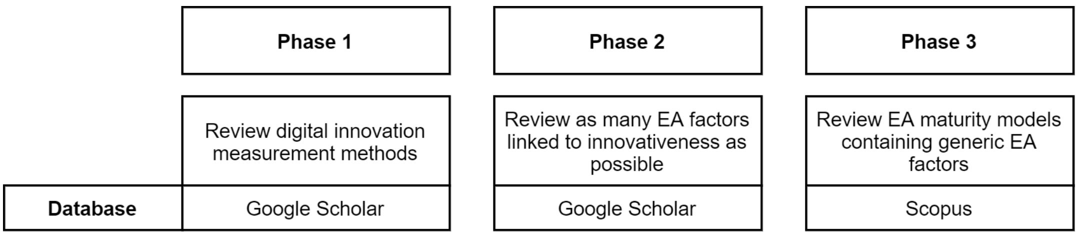

Figure B.2: Schematic overview of the databases used per phase

There are many databases available to search the literature, the most popular of which are Google Scholar, Scopus, and Web of Science (Martin-Martin et al., 2019). These services differ significantly in their approach to document inclusion. Scopus and Web of Science index journals, conference proceedings, and books based on a set of selection criteria developed by experts (Martin-Martin et al., 2019). Between the indexes of these two databases is much overlap, but Scopus usually returns a slightly more extensive set of results than Web of Science (Martin-Martin et al., 2019). Google Scholar, on the other hand, takes a more comprehensive approach, indexing any (supposedly) scholarly paper found by its robot crawlers on the academic web (Martin-Martin et al., 2019).

Because the scoping search revealed that there is very little literature written about digital innovation measurement methods and EA factors linked before to digital innovativeness, I use for *Phase 1* and *Phase 2* Google Scholar. For *Phase 3* Google Scholar turns out to produce more literature than I can review given the time constraints. Because I prefer reviewing papers from respected sources rather than lesser qualified ones, I gather for these phases the literature by using Scopus.

Keywords used for the Search

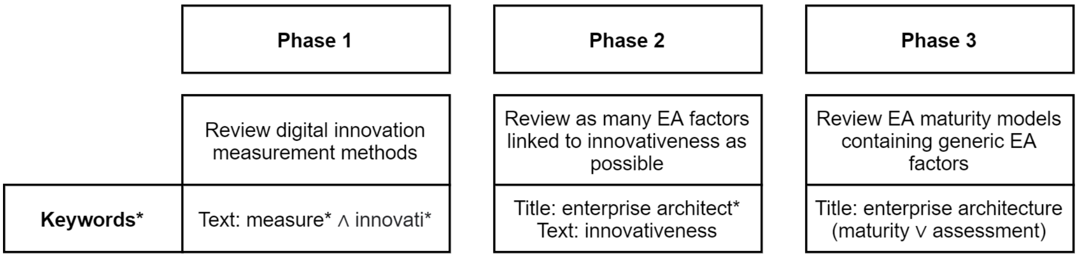

Figure B.3: Schematic overview of the keywords used per phase
*: synonyms of the keywords have been omitted to save space

After deciding which literature database to use, I need to choose the right keywords for each phase. In the keyword enumeration below, || denotes the logical disjunction (”or”). I used Thesaurus (Thesaurus, n.d.) to obtain a list of synonyms for each keyword, which are listed below. Because Google Scholar is unable to search through the articles' abstracts only or to use a mixture between conjunctions and disjunctions when searching through the title, and because Scopus is unable to search through the full text of the articles, I developed the keywords with the limitations of these databases in mind. Based on the research questions, I formulated an initial set of keywords to search for, which was then extended with new, relevant keywords found in the literature with each iteration.

For each phase, I tried to strike a reasonable balance between the degree of precision and exhaustiveness, as recommended by Wanden-Berghe and Sanz-Valero (2012). While broadening the search yields a more exhaustive set of results, it may also yield more irrelevant articles, which costs more time to evaluate. In comparison, employing more specific terms increases the search accuracy but may also result in missing articles.

I consulted an expert in the field (which led to also including articles about ”enterprise architects” instead of only ”enterprise architecture”) and checked the results of the final version of the keywords against a list of several primary studies I already knew would be included in the literature review, as suggested by B. Kitchenham and Charters (2007). I require all results to be in English and only include articles that are online accessible and seem to be relevant for answering the research questions based on their title. In the next few steps, I will apply a more fine-grained filter to select the final set of papers to include in the review.

For each phase, I use backward and forward-snowballing to find more articles as recommended by Webster and Watson (2002).

Phase 1: digital innovativeness measurement methods

- **Text contains:** ”measure digital innovation” || ”measure for digital innovation” || ”measuring digital innovation” || ”measure for digital innovativeness” || ”measure digital innovativeness” || ”measuring digital innovativeness” || ”measure digital innovativeness” || ”digital innovativeness construct” || ”digital innovation construct” || ”digital innovation measure” || ”digital innovativeness measure”

To find digital innovation measurement methods, I experimented with several search queries on Scopus, but Scopus found very few results by restricting the search query to words found in the title, abstract, or keywords (the broadest type of data searchable on Scopus). Therefore, I decided to use Google Scholar and search for every possible combination of words targeting digital innovativeness in the full text. This resulted in 35 results.

Phase 2: EA factors linked to innovativeness

- **Title contains:** ”enterprise architecture” || ”EA” || ”enterprise architect”
- **And text contains:** innovativeness || ”innovation capability” || ”innovation ability” || ”capacity to innovate” || ”ability to innovate” || ”innovation strength” || ”innovation competence”

To find EA factors linked to firms' innovativeness by other researchers, I first searched for EA factors linked to digital innovativeness but could not find even a single article. Then, I searched for EA factors linked to innovativeness in general on Scopus but found only a few articles. Eventually, I ended up using Google Scholar. It is important not to require anything related to innovation in the title because

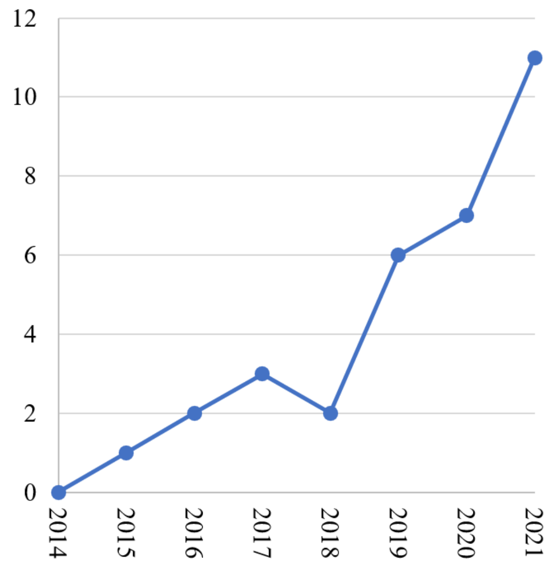

Figure B.4: Number of hits per year for phase 1

that will result in missing numerous relevant articles. However, I required the article title to mention enterprise architecture (or a variant) because otherwise, the total number of hits would be too large to review. The final search query resulted in a total number of 105 hits.

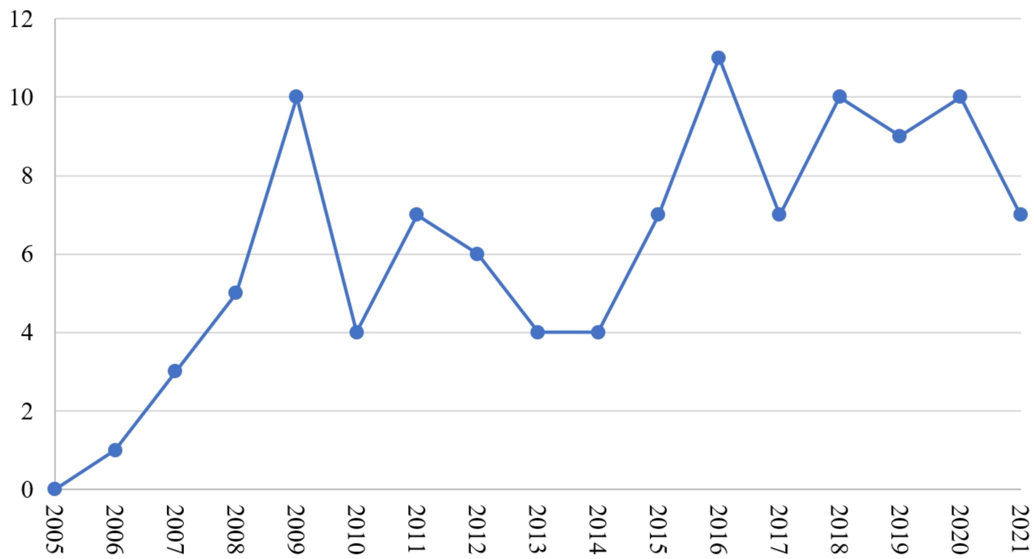

Figure B.5: Number of hits per year for phase 2

Phase 3: EA maturity models

- **Title, abstract, or keywords contain:** ”Enterprise Architecture maturity” || ”EA maturity” || ”Enterprise architecture assessment” || ”EA assessment”

I found a decent number of articles about EAMMs on Scopus, namely 31 in total. These articles were all peer-reviewed, and many of them contained a significant number of references that were suitable for snowballing.

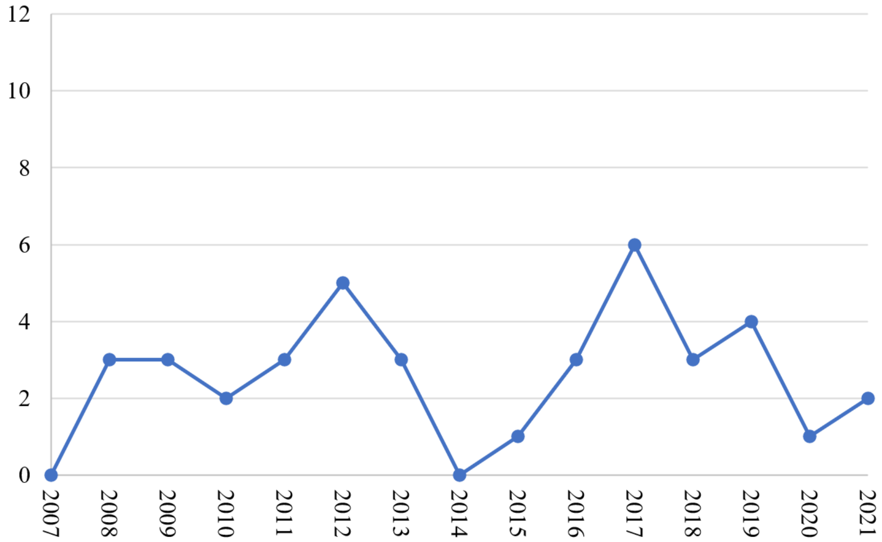

Figure B.6: Number of hits per year for phase 3

B.2.2. Review Protocol - *Step 4: Search for Inclusion*

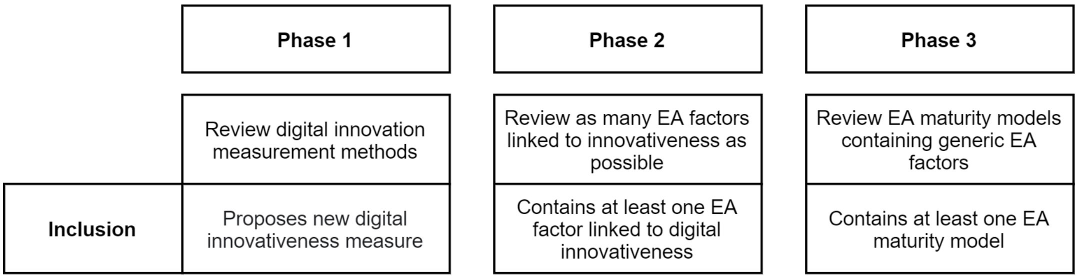

Figure B.7: Schematic overview of the inclusion / exclusion step

Following the generation of the reference list, the articles must be examined to determine if they are suitable to be included in the data extraction and analysis step. An efficient approach is to begin with a crude filter of which articles should be included based on reading the titles, then the abstracts, and then to refine the remaining articles based on a full-text review (see Figure B.1). The first screening excludes publications that clearly do not contain material related to the research question. In this stage, I give articles the benefit of the doubt when I am unsure if they should be included. Papers are excluded when they clearly do not contain information relevant to answering the research question. Although numerous authors recommend that at least two reviewers evaluate the collected papers against the inclusion and exclusion criteria separately (Brereton et al., 2007; Gomersall et al., 2015; B. Kitchenham & Charters, 2007; Templier & Paré, 2015), this is not an option for this research since this is a master thesis, which is written by a single person.

For each phase, I applied the following inclusion/exclusion criteria:

- The study is written in English
- The study is published after 2010
- *(For phase 1:)* The study proposes a new measure for a firm's digital innovativeness
- *(For phase 2:)* The study contains at least one EA factor that is somehow linked to innovativeness
- *(For phase 3:)* The study contains at least one EA maturity model

The first two criteria were already applied during the database search as mentioned in Section B.2.1. The remaining three criteria were applied by studying the texts.

B.2.3. Review Protocol - *Step 5: Assess Quality*

	Phase 1	**Phase 2**	**Phase 3**
	Review digital innovation measurement methods	Review as many EA factors linked to innovativeness as possible	Review EA maturity models containing generic EA factors
Quality assessment	Evaluation of reliability and validaty assessment	Evaluate empirical evidence	(already done by the peer review)

Figure B.8: Schematic overview of the quality assessment step

Whereas in a full systematic literature review, the articles should be assessed using an extensive quality assessment, a full quality assessment was infeasible given the time constraints of a master's thesis. Instead, in consultation with the university supervisors, I decided that all peer-reviewed papers are considered high-quality and determined for the remaining papers the quality and relevance of a paper based on an informal inspection of the reliability and validity of the research results.

B.2.4. Review Protocol - *Step 6: Extract Data*

	Phase 1	**Phase 2**	**Phase 3**
	Review digital innovation measurement methods	Review as many EA factors linked to innovativeness as possible	Review EA maturity models containing generic EA factors
Extraction	• Short description • Type of data being used	• Short description • Presumed to be correlated with DI? • Proven to be correlated with DI? • Presumed to be causally correlated with DI? • Proven to be causally correlated with DI? • Presumed to be uncorrelated with DI? • Proven to be uncorrelated with DI?	• Short description • Year of publication • Continuous, staged, or focus area model? • Product-based or process-based? • #levels • Scoring method

Figure B.9: Schematic overview of the data extraction step

In each of the phases, I extract the elements of the articles that are relevant in that particular phase. The elements that will be extracted for the first two phases result directly from the research questions formulated for the literature review (see Section 3.1). The elements that will be extracted for the third phase are based on literature (Meyer et al., 2011; Van Steenbergen et al., 2008; van Zwienen et al., 2019) (see Section 3.4.2). Extracting EA factors involves carefully examining the sources and determining if they contain concepts that can be classified as EA factors under their definition specified in Section 1.4.4.

Data extracted for all phases

- Title
- Name of authors
- Publication year

Phase 1: Review digital innovation measurement methods

- Short description
- Type of data being used

Phase 2: Review as many EA factors linked to innovativeness as possible

- Short description
- Presumed to be correlated with DI?
- Proven to be correlated with DI?
- Presumed to be causally correlated with DI?
- Proven to be causally correlated with DI?
- Presumed to be uncorrelated with DI?
- Proven to be uncorrelated with DI?

Phase 3: Review EA maturity models containing generic EA factors

- Short description
- Year of publication
- Continuous, staged, or focus area model?
- Product-based or process-based?
- #levels
- Scoring method

B.2.5. Review Protocol - *Step 7: Analyze and Synthesize Data*

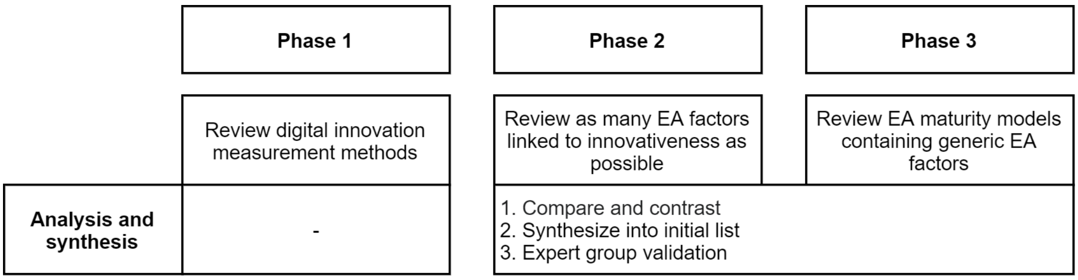

Figure B.10: Schematic overview of the analysis and synthesis step

The innovation measurement methods do not need further analysis or synthesis, but the EA factors do need further processing due to their broad definition.

1. **Compare and Contrast**
   After extracting descriptions of the EA factors, I compare and contrast these descriptions to identify distinct groups denoting the same capabilities.

2. **Synthesize into Initial List**
   I compare and contrast the selected groups to minimize their overlap: when too much overlap is found, the overlapping groups are divided or merged. Moreover, I give the groups names and descriptions that reflect the underlying capabilities in their respective group. This definition-description collection is the first draft of the overview of EA factors.

B.2.6. Review Protocol - Summary

The entire review protocol is summarized in Figure B.11. EA experts and innovation experts validate the results of the literature review before these are used as input for specifying the structural model (see Section D).

	Phase 1	**Phase 2**	**Phase 3**
	Review digital innovation measurement methods	Review as many EA factors linked to innovativeness as possible	Review EA maturity models containing generic EA factors
Database	Google Scholar	Google Scholar	Scopus
Keywords*	Text: measure* ∧ innovati*	Title: enterprise architect* Text: innovativeness	Title: enterprise architecture (maturity ∨ assessment)
Inclusion	Proposes new digital innovativeness measure	Contains at least one EA factor linked to digital innovativeness	Contains at least one EA maturity model
Quality assessment	Evaluation of reliability and validaty assessment	Evaluate empirical evidence	(already done by the peer review)
Extraction	• Short description • Type of data being used	• Short description • Presumed to be correlated with DI? • Proven to be correlated with DI? • Presumed to be causally correlated with DI? • Proven to be causally correlated with DI? • Presumed to be uncorrelated with DI? • Proven to be uncorrelated with DI?	• Short description • Year of publication • Continuous, staged, or focus area model? • Product-based or process-based? • #levels • Scoring method
Analysis and synthesis	-	1. Compare and contrast 2. Synthesize into initial list 3. Expert group validation	

Figure B.11: Full literature review structure summary
*: synonyms of the keywords have been omitted to save space; the full set of keywords can be found in Section B.2.1

C

Literature Review - Results

This section contains the results of each phase of the literature review, executed as described in Appendix B.

For each paper, I show:

- If the title indicated that the paper might be useful
- If so, if the abstract indicated that the paper might be useful
- If so, if the full-text contained relevant information

All papers of which the full-text contains relevant information and all papers that were found by backward/forward-snowballing are included in the final category ”snowballing”. A 0 indicates that a paper was not selected for a particular phase, and a 1 indicates the contrary. The total number of papers selected for each phase is shown at the end of each table.

The literature search for the phases were conducted on the following dates:

- Phase 1: September 28th, 2021
- Phase 2: September 29th, 2021
- Phase 3: October 1st, 2021

C.1. Phase 1: Digital Innovativeness Measurement Methods

Paper		Inclusion			
(Author, Year)	**Title**	**Title**	**Abstr**	**Full-text**	**Snowb.**
(Wei et al., 2019)	The impact of iOS use and interpersonal ties on digital innovation: Insights from boundary spanning and institutional theories	1	1	0	0
(Xu, 2011)	Internet Finance: A Systematic Literature Review and Bibliometric Analysis	0	0	0	0
(Koutsogeorgo & Cho, 2021)	Fostering innovation for the digital era	1	0	0	0
(Khin & Ho, 2019)	Digital technology, digital capability and organizational performance: A mediating role of digital innovation	1	1	0	0

Table C.1 continued from previous page

Paper		Inclusion			
(Author, Year)	**Title**	**Title**	**Abstr**	**Full-text**	**Snowb.**
(Liu et al., 2021)	Status and digital innovation: A middle-status conformity perspective	1	1	0	0
(Perry & Pollock, 2016)	Digital Identity in Mobile Products for Digital Innovation	1	1	0	0
(Braesemann & Stephany, 2020)	Measuring Digital Development with Online Data: Digital Economies in Eastern Europe and Central Asia	1	0	0	0
(Behrens & Viete, 2021)	A Note on Germany's Role in the Fourth Industrial Revolution	0	0	0	0
(Hjalmarsson et al., 2017)	Monitor Contest	0	0	0	0
(Lokuge et al., 2019)	Organizational readiness for digital innovation: Development and empirical calibration of a construct	1	1	0	0
(Ntene, 2018)	Digital Innovation Management Ecosystem : Managing Digital Innovation for Improved Competitiveness and Continued Sustainability	1	0	0	0
(Zuidgeest, 2021)	Empirical Exploration	1	0	0	0
(Nylén & Holmström, 2015)	Digital innovation strategy: A framework for diagnosing and improving digital product and service innovation	1	1	0	0
(Kohli & Melville, 2019)	Digital innovation: A review and synthesis	1	1	1	1
(Van Looy, 2021)	A quantitative and qualitative study of the link between business process management and digital innovation	1	1	0	0
(Eirich et al., 2019)	An organization design framework for digital innovation: Critical review of Galbraith's STAR Model	1	0	0	0
(Wei et al., 2021)	The effects of information technology capability and knowledge base on digital innovation: the moderating role of institutional environments	1	1	0	0
(Stavem & Presthus, 2017)	Checking in At the Bates Motel? Exploring the Feedback Loop Between Airbnb Host and Guest	0	0	0	0
(Drechsler et al., 2021)	Digital Innovation… And the Cross-Section of Stock Returns	1	1	0	0
(Hammerton et al., 2021)	Digital readiness within General Practice Evaluation Team Evaluation Team	1	0	0	0

Table C.1 continued from previous page

Paper		Inclusion			
(Author, Year)	**Title**	**Title**	**Abstr**	**Full-text**	**Snowb.**
(Arias-Pérez & Vélez-Jaramillo, 2022)	Ignoring the three-way interaction of digital orientation, Not-invented-here syndrome and employee's artificial intelligence awareness in digital innovation performance: A recipe for failure	1	1	1	1
(Firk et al., 2021)	Top management team characteristics and digital innovation: Exploring digital knowledge and TMT interfaces	1	1	1	1
(Shirish et al., 2021)	Effective Ict Use For Digital Innovation: An Actualized Affordance Perspective Through Ict Enabled Design Thinking	1	0	0	0
(Zwiers, 2021)	The combined effect of digital innovation and human digital resources on market evaluation in a digital environment: a quantitative study	1	1	1	1
(Choi et al., 2019)	International Comparison and Trade Effects of Digital Innovation According to Various Scenarios	0	0	0	0
(Tuğba Karabulut, 2020)	Digital innovation: an antecedent for digital transformation	1	1	0	0
(Haskamp et al., 2021)	Performance Measurement in Digital Innovation Units-An Exploratory Study on Barriers and Potential Enablers	1	1	0	0
(Yamashita et al., 2021)	Measuring the AI content of government-funded R&D projects : A proof of concept for the OECD Fundstat initiative	1	0	0	0
(Nasiri et al., 2020)	Shaping Digital Innovation Via Digital-related Capabilities	1	1	0	0
(Vakirayi, 2020)	Investigating the factors affecting the development of digital innovations in Zimbabwe's SMEs	1	0	0	0
(Ayele et al., 2018)	Unveiling DRD : A Method for Designing Digital Innovation Contest Measurement Models	1	1	0	0
(Eirich, 2020)	Basic Theories and Concepts	1	1	1	1
Total:		27	18	5	5

Table C.1: Literature review articles - Phase 1

C.2. Phase 2: EA Factors Linked With Innovativeness

Paper		Inclusion			
(Author, Year)	Title	Title	Abstr	Full-text	Snowb.
(Ahmad et al., 2019)	Assessing content validity of enterprise architecture adoption questionnaire (EAAQ) among content experts	1	0	0	0
(Bachoo, 2019)	On the Yellow Brick Road, A Path to Enterprise Architecture Maturity	1	0	0	0
(Bachoo, 2018a)	Achieving value from enterprise architecture maturity	1	1	0	0
(Bachoo, 2018b)	Enterprise architecture practices to achieve business value	1	1	0	0
(Comparini, 2019)	Regional related variety and companies' productivity in Brazil	0	0	0	0
(Darling, 2008)	The Journal of Enterprise Architecture	1	0	0	0
(Debnath, 2020)	Green IS—Exploring Environmental Sensitive IS Through the Lens of Enterprise Architecture	1	0	0	0
(Dejoux Lirsa & Charrière-Grillon, 2016)	How digital technologies are revolutionising the training function in companies : an exploratory study of a population of managers attending a MOOC	1	0	0	0
(Doshi & Vembu, 2013)	Service-driven Approaches to Architecture and Enterprise Integration	0	0	0	0
(Dreyfus & Iyer, 2006)	Enterprise architecture: A social network perspective	1	1	0	0
(Enagi, 2017)	Enterprise Architecture Driven Design of an Artefact to Support Strategic Information Technology Decision-Making of Small	1	0	0	0
(Essien, 2015)	Model Driven Validation Approach for Enterprise Architecture and Motivation Extentions	1	0	0	0
(Essien & Ousenna, 2019)	Schematization of Enterprise Architecture Models for Ontology Validation	0	0	0	0
(Goel et al., 2011)	A Survey of Approaches to Virtual Enterprise Architecture: Modeling Languages, Reference Models, and Architecture Frameworks Conceptual Outline for Rapid IT Application Information Discovery Michael Linke Rational Systems Design for Health Information Sys	0	0	0	0
(Hansen & Schinkel, 2020)	Open Innovation in Research Technology Organizations	0	0	0	0

Table C.2 continued from previous page

Paper		Inclusion			
(Author, Year)	**Title**	**Title**	**Abstr**	**Full-text**	**Snowb.**
(Haussener, 2014)	Land Tenure Policy Implications in Tanzania (EA) on Small Scale Investors	0	0	0	0
(Helfert et al., 2018)	Digital and smart services - The application of enterprise architecture	1	0	0	0
(Hrabe, 2011)	Supporting state competitiveness by government enterprise architecture	1	0	0	0
(Hugoson et al., 2010)	Enterprise architecture design principles and business-driven IT management	0	0	0	0
(Iyamu et al., 2013)	Enterprise architecture strategic framework	1	0	0	0
(Janssen, 2009)	Framing Enterprise Architecture: A Framework for Analyzing Architectural	1	0	0	0
(Jayakrishnan et al., 2020)	Digitalization railway supply chain 4.0: Enterprise architecture perspective	0	0	0	0
(Kalpazidou Schmidt et al., 2017)	Evaluation Framework for Promoting Gender Equality in R&I	0	0	0	0
(Kasteel, 2009)	The value of Enterprise Architecture The Enterprise Transformation Series	0	0	0	0
(Khanh et al., 2007)	Developing innovation capacity through effective research and development partnerships	0	0	0	0
(Kirikova & Stasko, 2007)	Enterprise architecture and foresight based business process adequacy analysis	1	0	0	0
(Laschitza, 2017)	Enterprise Architecture Implementation A qualitative study in opportunities and obstacles of EA implementation	1	0	0	0
(Lavin, 2014)	Towards an understanding of business design within enterprise architecture management: a cautionary tale	1	0	0	0
(Leppänen et al., 2007)	Towards a Contingency Framework for Engineering an Enterprise Architecture Planning Method	1	0	0	0
(Levy & Bui, 2019)	How field-level institutions become a part of organizations: A study of enterprise architecture as a tool for institutional change	0	0	0	0

Table C.2 continued from previous page

Paper		Inclusion			
(Author, Year)	**Title**	**Title**	**Abstr**	**Full-text**	**Snowb.**
(Li et al., 2010)	Research on enterprise software architecture based on social computing	1	0	0	0
(Lo, 2020)	Systematic Literature Reviews on Human Factors in Enterprise Architecture Implementation	0	0	0	0
(Lumor, 2016)	Towards the design of an agile Enterprise Architecture management method	0	0	0	0
(Makiya et al., 2012)	A multi-level investigation into the antecedents of Enterprise Architecture (EA) assimilation in the U.S. federal government	0	0	0	0
(Makovhololo et al., 2021)	The significance of Enterprise Architecture in driving Digital Transformation on Public sectors	1	0	0	0
(Martinho, 2017)	Novel tool use acquisition in human primates and the evolution of social learning : An experimental approach	0	0	0	0
(Mell et al., 2011)	Extension : An Enterprise Continuous Monitoring Technical Reference Architecture (Draft)	1	0	0	0
(Merenheimo, 2017)	Enterprise Architecture in Digital Business ' Strategy Making	1	0	0	0
(Mezzanotte, 2016)	Planning Enterprise Architecture: Creating organizational knowledge using the Theory of Structuration to build Information Technology	1	0	0	0
(Niemi & Ylimäki, 2007)	Evaluating Business-IT Alignment in the Enterprise Architecture Context AISA Project Report	1	0	0	0
(Nørgaard, 2009)	EA Active, Problem Based Learning	0	0	0	0
(Nowakowski & Breu, 2018)	Enterprise architecture planning for industry 4.0	1	0	0	0
(Oderinde, 2011)	Understanding Enterprise Architecture in Four UK Universities	0	0	0	0
(Ogundipe, 2020)	The role of enterprise architecture in the business and information technology alignment of a public organisation in South Africa	1	0	0	0
(Pallaspuro, 2012)	Organizational Practices and Praxes in the Implementation , Execution and Governance of Enterprise Architecture - A Strategic Management Perspective	1	0	0	0

Table C.2 continued from previous page

Paper		Inclusion			
(Author, Year)	**Title**	**Title**	**Abstr**	**Full-text**	**Snowb.**
(Pankowska, 2015)	Stakeholder oriented enterprise architecture modelling	1	0	0	0
(Pereira, 2020)	Políticas epistêmicas	0	0	0	0
(Perko, 2008)	IT Governance and Enterprise Architecture as Prerequisites for Assimilation of Service-Oriented Architecture An Empirical Study of Large Finnish Companies Thesis	1	0	0	0
(Rai et al., 2010)	Transitioning to a modular enterprise architecture: Drivers, constraints, and actions	0	0	0	0
(Rashid et al., 2018)	E-Accounting adoption in Malaysian Maritime Industry: A Conceptual Study and Future Direction	0	0	0	0
(Razak et al., 2008)	Evaluation of enterprise information architecture (EIA) practices in Malaysia	1	0	0	0
(Rosemann, 2012)	The Three Drivers of Innovation - What is the Related BPM/EA Readiness?	0	0	0	0
(Sallehudin et al., 2019)	Modelling the enterprise architecture implementation in the public sector using HOT-Fit framework	0	0	0	0
(Sigei, 2007)	Enterprise information security architecture (eisa) a methodology for adoption of an enterprise information security architecture model: a case study of major companies in the oil and gas industry in Kenya.	1	0	0	0
(Siti Nor Fatimah et al., 2016)	Elements of Building Defect: A review of the recent literature	0	0	0	0
(Sindane, 2018)	Challenges of enterprise architecture a systematic review	1	0	0	0
(Tambo & Clausen, 2018)	Business Process Management, continuous improvement and enterprise architecture: In the jungle of governance	1	0	0	0
(Tapio, 2014)	Discovering the core logic and purpose of enterprise architecture as a holistic approach to business execution	0	0	0	0

Table C.2 continued from previous page

Paper		Inclusion			
(Author, Year)	**Title**	**Title**	**Abstr**	**Full-text**	**Snowb.**
(This, 2009)	Improving health knowledge facilities by enterprise architecture exploring the options for sub-Saharan Africa Improving Health Knowledge Facilities by Enterprise Architecture : Exploring the Options for sub-Saharan Afric	0	0	0	0
(Ting, 2020)	a Review of Models for Critical Success Factors Affecting a Review of Models for Critical Success Factors Affecting	1	0	0	0
(van de Wetering, 2021)	How EA-Driven Dynamic Capabilities Enable Agility: The Mediating Role of Digital Project Benefits	0	0	0	0
(Vaniya, 2016)	Building Transformational Preparedness for Mergers and Acquisitions - An Enterprise Architecture Approach	0	0	0	0
(Wendt, 2015)	Ea superstitione: Christian martyrdom and the religion of freelance experts	0	0	0	0
(Zaher, 2017)	The Enterprise Architecture: An Empirical Study on The Organisational Benefits and Success Factors	1	1	0	0
(Zimmermann et al., 2016)	Adaptive enterprise architecture for digital transformation	1	0	0	0
(Lankhorst, 2012)	Enterprise Architecture at Work	0	0	0	0
(Niemi & Ylimäki, 2007)	Evaluating Business-IT Alignment in the EA Context	0	0	0	0
(van de Wetering, 2019)	Dynamic Enterprise Architecture Capabilities: Conceptualization and Validation	1	1	1	0
(Bontinck & Viaene, 2016)	From Enterprise Architect to Opportunity Architect	1	1	1	1
(Banaeianjahromi & Smolander, 2019)	Lack of Communication and Collaboration in Enterprise Architecture Development	1	1	0	0
(Bachoo, 2018c)	The Uncertain Path to Enterprise Architecture (EA) Maturity in the South African Financial Services Sector	1	1	0	0
(Velitchkov, 2008)	Integration of IT Strategy and Enterprise Architecture models	1	0	0	0
(Stouthandel, 2016)	Innovation-driven Enterprise Architecture	1	1	0	0

Table C.2 continued from previous page

Paper		Inclusion			
(Author, Year)	**Title**	**Title**	**Abstr**	**Full-text**	**Snowb.**
(Anderson, 2017)	Enterprise Architecture for Innovation Realization and Sustainability	1	1	0	0
(Lange & Mendling, 2011)	An experts' perspective on enterprise architecture goals, framework adoption and benefit assessment	0	0	0	1
(Louw et al., 2017)	Architecting the enterprise towards enhanced innovation capability	0	0	0	1
(Nardello et al., 2016)	How Does Enterprise Architecture Support Innovation?	0	0	0	1
Total:		74	10	5	11

Table C.2: Literature review articles - Phase 2

C.3. Phase 3: EA Maturity Models

Paper		Inclusion			
(Author, Year)	**Title**	**Title**	**Abstr**	**Full-text**	**Snowb.**
(Ali & Elnaz, 2012)	The phenomenon of Information technology and enterprise architecture of electronics city	0	0	0	0
(Anthopoulos, 2012)	An investigative assessment of the role of enterprise architecture in realizing e-Government transformation	1	1	0	0
(Arab-Mansour et al., 2017)	A business repository enrichment process: A case study for manufacturing execution systems	0	0	0	0
(Bachoo, 2018a)	Achieving value from enterprise architecture maturity	1	1	0	0
(Bachoo, 2018b)	Enterprise architecture practices to achieve business value	1	0	0	0
(Bakar et al., 2017)	A priority based enterprise architecture implementation assessment model: An analytic hierarchy process (AHP) approach	1	1	1	1
(Balci & Ormsby, 2008)	Network-centric military system architecture assessment methodology	0	0	0	0
(Bradley et al., 2012)	Enterprise architecture, IT effectiveness and the mediating role of IT alignment in US hospitals	0	0	0	0
(Bradley et al., 2011)	The role of enterprise architecture in the quest for IT value	0	0	0	0
(George & Feuerlicht, 2013)	Enterprise architecture value model	1	0	0	0

Table C.3 continued from previous page

Paper		Inclusion			
(Author, Year)	**Title**	**Title**	**Abstr**	**Full-text**	**Snowb.**
(Gifford et al., 2021)	Measuring the Exercise Component of Energy Availability during Arduous Training in Women	0	0	0	0
(Grabis & Kirikova, 2011)	Perspectives in Business Informatics Research - 10th International Conference, BIR 2011, Proceedings	0	0	0	0
(Hsieh et al., 1999)	Changes of pulse rate and skin temperature evoked by electroacupuncture stimulation with different frequency on both zusanli acupoints in humans	0	0	0	0
(Javanbakht et al., 2009)	A new method for enterprise architecture assessment and decision-making about improvement or redesign	1	1	0	0
(Johansson et al., 2017)	16th International Conference on Perspectives in Business Informatics Research, BIR 2017	0	0	0	0
(Kim & Moon, 2008)	Maturity model based on quality concept of enterprise information architecture (EIA)	1	1	0	0
(Lee & Kwon, 2013)	A study on strategy planning and outcome of EA in Korea	0	0	0	0
(Melin et al., 2016)	Low-energy density and high fiber intake are dietary concerns in female endurance athletes	0	0	0	0
(Meyer et al., 2011)	An analysis of enterprise architecture maturity frameworks	1	1	1	1
(Molinaro et al., 2010)	Maturity model for IT enterprise architecture	1	1	0	0
(Nguyen et al., 2020)	Multi-criteria decision theory for enterprise architecture risk assessment: theory, modeling and results	0	0	0	0
(Olsen, 2017)	Enterprise Architecture management challenges in the Norwegian health sector	0	0	0	0
(Pour & Fallah, 2019)	How enterprise architecture influences strategic alignment maturity: Structural equation modelling	1	0	0	0
(Premchand et al., 2016)	Roadmap for simplification of enterprise architecture at financial institutions	0	0	0	0

Table C.3 continued from previous page

Paper		Inclusion			
(Author, Year)	**Title**	**Title**	**Abstr**	**Full-text**	**Snowb.**
(Reinhartz-Berger et al., 2019)	24th International Conference on Evaluation and Modeling Methods for Systems Analysis and Development	0	0	0	0
(Robertson et al., 2018)	Enterprise architecture maturity: A crucial link in business and IT alignment	1	1	1	1
(W. A. Ross, 2004)	The new DoD automatic test systems executive organization	0	0	0	0
(Smith & Watson, 2015)	The jewel in the crown - Enterprise Architecture at Chubb	0	0	0	0
(Solverson et al., 2012)	A case study in the emergence of coherence through cultural change	0	0	0	0
(Törmer & Henningsson, 2017)	How enterprise architecture maturity enables post-merger IT integration	1	0	0	0
(Trieu, 2013)	Extending the theory of effective use: The impact of enterprise architecture maturity stages on the effective use of business intelligence systems	1	1	1	1
(Turner & Bernus, 2016)	Re-architecting the firm	1	0	0	0
(Turner et al., 2010)	Architecting the firm - Coherency and consistency in managing the enterprise	1	1	0	0
(van den Berg et al., 2019)	How enterprise architecture improves the quality of IT investment decisions	0	0	0	0
(van Zwienen et al., 2019)	A Process for Tailoring Domain-Specific Enterprise Architecture Maturity Models	1	1	1	1
(Information Systems Audit and Control Association, 2018)	COBIT® 2019 Framework: Introduction and Methodology	0	0	0	1
(Bakar et al., 2017)	A priority based enterprise architecture implementation assessment model: An analytic hierarchy process (AHP) approach	0	0	0	1
(Chrissis et al., 2003)	CMMI - Guidelines for process integration and product development	0	0	0	1
(Curley, 2008)	Introducing an IT capability maturity framework	0	0	0	1
(der Raadt et al., 2010)	The relation between EA effectiveness and stakeholder satisfaction	0	0	0	1

Table C.3 continued from previous page

Paper		Inclusion			
(Author, Year)	**Title**	**Title**	**Abstr**	**Full-text**	**Snowb.**
(Lange et al., 2012a)	A comprehensive EA benefit realization model - An exploratory study	0	0	0	1
(Luftman, 2011)	Assessing Business-IT Allignment Maturity	0	0	0	1
(Meyer et al., 2011)	An analysis of enterprise architecture maturity frameworks	0	0	0	1
(Meyer & Kenneally, 2012)	Applying design science research in enterprise architecture business value assessments	0	0	0	1
(Nascio, 2003)	Enterprise Architecture Maturity Model	0	0	0	1
(United States Government Accountability Office, 2010)	Organizational Transformation: A Framework for Assessing and Improving Enterprise Architecture Management (version 2.0).	0	0	0	1
(Office of Management and Budget, 2005)	OMB Enterprise Architecture Assessment Framework Version 1.5	0	0	0	1
(Plessius et al., 2012)	On the categorization and measurability of enterprise architecture benefits with the enterprise architecture value framework	0	0	0	1
(Pruijt, Slot, Plessius, et al., 2012)	The enterprise architecture realization scorecard: A result oriented assessment instrument	0	0	0	1
(Robertson et al., 2018)	Enterprise architecture maturity: A crucial link in business and IT alignment	0	0	0	1
(J. W. Ross, 2003)	Creating a strategic IT architecture competency: Learning in stages	0	0	0	1
(Schekkerman, 2003)	Extended Enterprise Architecture Maturity Model	0	0	0	1
(Sobczak, 2013)	Methods of the assessment of enterprise architecture practice maturity in an organization	0	0	0	1
(Trieu, 2013)	Extending the theory of effective use: The impact of enterprise architecture maturity stages on the effective use of business intelligence systems	0	0	0	1
(U.S Department of Commerce, 2007)	Architecture Capability Maturity Model	0	0	0	1
(van Zwienen et al., 2019)	A Process for Tailoring Domain-Specific Enterprise Architecture Maturity Models	0	0	0	1

Table C.3 continued from previous page

Paper		Inclusion			
(Author, Year)	**Title**	**Title**	**Abstr**	**Full-text**	**Snowb.**
(Velitchkov, 2008)	Integration of IT Strategy and Enterprise Architecture models	0	0	0	1
(Wagter et al., 2012)	The extended enterprise coherence-governance assessment	0	0	0	1
(Weiss & Winter, 2012)	Development of measurement items for the institutionalization of enterprise architecture management in organizations	0	0	0	1
Total:		16	11	5	24

Table C.3: Literature review articles - Phase 3

D

SEM Step 1: Specifying the Structural Model - Experts Contribution

This appendix accompanies Section 4 and explains the methodology used for the interviews conducted with EA experts to interpret the literature and gain additional insights. More specifically, these experts were asked to:

- Extend the list of EA factors obtained by the literature review with their insights
- Rank to list of EA factors included in DyAMM (the selected EA capability maturity model, as explained in Section 4.1.2) based on how likely they deem these factors to be related to digital innovativeness. This is done by using the BWM method, as elaborated upon in Section D.1.
- Determine the most appropriate digital innovativeness measure for the research

The EA experts are sampled as explained in Appendix L. The innovation experts are sampled in the same way, but with a focus on innovation:

1. **Define the population**
   Individuals who have sufficient knowledge about innovation measurement methods to understand the validity, reliability, and practical feasibility of each method.
2. **Determine the sample frame**
   A list of 13 innovation experts working at Deloitte Consulting NL - Strategy & Innovation
3. < all other steps are similar to the ones described in Appendix L >

Interviews can be either unstructured, semi-structured, or structured (Owen & Noonan, 2013). Based on evaluating the advantages and disadvantages of these interview methodologies (which are outlined in Appendix K), I choose to use semi-structured interviews.

Unstructured interviews would be unsuitable because I have specific interview questions in mind (see the list at the top of this section).

Structured interviews would be unsuitable because I am also curious about the underlying reasons behind the experts' responses.

Semi-structured interviews allow me to steer the interviews in the right direction by asking specific questions and simultaneously gaining rich data to understand the responses. In total, I interviewed 19 EA experts (7 of whom also completed the BWM scheme) and 6 innovation experts.

As a guideline for the interviews, I use the protocol shown in Table D.1.

The interviewees do not see the previously identified EA factors before the actual interview on purpose because that might bias them in their brainstorming to come up with EA factors themselves.

After interviewing the experts, I finish the BWM evaluation (see Section D.1) and combine, synthesize, and add the results to the structural model.

Semi-Structured Interview Protocol
Introduction
General introduction • Thank the person for his/her time • Objective of the research • Objective of the interview • Agenda of the interview *Permission & Expectation Management* • Verify time expectations: "Is it correct that I scheduled 30 minutes to have this interview?" • Indicate the interview is completely anonymous and no information that could be traced down to the respondent is stored other than that the person works for Deloitte Consulting • Ask if the person would like to review the final report before being publicly disclosed
Main questions
[For EA experts] • What are factors that enterprise architects influence that would probably influence their firm's digital innovativeness? • What factors influence enterprise architects that would probably increase or decrease their ability to stimulate digital innovation? • <Explanation of BWM and request to use the method, see Section D.1> *[For innovation experts]* • Which of the digital innovativeness measures are, do you think, most appropriate for the research? • Is there another digital innovativeness measure not included on the list that you would recommend? • What is the biggest risk (feasibility, reliability, validity) when using the previously chosen innovativeness measures?
Ending
• Summarize the main conclusion from the interview • Mention when the interviewee will hear from you when this person mentioned at the introduction that he/she would like to receive the final version of the report • Thank the person again for his/her time

Table D.1: Interview protocol used for obtaining expert insights for the structural model specification

D.1. Best Worst Method (BWM)

I use the Best Worst Method (BWM) (Rezaei, 2015, 2016) to rank the statements that I extracted from the DyAMM model (as explained in Section 4.1.2).

D.1.1. Steps

The steps needed to apply the BWM are listed below. The explanation is a combination of phrases directly copied and phrases that concisely summarize longer sentences from the original paper (Rezaei, 2015).

Step 1. Determine a set of decision criteria

Make the set of criteria that you want to compare explicit, as $\{c_1, c_2, ..., c_n\}$.

Step 2. Determine the best (e.g., most desirable, most important) and the worst (e.g., least desirable, least important) criterion

Let the decision-maker skim over all criteria and identify the best and worst one without explicitly comparing all the individual criteria.

Step 3. Determine the preference of the best criterion over all other criteria using a number between 1 and 9

The resulting Best-to-Others vector becomes:

$$A_B = (a_{B1}, a_{B2}, ..., a_{Bn})$$

where a_{Bj} indicates the degree to which the rater prefers the best criterion B over criterion j on a scale of 1 to 9. a_{BB} is always 1.

Step 4. Determine the preference of all criteria over the worst criterion using a number between 1 and 9

The resulting Others-to-Worst vector becomes:

$$A_W = (a_{1W}, a_{2W}, ..., a_{nW})^T$$

where a_{jW} indicates the degree to which the rater prefers criterion j over the worst criterion W on a scale of 1 to 9. a_{WW} is always 1.

Step 5. Find the optimal weights $(w_1^*, w_2^*, ..., w_n^*)$

The optimal weight for the criteria is the one where, for each pair of w_B/w_j and w_j/w_W, the following holds: $w_B/w_j = a_{Bj}$ and $w_j/w_W = a_{jW}$. To satisfy these conditions for all j, maximum value of j must be minimized for the maximum absolute differences $\left|\frac{w_B}{w_j} - a_{Bj}\right|$ and $\left|\frac{w_j}{w_W} - a_{jW}\right|$ such that the weight add up to 1, without any negative weights. This problem can be mathematically formulated as:

$$minmax_j \left\{\left|\frac{w_B}{w_j} - a_{Bj}\right|, \left|\frac{w_j}{w_W} - a_{jW}\right|\right\}$$

s.t.

$$\sum_j w_j = 1$$

$$w_j \geq 0, \text{ for all } j$$

This problem is equivalent to the linear programming problem:
Minimize ξ such that

$$\left|\frac{w_B}{w_j} - a_{Bj}\right| \leq \xi \text{ for all } j$$

$$\left|\frac{w_j}{w_W} - a_{jW}\right| \leq \xi \text{ for all } j$$

$$\sum_j w_j = 1$$

$$w_j \geq 0, \text{ for all } j$$

The optimal weights $(w_1^*, w_2^*, ..., w_n^*)$ and ξ^* are obtained by solving this problem. ξ^* indicates the consistency of the responses. The closer ξ^* is to 0, the higher the consistency and the more reliable the result.

D.1.2. Results

In total, 7 EA experts applied the BWM method to rank the statements listed in Table 4.2. The results are shown in Table D.2, namely the BWM weight for each factor (green when the weight is > 0.15, otherwise red), the standard deviation between the responses (green when it is < 0.1, red otherwise), and the consistency ξ of the categories.

Checkpoint (EA factor)	Calculated weight	Respondent standard deviation	Consistency
Alignment of To-Be architecture with business objectives			0.06
Architectural documents are only drafted in there is someone in need of the result	0.12	0.002	
All relevant parties are involved in the development of the architectural models (e.g., business managers, administrators, developers)	0.49	0.108	
The architecture is developed as a cohesive whole	0.42	0.115	
The architecture is explicitly linked to the organization's business objectives, resulting in up-to-date To-Be diagrams	0.22	0.078	
Development of the proper architecture			0.12
The architects continuously update the As-Is architecture	0.10	0.038	
There is a roadmap showing the migration from As-Is to To-Be	0.21	0.117	
The quality of the EA is continuously evaluated based on established quality requirements	0.16	0.065	
The architectural process is continuously evaluated and improved	0.17	0.080	
The architectural models are consistently developed and documented in the same modeling language	0.09	0.019	
The architectural method distinguishes a variety of perspectives for describing the architecture to different stakeholders	0.12	0.03	
The architectural tools used are all integrated with one another	0.11	0.04	
The staff carrying out projects offer feedback regarding the quality and applicability of the architecture	0.16	0.106	

Table D.2 continued from previous page

Checkpoint (EA factor)	Calculated weight	Respondent standard deviation	Consistency
New architectural assignments are budgeted and planned based on historical data	0.14	0.052	
Usage of the architecture to implement projects and adapt the business strategy			0.10
The architecture is visible for the entire organization	0.39	0.150	
The decision-makers consult enterprise architects or the architecture before starting a new project	0.36	0.101	
Staff carrying out projects consult enterprise architects or the architecture	0.43	0.105	
There are regular checks to verify that the staff carrying out projects work within the frameworks of the architecture	0.28	0.093	
Implementation of the enterprise architect role			0.11
A senior management member is ultimately responsible for the architecture	0.13	0.082	
There are sufficient resources allocated for the architectural process	0.17	0.119	
The architects are sufficiently skilled to meet the demands of their job	0.32	0.142	
The architects are supported with training programs, tools, and other methods to exchange best practices	0.21	0.073	
The enterprise architects form a strong team by working closely together	0.20	0.102	

Table D.2: BWM results; the BWM weight for each factor is green when the weight is > 0.15, otherwise red; the standard deviation between the responses for each factor is green when it is < 0.1, red otherwise

To decide which checkpoints to include in the structural model, I took not only the weight but also the standard deviation into account because, when there is significant disagreement among the EA experts, the scientific contribution of these factors is higher. I included in the structural model all statements that either have a weight of more than 0.15 (shown with the color green in the table) or have a standard deviation of more than 0.1 (also shown with the color green in the table). Both the numbers 0.15 and 0.1 are arbitrary and were chosen because they gave, in my opinion, a reduction in the number of statements that is sufficient to make the length of the questionnaire manageable. The consistency ξ of the four categories combined is 0.08, and the consistency of each category is, as shown in the table, at most 0.12. Given a minimum difference in the ranking between the best / worst alternative of 4, the consistency index is 1.63 (Rezaei, 2015). This results in a consistency ratio of at most 0.12 / 1.63 = 0.07, which indicates an excellent internal consistency according to the original BWM paper (Rezaei, 2015).

E

SEM Step 4: Assessing the Measurement Model - Methodology

This Appendix contains more information about the methods and threshold values used to assess the measurement model, as explained in Section 7.1.

To assist the reader, a copy of the original table showing an overview of the methodology used (namely, Table 7.1) is shown in Table E.1.

First, the methodology used to assess the reliability of the measurement model is explained in Section E.0.1.

Then, the methodology used to assess the validity of the measurement model is explained in Section E.0.2.

For more information about the assessment of the measurement model, see Section 7.1.

E.0.1. Reliability Assessment Methodology

The *reliability* of a measure is defined by Hair et al. as the consistency of the measure in measuring whatever concept it is measuring (Hair et al., 2007). To assess the reliability of a measure, I need to differentiate between reflective and formative constructs.

Reflective - Internal Consistency

There is some debate about the exact meaning of the term ”*internal consistency*” (Tang et al., 2014). A few popular definitions are, for example, the degree of bivariate correlations between different items on the same test (Cronbach, 1951), the extent to which all the items on a test measure the same construct (Revelle, 1979), or the consistency of behavior within the time interval during to which the items in the test are being responded to (Horst, 1953) (which is a definition that is highly criticized by other researchers (Tang et al., 2014)). I will use the definition used by Hair et al.: ”the homogeneity of the items in the measure that taps the construct” (2007, p. 250).

Traditionally, the internal consistency of a construct is assessed by calculating Cronbach’s alpha which measures the correlation between the indicator’s values (Cronbach, 1951). A Cronbach’s alpha value of 0 indicates that the dimensions are entirely uncorrelated and thus the construct is completely unreliable, while a value of 1 indicates that the dimensions correlate perfectly and thus the construct is perfectly reliable (Urbach & Ahlemann, 2010).

The threshold values recommended by the literature are quite consistent: 0.6 for exploratory research (such as this thesis) and 0.7 for confirmatory research (Hair et al., 2019; Nunnally, 1994; Petter et al., 2007). Some researchers also mention that Cronbach’s alpha should not be higher than 0.95 because this may indicate that indicators are redundant (Diamantopoulos et al., 2012; Drolet & Morrison, 2001).

Formative - Multicollinearity

For reflective indicators, a high internal consistency is desirable because the indicators should ”reflect” the underlying construct (see Section 2). However, for formative constructs, the dimensions are not

Type	Subtype	Test	Condition	Reference
To assess reflective constructs				
Reliability	Internal consistency	Cronbach's alpha	> 0.6 <= 0.95	(Cronbach, 1951)
Construct validity	Convergent validity	AVE	> 0.5	(Fornell & Larcker, 1981)
	Discriminant validity	Fornell-Larcker criterion		(Fornell & Larcker, 1981)
		HTMT	<= 0.85	(Henseler et al., 2015)
To assess formative constructs				
Reliability	Multicollinearity	Variance Inflation Factor (VIF)	< 5.0	(Becker et al., 2015)
Construct validity	Convergent validity	Omitted		(see Section E.0.2)
	Discriminant validity	PCA	> 0.5	(Hair Jr et al., 2020)
To assess reflective & formative constructs				
Content validity	N/A	• Structured Literature Review • EA expert review • Face validity assessment by respondents		(see Section E.0.2)
Criterion-related validity	N/A			(see Section E.0.2)

Table E.1: A copy of the overview of the reliability and validity assessment methods used for the measurement model (see Table 7.1)

necessarily correlated since they measure different aspects of the construct. Therefore, a high internal consistency is actually undesirable for formative constructs and can destabilize the model (Petter et al., 2007). Instead, I measure the degree of *multicollinearity*, which is defined as the extent to which "two or more explanatory (predictor) variables in a multiple regression model are related with each other and likewise related with the response variable. We have perfect multicollinearity if the correlation between two independent variables is equal to 1 or −1" (Akinwande et al., 2015, p. 2). One popular tool to measure the degree of multicollinearity is the *Variance Inflation Factor* (*VIF*). The VIF reports "how much of a regressor's variability is explained by the rest of the regressors in the model due to correlation among those regressors" (Craney & Surles, 2002, p. 3). It is defined as:

$$VIF_i = \frac{1}{r - r_i^2} \tag{E.1}$$

Where i denotes an independent variable, and r_i^2 denotes the coefficient of determination obtained by fitting a regression model for the ith independent variable on the other independent variables.

The scientific literature is inconsistent about the cut-off point for when the VIF is too high. Whereas some researchers recommend a maximum VIF value of 10 (Hair et al., 2007; Urbach & Ahlemann, 2010), other researchers set it at 5 (Diamantopoulos & Siguaw, 2006; Hair et al., 2011; Hair et al., 2019). For this thesis, I use a maximum value of 5, which is more conservative than using 10, but also suitable specifically for formative measures in PLS-SEM models as stated in the very highly cited article of Hair et al. (2011) (> 14500 citations).

When the VIF value is too high, there are four options to reduce the multicollinearity as cited from

Petter et al. (2007, p. 15):

1. ”Model the construct as having both formative and reflective measurement items”
2. ”Remove correlated items if content validity is not affected”
3. ”Collapse correlated items into a composite index”
4. ”Convert into a multidimensional construct”

For each construct whose VIF value is too high, I choose one of these options. I will try not to use option 1 since this would seriously harm the parsimony of the structural model. Option 2 will often be an excellent option because all independent variables are reflective constructs with two similarly-worded items. Removing one of these items removes the double-check but does not compromise the content validity. Option 3 is a good option when the number of correlated items is high and also reduces the structural model’s complexity. Option 4 would be a good option when one construct would be the primary focus of the study, worth the additional complexity of modeling each aspect with separate dimensions. However, because none of the formative constructs in the structural model can be seen as a particularly important one, this option does not have my preference.

E.0.2. Validity Assessment Methodology

The *validity* of a measure is defined by Hair et al. as the extent to which the measure indeed measures the concept it is intended to measure (2007). The three main types of measure validity are content validity, criterion-related validity, and construct validity (Hair et al., 2007).

Reflective / Formative - Content Validity

Content validity ensures that ”the measure includes an adequate and representative set of items that tap the concept” (Hair et al., 2007, p. 247). It has been a controversial type of validity since it was first referred to (Sireci, 1998) because the way of evaluating content validity is judgmental and highly subjective (Straub et al., 2004). Because there is no consensus yet on the best method to establish content validity (Straub et al., 2004), I use three different methods:

- *Structured Literature Review* (Diamantopoulos & Winklhofer, 2001; Hair et al., 2007; Straub et al., 2004)
  A literature review, the approach, and results of which can be found in Section 3.
- *EA Expert Reviews* (Diamantopoulos & Winklhofer, 2001; Hair et al., 2007; Straub et al., 2004)
  A review by several EA experts of the measurement instrument (see Section F.1).
- *Face Validity Assessment by Respondents* (Hair et al., 2007; Urbach & Ahlemann, 2010)
  Incorporation of the feedback provided during the pilot tests (see Section F.1. Face validity is argued by some researchers to be a minimum index of content validity and indicates if items intended to measure a particular concept look like they indeed measure that concept (Hair et al., 2007).

Reflective / Formative - Criterion-related Validity

Criterion-related validity, also known as practical, postdiction, criterion, or concurrent validity, ensures that ”the measure differentiates correctly on a criterion it is expected to predict” (Hair et al., 2007, p. 247). However, testing the criterion-related validity requires an oracle, i.e., an indisputable second measurement instrument that is always correct. Because an oracle is usually unavailable, it is now widely accepted that it is not necessary for scientific authenticity and therefore omitted from the analysis (Straub et al., 2004).

Reflective - Construct Validity

Construct validity ensures that ”the results obtained from the use of the measure fit the theories around which the test is designed” (Hair et al., 2007, p. 248). It is typically assessed through convergent and discriminant validity.

Convergent validity is established ”when the scores obtained with two different instruments measuring the same concept are highly correlated” (Hair et al., 2007, p. 248).

Discriminant validity is established "when, based on theory, two variables are predicted to be uncorrelated, and the scores obtained by measuring them are indeed empirically found to be so" (Hair et al., 2007, p. 248).

Convergent Validity.

Because the reflective measures should always be unidimensional, I assess their convergent validity. The most popular method to establish convergent validity is by measuring their *Average Variance Extracted* (*AVE*) (Fornell & Larcker, 1981; Henseler et al., 2016). It is defined as follows:

$$AVE_{\xi_j} = \frac{\sum_{k=1}^{K_j} \lambda_{jk}^2}{\sum_{k=1}^{K_j} \lambda_{jk}^2 + \Theta_{jk}} \tag{E.2}$$

where λ_{jk} is the indicator loading, and Θ_{jk} is the error variance of the kth indicator (k = 1, ..., K_j) of construct ξ_j. When I standardize the indicators, the equation can be simplified to:

$$AVE_{\xi_j} = \frac{1}{K_j} \sum_{k=1}^{K_j} \lambda_{jk}^2 \tag{E.3}$$

Because all reflective measures being used have two indicators, the loadings of both items are identical. Therefore, the calculation of the AVE simplifies even further to:

$$AVE_{\xi_j} = \lambda_{j1}^2 \tag{E.4}$$

The AVE criterion is based on the insight that "if the first factor extracted from a set of indicators explains more than one half of their variance, there cannot be any second, equally important factor" (Henseler et al., 2016, p. 10). Therefore, the AVE of a construct should be 0.5 or higher. There are also less conservative (and less popular) measures of convergent validity, such as checking if the first factor explains significantly more variance than the second-factor (Sahmer et al., 2006), but to err on the more conservative side, I use the AVE value to assess the convergent validity.

There are two reasons why the AVE of a construct is lower than 0.5, and subsequently, convergent validity cannot be established (Goyal & Mishra, 2016): either one indicator does not correlate well with the other indicator, or the variance due to measurement error is too significant. The first problem can be solved by removing one of the indicators or reformulating at least one indicator so that the remaining indicators correlate better. The second problem can be solved by either gathering more data to take advantage of the law of large numbers or reformulating the indicators to a version that is more explicit and less noisy.

Discriminant Validity.

There are two different ways of defining discriminant validity. Some researchers define a measure

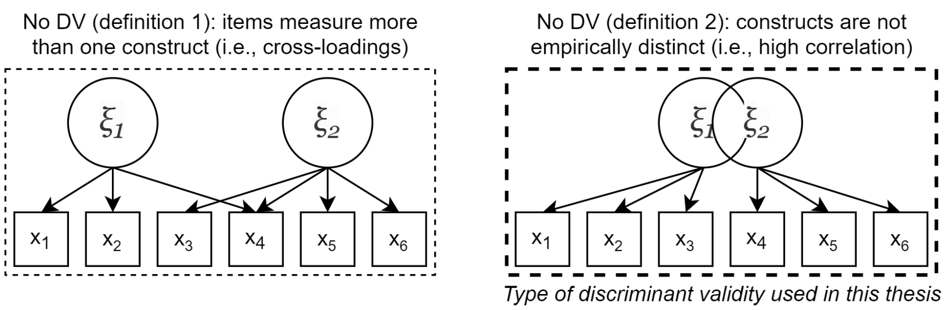

Figure E.1: Graphical illustration of the difference between two discriminant validity definitions. The figure is adapted from (Rönkkö & Cho, 2022).

to have discriminant validity "if it measured the construct that it was supposed to measure but not any other construct of interest" (Rönkkö & Cho, 2022, p. 2) (left side of Figure E.1). Other researchers use discriminant validity to refer to "whether two constructs were empirically distinguishable (distinct from each other)" (Rönkkö & Cho, 2022, p. 2) (right side of Figure E.1).

In this thesis, I want to make explicit that the constructs are empirically distinguishable and therefore use the definition of Rönkkö and Cho: "Two measures intended to measure distinct constructs have discriminant validity if the absolute value of the correlation between the measures after correcting for measurement error is low enough for the measures to be regarded as measuring distinct constructs" (2022, p. 6).

Another area on which there is no consensus is on what kind of attribute discriminant validity is. Whereas some researchers regard discriminant validity as a dichotomous value (Schmitt & Stults, 1986; Werts & Linn, 1970), other researchers regard it as a matter of degree (Bagozzi & Phillips, 1982; Hamann et al., 2013). I prefer to consider discriminant validity a dichotomous value because of two reasons: on the one hand, it simplifies the measurement instrument assessment because discriminant validity is either established or not, and on the other hand, the most popular methods to establish discriminant validity are also dichotomous (namely the Fornell-Larcker and HTMT criterion) (Henseler et al., 2016).

The *Fornell-Larcker criterion* (also called AVE/SV criterion, where SV stands for "Shared Variance" (Rönkkö & Cho, 2022)) is a very popular criterion to establish discriminant validity (Hair Jr, Matthews, et al., 2017). It requires the latent construct to "share more variance with its assigned indicators than with any other latent variable in the structural model. In statistical terms, the AVE of each latent construct should be greater than the latent construct's highest squared correlation with any other latent construct." (Hair et al., 2011, p. 8) The criterion has a high false-positive rate (Hair et al., 2011) which has been taken as evidence that it is "a very conservative test" (Voorhees et al., 2016). This bias results from the observation that variance-based SEM methods (such as PLS-SEM) tend to overestimate indicator loadings (Hui & Wold, 1982; Kroonenberg, 1990).

Therefore, a more accurate method to establish discriminant validity was proposed recently, namely the *HTMT* method (short for Heterotrait-Monotrait ratio of correlations). This ratio compares the Heterotrait-Heteromethod correlations with the Monotrait-Heteromethod correlations. In other words, it is "the mean value of the item correlations across constructs relative to the (geometric) mean of the average correlations for the items measuring the same construct" (Hair et al., 2019, p. 9).

The HTMT of the constructs ξ_i and ξ_j with K_i and K_j indicators is defined as follows, where $r_{ig,jh}$ denotes the Pearson correlation between the responses on item g measuring construct i and item h measuring construct j:

$$HTMT_{ij} = \underbrace{\frac{1}{K_i K_j}\sum_{g=1}^{K_i}\sum_{h=1}^{K_j} r_{ig,jh}}_{\text{(1) average heterotrait-heteromethod}} \div \overbrace{\Big(\frac{2}{K_i(K_i-1)} * \sum_{g=1}^{K_i-1}\sum_{h=g+1}^{K_i} r_{ig,ih}}^{\text{(2) geometric mean of the average monotrait-heteromethod correlation of construct } \xi_i \text{ and ...}} * \underbrace{\frac{2}{K_j(K_j-1)} * \sum_{g=1}^{K_j-1}\sum_{h=g+1}^{K_j} r_{jg,jh}\Big)^{1/2}}_{\text{(3) ... and the average monotrait-heteromethod correlation of construct } \xi_j} \tag{E.5}$$

Because all reflective measures in this research have two indicators, I can simplify the calculation of the HTMT significantly as follows:

$$HTMT_{ij} = \frac{1}{4}\sum_{g=1}^{2}\sum_{h=1}^{2} r_{ig,jh} \div \left(r_{i1,i2} * r_{j1,j2}\right)^{1/2} \tag{E.6}$$

The authors recommend a maximum threshold value of 0.9 when the constructs are conceptually quite similar and 0.85 when they are more distinct (Henseler et al., 2015). To err on the safe side, I use the more conservative threshold of 0.85 in this thesis. For this research, I follow the PLS-SEM literature recommendation and use both the Fornell-Larcker criterion and the HTMT ratio to establish discriminant validity (Aslam et al., 2021).

When these criteria fail, and discriminant validity cannot be established, I use the three-step process recently proposed by Rönkkö and Cho (2022).

1. If the constructs are found to overlap conceptually after following the guidelines by Shaffer et al. (2016) and Podsakoff et al. (2016) (which are similar to the methods that I use to establish content validity, see Section E.0.2), one of the constructs should be dropped due to its redundancy.
2. Scrutinize the measurement model and try to understand the source of misspecification so that incorrectly specified items can be reformulated.
3. Re-evaluate the sampling design to check if it is not biased. If that is not the case, the most effective remedy is to collect more data.

Formative - Construct Validity

Construct validity for the formative constructs is established by evaluating only their discriminant validity. The reason why convergent validity should not be established for formative constructs is explained in this section.

Convergent Validity.

In contrast to reflective construct, the indicators of formative constructs represent independent causes and cannot be expected to have higher correlations with each other than with indicators of other constructs (MacCallum & Browne, 1993). Additionally, the magnitude of the correlations between formative indicators is unrestricted, making it hard to set a threshold on the between- versus within-construct correlations (K. Bollen & Lennox, 1991). Therefore, the concept of convergent validity is not meaningful for formative constructs (Hair et al., 2011; Petter et al., 2007) and thus excluded from the validity assessment.

Discriminant Validity.

Formative constructs aim to retain the unique variance of each measure, which means that *Principal Component Analysis* (*PCA*) should be used to evaluate the measures (Petter et al., 2007). These principal components are the most important vectors to explain the variance present in the original data. The factor loadings are the indicators' relative contribution to the construct and are measured as the degree to which the data correlates with the first principal component. When a factor loading is insignificant, the factor should be removed (Diamantopoulos & Winklhofer, 2001) but only when the construct is still measuring the entire domain, and the content validity is preserved (K. Bollen & Lennox, 1991). In the words of Russo and Stol: "considering that the elimination of formative specified items has almost no effect on the parameter estimates when re-estimating the measurement model, formative items should not be removed just for statistical reasons but for theoretical reasons concerning the research model" (2021, p. 13).

The minimum PCA factor loading varies between 0.4 (Straub et al., 2004) and 0.5 (Hair Jr et al., 2021), where I choose for the more conservative value of 0.5 to err on the safe side. The method to perform PCA and calculate the factor loadings is relatively complex and considered out of scope for this thesis.

F

SEM Step 4: Assessing the Measurement Model - EA Expert Review & Pilot Test Results

This appendix contains more information about the content validity of the questionnaire and the intermediate results of the measurement model assessment outlined in Section 7.1. This assessment is needed to ensure that the measurement model is specified correctly.

Before conducting the pilot tests, I first let EA experts examine the content validity of the questionnaire, as explained in Section F.1.

After the experts established the questionnaire's content validity, the reliability and construct validity of the reflective and formative constructs of the first pilot test is investigated in Section F.2.

Subsequently, the same method is repeated for the second pilot test in Section F.3.

Based on the insights gained by these two pilot tests, the final version of the EA factor questionnaire is formulated, which is presented in Section F.4.

Finally, this final version is evaluated on the same dimensions as the pilot tests in Section F.5.

F.1. Content Validity

I validate the content validity by using EA expert reviews (see Section E.0.2).

These EA experts are sampled as explained in Appendix L.

Based on evaluating the advantages and disadvantages of the various interview methodologies as outlined in Appendix K, I choose to use semi-structured interviews to validate the questionnaire.

Unstructured interviews would be unsuitable because I have specific questions in mind.

Structured interviews would be unsuitable because I am also curious about the underlying reasons behind the experts' responses.

Semi-structured interviews allow me to steer the interviews in the right direction by asking specific questions and simultaneously gaining rich data for understanding the responses.

To this end, as a guideline for the interviews, I use the protocol shown in Table F.1.

The interviewees all get the measurement instruments several days before the actual interview to be able to think about the content beforehand.

After interviewing the experts, the results are combined, synthesized, and added to the measurement instrument in Section F.2.1. The most significant change was the redefinition of the original research problem (namely, the influence of enterprise architecture on innovation) to a more relevant and better-defined alternative (namely, the influence of EA-related factors on a firm's digital innovativeness).

Semi-Structured Interview Protocol

Introduction

General introduction

- Thank the person for his/her time
- Objective of the research
- Objective of the interview
- Agenda of the interview

Permission & Expectation Management

- Verify time expectations: ”Is it correct that I scheduled 30 minutes to have this interview?”
- Indicate the interview is completely anonymous and no information that could be traced down to the respondent is stored other than that the person works for Deloitte Consulting
- Ask if the person would like to review the final report before being publicly disclosed

Main questions

- Are certain questions unnecessary (i.e., EA factors that are highly unlikely to be related to innovation)?
- Are certain questions missing (i.e., EA factors that probably influence innovation but are not mentioned in the table)?
- Are certain questions formulated in an ambiguous or unclear manner?

Ending

- Summarize the main conclusion from the interview
- Mention when the interviewee will hear from you when this person mentioned at the introduction that he/she would like to receive the final version of the report
- Thank the person again for his/her time

Table F.1: Interview protocol used for obtaining expert insights for the content validity

F.2. Pilot Test #1

The first pilot test was done with five enterprise architects, as explained in Section 7.1.

During the first pilot interview, I experimented with making the most important words bold to see if this would improve the overall experience. However, this made it much easier for the interviewees to spot which questions correspond to the same pair, so I decided not to use bold words for the final questionnaire.

Two constructs were already validated in previous work, published in peer-reviewed journals, namely ”digital innovation readiness” (Lokuge et al., 2019) and ”digital innovativeness” (Arias-Pérez & Vélez-Jaramillo, 2022) (see Section 7.1). Because they were already validated on a dataset that contained significantly more responses that were less biased than the dataset that was obtained for this thesis (see Section 6), they are not be validated again and excluded from the questionnaire. The items of the remaining constructs are all EA factors and therefore grouped under the name ”EA factor questionnaire” in this section.

The constructs are assessed based on the methods explained in Section 7.1.

The closed questions used for the first pilot test are shown in Table F.2.

F.2.1. Reliability & Validity of the Reflective Constructs

To evaluate the reliability, I calculate the Cronbach’s alpha of each reflective construct, and to assess the construct validity, I calculate the AVE and evaluate the Fornell-Larcker and HTMT criterion (see Section 7.1).

Internal Consistency & Convergent Validity

Item #	Items	Cronbach’s alpha	AVE
Innovation-focused Enterprise Architecture design			
1.1.a	The enterprise architects typically allow shadow IT systems to run alongside the established IT systems	0.46	0.66
1.1.b	Pilots are allowed and supported by the enterprise architects		
1.2.a	The IT systems are usually modular	0.52	0.69
1.2.b	Micro-services are often used in the IT infrastructure of the firm		
1.3.a	Most IT systems run in the cloud	0.64	0.74
1.3.b	Various cloud providers (such as Amazon or Microsoft) are facilitating the infrastructure for the IT landscape		
1.4.a	Most of the data is stored at a central location rather than being scatted across independent databases	0.87	0.88
1.4.b	A single database contains (almost) all information about the firm’s clients, suppliers, and internal processes		
1.5.a	A large number of IT systems are low-code	0.48	0.66
1.5.b	Employees without a programming background can experiment with new initiatives by using low-code solutions		
Enterprise Architecture Capability => Innovation-focused alignment of To-Be architecture with business objectives			
2.1.a	All relevant parties are involved in the development of the architectural models (e.g. business managers, administrators, developers)	0.81	0.85
2.1.b	The non-functional requirements are adequately incorporated in the architectural models and principles		
2.2.a	The enterprise architecture and project architectures are consistent with each other		

Table F.2 continued from previous page

Item #	Items	Cronbach's alpha	AVE
2.2.b	The cohesion between the different architectural deliverables is effectively safeguarded during the development of the architecture	0.92	0.90
2.3.a	The relationship between the architectural choices and the organization's business objectives is clear	0.93	0.94
2.3.b	The architectural choices are in line with the business strategy and objectives		
	Enterprise Architecture Capability => Innovation-focused development of the proper architecture		
3.1.a	The architecture indicates the relationship between the existing situation and the desired situation	0.86	0.88
3.1.b	The architecture offers guidelines in the area of migration (how to proceed from an existing to a desired situation)		
3.2.a	Attempts are made to review the architectural models and principles in some way or other with regard to quality	0.61	0.64
3.2.b	Quality standards have been formulated for the architecture		
3.3.a	The architectural process is evaluated according to a regular cycle	0.63	0.71
3.3.b	Improvement proposals regularly results in actual modifications to the architectural process		
3.4.a	The architects pay specific attention to the architecture's practical value for projects	0.53	0.81
3.4.b	The architectural process is regularly provided with feedback by the development process		
3.5.a	The architects develop the architecture in an agile way	0.75	0.81
3.5.b	The architects work iteratively, where they regularly get and incorporate feedback about the deliverables they're working on		
	Enterprise Architecture Capability => Innovation-focused usage of the architecture		
4.1.a	The architecture can be accessed by all employees	0.48	0.67
4.1.b	The architecture offers a clear picture of what the organization wants		
4.2.a	The architecture plays an integral role in the organization's decision-making process	0.00	0.25
4.2.b	If the business intends to make changes, it automatically involves architects as a partner in the discussion		
4.3.a	Before a project is started up, it is first checked how it will fit within existing and planned development	-0.30	0.58
4.3.b	The architecture is used to realise integral coordination between all current and scheduled projects		
4.4.a	Compliance with the requirements set by the architecture is a standard feature of a project's execution	-5	0.9
4.4.b	Actions are taken to ensure that projects satisfy the requirements of the architecture (e.g. communication session or trainings)		

Table F.2 continued from previous page

Item #	Items	Cronbach's alpha	AVE
4.5.a	If a project does not comply with the architecture, there is a system in place to ensure compliance or make an exception	0.92	0.94
4.5.b	Deviations from the architecture are actively managed (e.g. in an architecture board)		
	Enterprise Architecture Capability => Innovation-focused implementation of the enterprise architect role		
5.1.a	Budget and time are structurally allocated to architecture	0.31	0.75
5.1.b	Architects are supported by management in the ongoing improvement of the architectural process		
5.2.a	The architects' tasks and responsibilities have been laid down	0.83	0.81
5.2.b	The architects have the required knowledge and skills		
5.3.a	Training programs have been defined for the architects	0.00	0.94
5.3.b	The exchange of best practices among architects is supported		
5.4.a	The architects share a common perspective on architecture	0.60	0.73
5.4.b	There is structural interaction between the architects		
	Innovation-focused enterprise architect behavior		
6.1.a	The enterprise architects have articulated a clear innovation ambition	0.59	0.71
6.1.b	There is a detailed plan of how the architects intend to contribute to innovation		
6.2.a	The enterprise architects ensure the link between the organization's different innovation ambitions	-0.5	0.62
6.2.b	The people responsible for coordinating the firm's innovation efforts regularly involve architects		
6.3.a	The enterprise architects are involved in innovation strategy discussions	0.95	0.96
6.3.b	Enterprise architects are part of the strategic discussions about the firm's innovation strategy		
6.4.a	The enterprise architects are involved with analyzing the impact of proposed optimizations of existing products on the organization's different departments	0.65	0.76
6.4.b	The effect that innovations will have on the firm's divisions is investigated by the enterprise architects		
6.5.a	The enterprise architects actively identify external opportunities for innovation	0.2	0.56
6.5.b	The architects proactively bring trends and developments in the market to the attention of business management		
6.6.a	The enterprise architects are involved with analyzing the desirability of new innovations	0.48	0.41
6.6.b	The architects assess whether the customers actually want the proposed innovations		
6.7.a	The enterprise architects are involved with analyzing the validity of new innovations		

Table F.2 continued from previous page

Item #	Items	Cronbach's alpha	AVE
6.7.b	The architects assess whether new innovations do deliver value to the business	0.22	0.33
6.8.a	The enterprise architects are involved with analyzing the feasibility of new innovations	0.75	0.81
6.8.b	The architects assess whether the organization has the required capabilities of delivering the innovation		

Table F.2: EA factor questionnaire for pilot 1

Many reflective constructs have an insufficient Cronbach's alpha (< 0.6) to be considered reliable, as can be seen in Table F.2. These constructs are reformulated as shown in Table F.3. Although in most cases, both items of a construct were reformulated when its Cronbach's alpha was too low, in some cases, only a single item was reformulated. Only the reformulated item is shown in the table in the latter case. I also note that there are no constructs whose Cronbach's alpha exceeds 0.95 (which would be too high, as explained in Section E.0.1).

Item #	Old item	New item
1.1.a	The enterprise architects typically allow shadow IT systems to run alongside the established IT systems	The enterprise architects typically allow shadow IT systems to run alongside the established IT systems as temporary, small-scale experiments
1.1.b	Pilots are allowed and supported by the enterprise architects	Pilots of new IT systems are allowed and supported by the enterprise architects
1.2.a	The IT systems are usually modular	The IT systems are usually loosely coupled components
1.2.b	Micro-services are often used in the IT infrastructure of the firm	The IT landscape within the firm is largely modular
1.5.a	A large number of IT systems are low-code	The organization makes extensive use of low-code IT systems
3.4.a	The architects pay specific attention to the architecture's practical value for projects	The enterprise architecture is continuously adjusted based on suggestions from a wide range of employees (such as developers and administrators)
3.4.b	The architectural process is regularly provided with feedback by the development process	The architectural process is regularly provided with feedback by the software implementation teams
4.1.a	The architecture can be accessed by all employees	The target architecture can be directly accessed by all relevant employees
4.1.b	The architecture offers a clear picture of what the organization wants	Everyone in the firm who should know about the enterprise architecture knows where to find it
4.2.b	If the business intends to make changes, it automatically involves architects as a partner in the discussion	If the business intends to change its strategic objectives, it automatically involves architects as a partner in the discussion

Table F.3 continued from previous page

Item #	Old item	New item
4.3.a	Before a project is started up, it is first checked how it will fit within existing and planned development	As soon as a project is started, enterprise architects are involved in the execution
4.3.b	The architecture is used to realize integral coordination between all current and scheduled projects	The enterprise architects help coordinate projects during the entire existence of these projects
4.4.a	Compliance with the requirements set by the architecture is a standard feature of a project's execution	Compliance with the requirements set by the target architecture is a standard feature of a project's execution
4.4.b	Actions are taken to ensure that projects satisfy the requirements of the architecture (e.g., communication session or trainings)	Actions are taken to ensure that projects satisfy the requirements of the target architecture (e.g., communication session or trainings)
5.1.a	Budget and time are structurally allocated to architecture	<removed and split up into two separate questions, see 5.4 and 5.5 in Section F.2.5>
5.1.b	Architects are supported by management in the ongoing improvement of the architectural process	
5.3.a	Training programs have been defined for the architects	The architects are stimulated to use seminars, trainings, consultants, and other opportunities to enhance their skill-set
5.3.b	The exchange of best practices among architects is supported	The exchange of best practices with architects or EA experts from outside the firm is supported
6.1.a	The enterprise architects have articulated a clear innovation ambition	The enterprise architects have articulated a clear ambition of how they want to contribute to the firm's innovation
6.1.b	There is a detailed plan of how the architects intend to contribute to innovation	The role and mandate of the architects is clear with regards to digital innovation
6.2.b	The people responsible for coordinating the firm's innovation efforts regularly involve architects	The cohesion between the numerous innovation projects is safeguarded by the enterprise architects
6.5.a	The enterprise architects actively identify external opportunities for innovation	The enterprise architects actively identify external opportunities and trends, such as better software systems or new IT-related innovations
6.6.a	The enterprise architects are involved with analyzing the desirability of new innovations	<removed because almost all interviewees misinterpreted or did not understand what desirability or validity meant. After explaining the meaning of these terms, they indicated that this was out of the scope of enterprise architects>
6.6.b	The architects assess whether the customers actually want the proposed innovations	
6.7.a	The enterprise architects are involved with analyzing the validity of new innovations	<removed because almost all interviewees misinterpreted or did not understand what desirability or validity meant.

Table F.3 continued from previous page

Item #	Old item	New item
6.7.b	The architects assess whether new innovations do deliver value to the business	After explaining the meaning of these terms, they indicated that this was out of the scope of enterprise architects>

Table F.3: Reformulated items based on an insufficient Cronbach's alpha after Pilot test #1

There are also three reflective constructs for which the AVE value is below the 0.5 threshold: 4.2, 6.6, and 6.7.

Construct 4.2 has a Cronbach's alpha of 0 and is therefore already reformulated (see Table F.3).

Construct 6.6 and 6.7 are removed because they are outside of the scope of enterprise architects (see Table F.3).

Discriminant Validity

The Fornell-Larcker criterion for the first pilot test is shown as a matrix in Table F.4, and the HTMT criterion is similarly shown in Table F.5. In both tables, there are many red-colored cells that indicate an insufficient discriminant validity between the constructs. The first step to handle discriminant validity is to establish content validity (which was already established in Section F.1), followed by scrutinizing the measurement model and re-evaluating the sampling design (as explained in Section E.0.2).

However, the number of samples for the first pilot is meager, namely only 5. As Rönkkö and Cho put it: "If a systematic error can be ruled out, the most effective remedy is to collect more data" (2022). Combined with the fact that I already reformulated most of the items (see Section F.2.3), I decide to collect more data before changing the measurement instrument based on their discriminant validity.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.
1. Support for pilots	0.66																													
2. Modular design	0.43	0.69																												
3. Cloud usage	0.27	0.49	0.74																											
4. Central data access point	0.04	0.01	0.31	0.88																										
5. Low-code usage	0.47	0.09	0.12	0.02	0.66																									
6. EA stakeholder collaboration	0.02	0.01	0.05	0.1	0.57	0.85																								
7. EA cohesion	0.07	0.11	0.01	0	0.17	0.36	0.9																							
8. EA alignment with objectives	0.01	0.05	0.17	0.08	0.32	0.57	0.38	0.94																						
9. Roadmap	0	0.02	0.06	0.07	0.03	0.01	0.58	0.02	0.88																					
10. Continuous EA quality improvement	0.45	0.3	0.24	0.09	0.11	0.1	0.45	0.02	0.28	0.64																				
11. Continous EA process improvement	0.55	0.33	0.32	0.11	0.15	0.15	0.63	0	0.35	0.61	0.71																			
12. Feedback-driven EA design	0.3	0.59	0.1	0.05	0.06	0.05	0.61	0	0.51	0.6	0.5	0.71																		
13. Agile EA working method	0.44	0.5	**0.82**	0.21	0.49	0.29	0.03	0	0.05	0.63	0.69	0.5	0.81																	
14. EA visibility	**0.75**	0.57	0.62	0.24	0.53	0.22	0.14	0	0	0	0.08	0.4	0.84	0.67																
15. Strategy consultation	0.08	0.15	0.19	**0.49**	0.17	**0.67**	**0.51**	0.06	**0.37**	**0.33**	**0.38**	**0.47**	**0.31**	**0.4**	0.25															
16. Program / project consultation	0	0.25	0.43	0.47	0	**0.59**	0.14	0.02	0.16	0.28	0.32	0.3	0.34	0.27	**0.71**	0.58														
17. Compliancy verification	0.04	0.42	**0.75**	0.36	0.03	0.15	0.02	0.06	0.01	0.3	0.37	0.2	0.6	0.4	**0.46**	**0.86**	0.9													
18. Escalation / exception handling	0.02	0.4	0.25	0.04	0.15	0.47	0.39	0.12	0.08	0.15	0.2	0.37	0.41	0.29	**0.55**	**0.6**	0.59	0.94												
19. EA funding	0.3	0.67	0.72	0.38	0.12	0.15	0.15	0.1	0.12	0.41	0.41	0.55	0.69	0.66	**0.48**	**0.7**	**0.8**	0.55	0.75											
20. Architect recruitment	0.24	0.67	0.69	0.35	0.08	0.12	0.15	0.05	0.09	0.39	0.37	0.54	0.63	0.65	**0.6**	**0.78**	**0.84**	0.56	0.65	0.81										
21. Architect development	0.42	**0.81**	**0.88**	0.16	0.16	0.05	0.02	0.1	0	0.28	0.31	0.33	**0.82**	**0.75**	0.24	0.42	0.7	0.39	0.73	**0.82**	0.94									
22. Architect bonding	0.38	0.68	**0.74**	0.12	0.12	0.06	0.03	0.05	0.02	0.24	0.27	0.33	**0.79**	0.66	0.23	0.35	0.6	0.31	0.35	0.7	**0.88**	0.73								
23. Clear innovation ambition	0.54	**0.7**	**0.8**	0.28	0.32	0.16	0.1	0.02	0	0	0.03	0.42	**0.88**	**0.92**	**0.44**	0.47	0.65	0.43	**0.72**	**0.86**	**0.92**	0.7	0.71							
24. Linkage different innovations	0.27	**0.68**	**0.7**	0.36	0.03	0.03	0.08	0.16	0.09	0.28	0.31	0.53	0.54	0.61	**0.46**	**0.68**	**0.76**	0.38	**0.69**	**0.96**	**0.82**	**0.65**	**0.82**	0.62						
25. EA involvement innovation	0.02	0.06	0.03	0.01	0.38	0.74	0.15	0.83	0.02	0.33	0.35	0.03	0.04	0	0.08	0	0	0.18	0.08	0.02	0.03	0.05	0	0.11	0.96					
26. Innovation impact analysis	**0.87**	0.54	0.53	0.21	0.26	0.01	0.03	0.11	0	0.41	0.39	0.36	0.56	**0.83**	0.17	0.11	0.21	0.05	0.4	0.5	0.65	0.68	**0.74**	0.58	0.11	0.76				
27. Active EA opportunity scouting	0.26	0.41	**0.73**	0.4	0	0.04	0.04	**0.57**	0	0.02	0	0.16	0.39	0.42	0.11	0.33	0.49	0.03	**0.59**	**0.59**	**0.66**	0.55	**0.57**	**0.75**	0.37	**0.61**	0.56			
28. Innovation desirability analysis	**0.61**	**0.42**	**0.67**	**0.48**	0.25	0.05	0	0.18	0	0.22	0.33	0.25	**0.6**	**0.62**	**0.29**	0.22	0.35	0.1	**0.44**	**0.55**	**0.66**	0.4	**0.66**	**0.6**	0.15	**0.75**	**0.51**	0.41		
29. Innovation validity analysis	**0.63**	0.33	**0.6**	**0.41**	0.15	0	0.02	0.1	0.05	0.11	0.23	0.19	**0.52**	**0.59**	0.18	0.15	0.25	0	**0.4**	**0.48**	**0.53**	**0.45**	**0.62**	**0.55**	0.08	**0.7**	**0.51**	**0.45**	0.33	
30. Innovation feasibility analysis	**0.67**	0.38	0.65	0.42	0.19	0.01	0	0.2	0	0.18	0.28	0.22	0.58	**0.76**	0.2	0.18	0.3	0.03	0.48	0.52	0.63	0.47	**0.73**	0.61	0.12	**0.92**	**0.76**	**0.44**	**0.38**	0.81

Table F.4: Matrix mapping of the Fornell-Larcker criterion for the first pilot, where the diagonal cells contain the AVE value of each reflective construct, the non-diagonal cells contain the squared Pearson correlation between the two reflective constructs, and the red-colored cells indicate squared correlations that exceed the AVE value in the corresponding row or column

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.
1. Support for pilots																														
2. Modular design	0.82																													
3. Cloud usage	0.68	0.59																												
4. Central data access point	0.33	0.07	0.44																											
5. Low-code usage	1.11	0.47	0.35	0.13																										
6. EA stakeholder collaboration	0.22	0.34	0.47	0.45	0.63																									
7. EA cohesion	0.19	0.33	-0.08	0.08	0.47	0.36																								
8. EA alignment with objectives	-0.18	-0.11	-0.31	-0.2	0.62	0.33	0.5																							
9. Roadmap	-0.05	0.14	-0.2	0.2	-0.14	0.06	0.61	0.13																						
10. Continuous EA quality improvement	1.05	0.98	0.61	0.48	0.61	0.5	0.81	0.08	0.8																					
11. Continous EA process improvement	0.98	0.82	0.66	0.45	0.49	0.58	0.76	0.04	0.84	0.9																				
12. Feedback-driven EA design	1.3	1.52	0.54	0.35	0.71	0.55	1.27	0.1	1.2	0.7	0.78																			
13. Agile EA working method	0.83	0.65	0.72	0.37	0.76	0.62	0.14	0.01	-0.18	0.59	0.66	0.72																		
14. EA visibility	1.21	0.82	0.74	0.42	0.94	0.58	0.31	0	0.01	1.02	0.82	1.24	0.88																	
15. Strategy consultation	0.6	0.76	0.59	0.92	0.76	1.11	1.06	0.38	0.91	1.51	1.44	2.2	0.78	0.99																
16. Program / project consultation	0.12	0.55	0.6	0.63	0.06	0.7	0.36	-0.1	0.38	0.79	0.82	1.12	0.54	0.54	1.37															
17. Compliancy verification	0.35	0.68	0.81	0.6	0.18	0.71	0.15	-0.23	0.08	0.8	0.75	0.93	0.74	0.71	1.14	1.02														
18. Escalation / exception handling	0.11	0.59	0.36	0.16	0.4	0.63	0.49	0.29	0.23	0.59	0.55	1.04	0.49	0.49	1.04	0.69	0.67													
19. EA funding	0.62	0.7	0.65	0.47	0.33	0.5	0.36	-0.05	0.27	0.84	0.78	1.22	0.64	0.73	1.01	0.82	0.83	0.58												
20. Architect recruitment	0.59	0.71	0.62	0.45	0.31	0.52	0.3	-0.15	0.24	0.83	0.76	1.23	0.62	0.72	1.07	0.79	0.83	0.56	0.82											
21. Architect development	0.82	0.87	0.84	0.39	0.42	0.52	0.09	-0.29	-0.05	0.85	0.8	1.1	0.81	0.89	0.83	0.74	0.94	0.55	0.84	0.8										
22. Architect bonding	0.79	0.75	0.81	0.3	0.38	0.46	0.06	-0.31	-0.07	0.85	0.74	1.05	0.76	0.82	0.79	0.72	0.87	0.49	0.81	0.75	0.88									
23. Clear innovation ambition	0.95	0.79	0.73	0.45	0.69	0.59	0.28	-0.07	0.06	0.83	0.84	1.2	0.81	0.96	1.03	0.67	0.81	0.54	0.77	0.75	0.89	0.88								
24. Linkage different innovations	0.72	0.86	0.76	0.54	0.19	0.48	0.25	-0.37	0.29	0.69	0.75	1.48	0.68	0.82	1.15	0.93	0.99	0.57	0.91	0.89	0.98	0.95	0.87							
25. EA involvement innovation	0.25	0.16	0.13	0.07	-0.59	-0.46	-0.3	-0.7	0.09	0.19	0.11	0.27	-0.13	-0.03	-0.33	0	0.05	-0.31	0.15	0.11	0.18	0.09	0.02	0.32						
26. Innovation impact analysis	1.34	0.7	0.68	0.36	0.69	0.19	0.12	-0.26	0.02	0.77	0.74	1.19	0.71	0.96	0.58	0.27	0.44	0.13	0.76	0.74	0.72	0.86	0.87	0.72	0.29					
27. Active EA opportunity scouting	0.8	0.61	0.76	0.55	0.02	0.21	-0.16	-0.65	-0.01	0.66	0.54	0.79	0.58	0.69	0.54	0.61	0.79	0.17	0.77	0.67	0.85	0.75	0.71	0.92	0.53	0.8				
28. Innovation desirability analysis	1.28	0.55	0.63	0.49	0.69	0.25	0.11	-0.09	0.1	0.65	0.63	1	0.67	0.84	0.58	0.22	0.39	0.1	0.71	0.66	0.53	0.66	0.77	0.65	0.31	0.8	0.74			
29. Innovation validity analysis	1.15	0.41	0.58	0.44	0.6	0.1	0.03	-0.22	0.01	0.82	0.88	0.85	0.61	0.82	0.51	0.17	0.33	-0.03	0.61	0.53	0.48	0.58	0.72	0.52	0.18	0.82	0.65	0.73		
30. Innovation feasibility analysis	1.25	0.49	0.6	0.45	0.67	0.19	0.1	-0.21	0.04	0.7	0.76	0.92	0.63	0.86	0.55	0.19	0.34	0.02	0.65	0.61	0.5	0.59	0.76	0.56	0.24	0.96	0.71	0.67	0.62	

Table F.5: Matrix mapping of the HTMT criterion for the first pilot where the red-colored cells indicate that the value of the HTMT is above the 0.85 threshold

F.2.2. Reliability & Validity of the Formative Constructs

To assess the reliability, the multicollinearity of the formative constructs is evaluated by calculating the VIF. The discriminant validity is assessed by calculating the PCA factor loading for each formative construct. The results are shown in Table F.6.

Item #	Item name	VIF	PCA factor loading
	Innovation-focused Enterprise Architecture design		
1.1	Support for pilots	6.80	0.95
1.2	Modular design	1.28	0.72
1.3	Cloud usage	3.08	0.89
1.4	Central data access point	1.21	0
1.5	Low-code usage	3.54	0.83
	Enterprise Architecture Capability => Innovation-focused alignment of To-Be architecture with business objectives		
2.1	EA stakeholder collaboration	9.16	0.9
2.2	EA cohesion	3.23	0.67
2.3	EA alignment with objectives	12.74	0.93
	Enterprise Architecture Capability => Innovation-focused development of the architecture		
3.1	Roadmap	1.93	0.95
3.2	Continous EA quality improvement	1.53	0.75
3.3	Continous EA process improvement	1.75	0.78
3.4	Feedback-driven EA design	8.08	0.92
3.5	Agile EA working method	1.27	0.55
	Enterprise Architecture Capability => Innovation-focused usage of the architecture		
4.1	EA visibility	1.71	0.26
4.2	Strategy consultation	5.44	0.85
4.3	Program / project consultation	2.42	0.71
4.4	Compliancy verification	7.91	0.9
4.5	Escalation / exception handling	3.49	0.75
	Enterprise Architecture Capability => Innovation-focused implementation of the enterprise architect role		
5.1	EA funding	8.52	0.76
5.2	Architect recruitment	6.02	0.9
5.3	Architect development	6.52	0.88
5.4	Architect bonding	12.05	0.59
	Innovation-focused enterprise architect behavior		
6.1	Clear innovation ambition	1.93	0.64
6.2	Linkage different innovations	3.45	0.65
6.3	EA involvement innovation	1.39	0.56

Table F.6 continued from previous page

Item #	Item name	VIF	PCA factor loading
6.4	Innovation impact analysis	8.66	0.98
6.5	Active EA opportunity scouting	5.50	0.73
6.6	Innovation desirability analysis	2.33	0.65
6.7	Innovation validity analysis	2.65	0.61
6.8	Innovation feasibility analysis	7.11	0.9
6.9	Innovation-driven To-Be architecture	1.34	0.45

Table F.6: VIF and PCA values of the formative constructs of pilot 1

Reliability

Table F.6 shows that there are several constructs for which the VIF value exceeds the threshold value of 5.0 (see Section E.0.1). For each of these constructs, I take action based on the four options described in Section E.0.1.

- **1.1 - Support for pilots.** It is unclear why this construct highly correlates with the "Enterprise Architecture Design" construct. However, its Cronbach's alpha value is also too low, which indicates that at least one of the elements of these constructs is not interpreted as intended. Therefore, I first change the wording of the elements (see Section F.2.3) and evaluate after the second pilot test how this has affected its VIF.

- **2.X - Innovation-focused alignment of To-Be architecture with business objectives.** The VIF value of all dimensions of the "Innovation-focused alignment of To-Be architecture with business objectives" construct is very high, almost crossing or crossing with a significant margin the 5.0 threshold. Upon closer examination, it seems that these dimensions measure the same thing, namely the communication of the enterprise architects with all relevant stakeholders (which is also confirmed by the PCA-values >= 0.9, which is very high). Therefore, it makes sense to collapse these correlated constructs into a composite index, consequently changing "Alignment of To-Be architecture with business objectives" into a reflective construct. However, the number of responses used for the first pilot study is limited, and the change affects both a relatively large number of questions and, to a significant degree, the parsimony of the structural model. Therefore I do not apply this change yet, but only when the results of the second pilot study confirm the multicollinearity between these constructs. I also reformulate construct 2.1 to make it more distinct from the other constructs.

- **3.4 - Feedback-driven EA design.** The VIF value of this construct is significantly higher than the 5.0 threshold (namely, 8.08). My preferred option would be to remove item 3.4.a, but because its wording will change significantly due to its low Cronbach's alpha (see Section F.2.1), I first evaluate how the reformulated item will score in the second pilot test.

- **4.2 - Strategy consultation / 4.4 - Compliancy verification.** Both constructs have a VIF value higher than the 5.0 threshold. Therefore, similarly to construct 2.X (Alignment of To-Be architecture with business objectives), I will consider collapsing the correlated constructs into a composite index, but only after the second pilot study. On the one hand, the number of responses seems too small to take such a big step and, on the other hand, I change these statements already because of their low Cronbach's alpha value (see Section F.2.3), which might influence the VIF values.

- **5.X - Innovation-focused implementation of the enterprise architect role.** The VIF value of all dimensions of the "Innovation-focused implementation of the enterprise architect role" construct is way too high, significantly exceeding the 5.0 threshold. I cannot simply combine the correlated dimensions because they measure fundamentally different things. Upon closer examination, item 5.1 is formulated too broadly because it measures both budget and time. Therefore, I replace it with a more specific question (see Section F.2.5, item 5.3). As suggested by an expert, I also add an item that measures the communication skills of architects (see Section F.2.5, item 5.4) that makes the construct more complete and is (according to the expert) likely to be related to digital innovativeness.

- **6.4 - Innovation impact analysis.** The VIF value of this construct of significantly higher than the 5.0 threshold (namely, 8.66). I choose to use the second option and remove item 6.4.b.
- **6.5 - Active EA opportunity scouting.** The Cronbach's alpha value of this construct is too low, which indicates that at least one of the elements of the construct is not interpreted as intended. Therefore, I first change the wording of the elements (see Section F.2.3) and evaluate after the second pilot test how this has affected the VIF.
- **6.8 - Innovation feasibility analysis.** The VIF value of this construct of significantly higher than the 5.0 threshold (namely, 7.11). I choose to use the second option and remove item 6.8.a.

Validity

Assessing the convergent validity is not meaningful for formative constructs (as described in Section E.0.2). However, it is important to establish discriminant validity by using principal component analysis on the formative dimensions of each construct and evaluating the factor loadings of the dimensions on the most important principal factor. This factor loading should be higher than 0.5 (see Section E.0.2). If this is not the case, the factor should be removed (Diamantopoulos & Winklhofer, 2001), but only when the construct is still measuring the entire domain and the content validity is preserved (K. Bollen & Lennox, 1991).

- **1.4 - Central data access point.** The question focuses on whether a central database exists, but this is not something that is neither reasonable nor desirable for large firms and raised some eyebrows. Because I still hypothesize that easy access to (almost) all of the firm's data can enable innovation, I rephrase the question to whether a data lake is implemented.
- **4.1 - EA visibility.** This question is very generic and does not measure a lot: it is irrelevant if all employees can access the architecture because most employees usually never need to do so. Therefore, I remove the question and replace it with a variant that investigates if everyone that needs to use the architecture can access the documentation and knows where to find it.
- **6.9 - Innovation-driven To-Be architecture.** The PCA value of this question is just below the 0.5 threshold that I set in Section E.0.2 and above the 0.4 threshold used by several other authors such as Straub et al. (2004). Because this is the first pilot study with only five samples, I want to have more evidence that the construct needs to be removed and postpone this decision until after the second pilot study.

F.2.3. Reformulated

Item #	Old item	Problem	New item
1.1.a	The enterprise architects typically allow shadow IT systems to run alongside the established IT systems	Cronbach's alpha too low	The enterprise architecture typically allows shadow IT systems to run alongside the established IT systems as temporary, small-scale experiments
1.1.b	Pilots are allowed and supported by the enterprise architects		Pilots of new IT systems are allowed and supported by the enterprise architecture
1.2.a	The IT systems are usually modular	Cronbach's alpha too low	The IT systems are usually loosely coupled components

Table F.7 continued from previous page

Item #	Old item	Problem	New item
1.2.b	Micro-services are often used in the IT infrastructure of the firm		The IT landscape within the firm is largely modular
1.3.a	Most IT systems run in the cloud	Misinterpreted statement	The IT systems run in the cloud
1.3.b	Various cloud providers (such as Amazon or Microsoft) are facilitating the infrastructure for the IT landscape		Cloud providers (such as Amazon or Microsoft) provide facilitating services such as the infrastructure, platforms, or applications
1.4.a	Most of the data is stored at a central location rather than being scatted across independent databases	PCA factor loading too low	The organization has a data lake that provides easy access to most of the data available
1.4.b	A single database contains (almost) all information about the firm's clients, suppliers, and internal processes		The firm has a storage repository containing almost all data available at the firm
1.5.a	A large number of IT systems are low-code	Cronbach's value too low	The organization makes extensive use of low-code IT systems
2.1.a	All relevant parties are involved in the development of the architectural models (e.g. business managers, administrators, developers)	VIF too high	The architectural models are developed in collaboration with all relevant parties, such as the business managers, administrators, developers, and line staff
2.1.b	The non-functional requirements are adequately incorporated in the architectural models and principles		The interests of all stakeholders are addressed by the architecture
3.1.a	The architecture indicates the relationship between the existing situation and the desired situation	Unclear statement	There is a clear roadmap on how to proceed from the existing As-Is situation to the desired To-Be situation
3.4.a	The architects pay specific attention to the architecture's practical value for projects	Cronbach's value too low & PCA factor loading too low	The enterprise architecture is continuously adjusted based on suggestions from a wide range of employees (such as developers and administrators)
3.4.b	The architectural process is regularly provided with feedback by the development process		The architectural process is regularly provided with feedback by the software implementation teams
4.1.a	The architecture can be accessed by all employees	Cronbach's value too low	The target architecture can be directly accessed by all relevant employees
4.1.b	The architecture offers a clear picture of what the organization wants		Everyone in the firm who should know about the enterprise architecture knows where to find it
4.2.b	If the business intends to make changes, it automatically involves architects as a partner in the discussion	Cronbach's value too low	If the business intends to change its strategic objectives, it automatically involves architects as a partner in the discussion

Table F.7 continued from previous page

Item #	Old item	Problem	New item
4.3.a	Before a project is started up, it is first checked how it will fit within existing and planned development	Cronbach's alpha too low	As soon as a project is started, enterprise architects are involved in the execution
4.3.b	The architecture is used to realize integral coordination between all current and scheduled projects		The enterprise architects help coordinate projects during the entire existence of these projects
4.4.a	Compliance with the requirements set by the architecture is a standard feature of a project's execution	Cronbach's alpha too low	Compliance with the requirements set by the target architecture is a standard feature of a project's execution
4.4.b	Actions are taken to ensure that projects satisfy the requirements of the architecture (e.g., communication session or trainings)		Actions are taken to ensure that projects satisfy the requirements of the target architecture (e.g., communication session or trainings)
5.2.a	The architects' tasks and responsibilities have been laid down	VIF value too high	The architects are generally sufficiently skilled to do their job well
5.3.a	Training programs have been defined for the architects	Cronbach's alpha too low	The architects are stimulated to use seminars, trainings, consultants, and other opportunities to enhance their skill-set
5.3.b	The exchange of best practices among architects is supported		The exchange of best practices with architects or EA experts from outside the firm is supported
6.1.a	The enterprise architects have articulated a clear innovation ambition	Cronbach's alpha too low	The enterprise architects have articulated a clear ambition of how they want to contribute to the firm's innovation
6.1.b	There is a detailed plan of how the architects intend to contribute to innovation		The role and mandate of the architects is clear with regards to digital innovation
6.2.b	The people responsible for coordinating the firm's innovation efforts regularly involve architects	Cronbach's alpha too low	The cohesion between the numerous innovation projects is safeguarded by the enterprise architects
6.4.a	The enterprise architects are involved with analyzing the impact of proposed optimizations of existing products on the organization's different departments	VIF value too high	The enterprise architects are involved in analyzing the impact of proposed improvements on the organization's performance
6.4.b	The effect that innovations will have on the firm's divisions is investigated by the enterprise architects		<removed>
6.5.a	The enterprise architects actively identify external opportunities for innovation	Cronbach's alpha too low	The enterprise architects actively identify external opportunities and trends, such as better software systems or new IT-related innovations

Table F.7 continued from previous page

Item #	Old item	Problem	New item
6.8.b	The architects assess whether the organization has the required capabilities of delivering the innovation	VIF value too high	<removed>
7.5.a	My organization has a decentralized decision-making process that facilitates the engagement of all business areas to use the IT portfolio for innovations	Sentence is too complex	All business areas are engaged when making decisions about the IT portfolio

Table F.7: Reformulated items after Pilot test #1

F.2.4. Removed

Item #	Old item	Problem
5.1.a	Budget and time are structurally allocated to architecture	Cronbach's alpha too low; The question is split up into two separate question, see 5.4 and 5.5 in Section F.2.5
5.1.b	Architects are supported by management in the ongoing improvement of the architectural process	
6.4.b	The effect that innovations will have on the firm's divisions is investigated by the enterprise architects	VIF too high
6.6.a	The enterprise architects are involved with analyzing the desirability of new innovations	Most interviewees misinterpreted or did not understand what desirability or validity meant. After explaining these terms, they indicated that these are irrelevant for enterprise architects
6.6.b	The architects assess whether the customers actually want the proposed innovations	
6.7.a	The enterprise architects are involved with analyzing the validity of new innovations	Almost all interviewees misinterpreted or did not understand what desirability or validity meant. After explaining the meaning of these terms, they indicated that this was out of the scope of enterprise architects
6.7.b	The architects assess whether new innovations do deliver value to the business	
6.8.a	The enterprise architects are involved with analyzing the feasibility of new innovations	VIF too high

Table F.8: Removed items after Pilot test #1

F.2.5. Added

Item #	New item	Reason
5.4.a	The architects have sufficient time to do their assigned tasks well	Derived from the removed question 5.1, see Table F.8

Table F.9 continued from previous page

Item #	New item	Reason
5.4.b	The organization has hired enough architects to maintain and improve the architecture	
5.5.a	The architects have good communication skills	Derived from the removed question 5.1, see Table F.8
5.5.b	Most architects have good listening skills and are effective in sharing their ideas	
6.7.a	The architects adapt the target architecture (to-be architecture; envisioned architecture) based on new innovation projects taking place	EA expert suggestion
6.7.b	The architects integrate new innovations in the enterprise architecture	

Table F.9: Added items after Pilot test #1

F.3. Pilot Test #2

As explained in Section 7.1, the second pilot test was done with ten more interviews to get more reliable insight into which items should be entirely removed from the questionnaire.

F.3.1. Reliability & Validity of the Reflective Constructs

To evaluate the reliability, I calculate the Cronbach's alpha of each reflective construct again, and to assess the construct validity, I calculate the AVE value again and re-evaluate the Fornell-Larcker and HTMT criterion (see Section 7.1.

Internal Consistency & Convergent Validity

Item #	Items	Cronbach's alpha	AVE
	Innovation-focused Enterprise Architecture design		
1.1.a	The enterprise architecture typically allows shadow IT systems to run alongside the established IT systems as temporary, small-scale experiments	-1.24	0.69
1.1.b	Pilots of new IT systems are allowed and supported by the enterprise architecture		
1.2.a	The IT systems are usually loosely coupled components	0.57	0.71
1.2.b	The IT landscape within the firm is largely modular		
1.3.a	Most IT systems run in the cloud	0.81	0.85
1.3.b	Cloud providers (such as Amazon or Microsoft) provide facilitating services such as the infrastructure, platforms, or applications		
1.4.a	The organization has a data lake that provides easy access to most of the data available	0.71	0.53
1.4.b	The firm has a storage repository containing almost all data available at the firm		
1.5.a	The organization makes extensive use of low-code IT systems	0.42	0.72
1.5.b	Employees without a programming background are able to experiment with new initiatives by using low-code solutions		
	Enterprise Architecture Capability => Innovation-focused alignment of To-Be architecture with business objectives		
2.1.a	The architectural models are developed in collaboration with all relevant parties, such as the business managers, administrators, developers, and line staff	0.44	0.64
2.1.b	The interests of all stakeholders are addressed by the architecture		
2.2.a	The enterprise architecture and project architectures are consistent with each other	0.75	0.81
2.2.b	The cohesion between the different architectural deliverables is effectively safeguarded during the development of the architecture		
2.3.a	The relationship between the architectural choices and the organization's business objectives is clear	0.90	0.92
2.3.b	The architectural choices are in line with the business strategy and objectives		
	Enterprise Architecture Capability =>		

Table F.10 continued from previous page

Item #	Items	Cronbach's alpha	AVE
	Innovation-focused development of the proper architecture		
3.1.a	There is a clear roadmap on how to proceed from the existing As-Is situation to the desired To-Be situation	0.62	0.83
3.1.b	The architecture offers guidelines in the area of migration (how to proceed from an existing to a desired situation)		
3.2.a	Attempts are made to review the architectural models and principles in some way or other with regard to quality	0.64	0.68
3.2.b	Quality standards have been formulated for the architecture		
3.3.a	The architectural process is evaluated according to a regular cycle	0.67	0.73
3.3.b	Improvement proposals regularly results in actual modifications to the architectural process		
3.4.a	The enterprise architecture is continuously adjusted based on suggestions from a wide range of employees (such as developers and administrators)	0.21	0.56
3.4.b	The architectural process is regularly provided with feedback by the software implementation teams		
3.5.a	The architects develop the architecture in an agile way	0.69	0.78
3.5.b	The architects work iteratively, where they regularly get and incorporate feedback about the deliverables they're working on		
	Enterprise Architecture Capability => Innovation-focused usage of the architecture		
4.1.a	The target architecture can be directly accessed by all relevant employees	0.61	0.72
4.1.b	Everyone in the firm who should know about the enterprise architecture knows where to find it		
4.2.a	The architecture plays an integral role in the organization's decision-making process	0.89	0.90
4.2.b	If the business intends to change its strategic objectives, it automatically involves architects as a partner in the discussion		
4.3.a	As soon as a project is started, architects are involved in the execution	0.07	0.52
4.3.b	The architects help coordinate projects during the entire existence of these projects		
4.4.a	Compliance with the requirements set by the target architecture is a standard feature of a project's execution	0.88	0.88
4.4.b	Actions are taken to ensure that projects satisfy the requirements of the target architecture (e.g., communication session or trainings)		
4.5.a	If a project does not comply with the target architecture, there is a system in place to ensure compliance or make an exception	0.77	0.82
4.5.b	Deviations from the target architecture are actively managed (e.g., in an architecture board)		
	Enterprise Architecture Capability => Innovation-focused implementation of the enterprise architect role		

Table F.10 continued from previous page

Item #	Items	Cronbach's alpha	AVE
5.1.a	The architects are generally sufficiently skilled to do their job well	0.91	0.83
5.1.b	The architects have the required knowledge and skills		
5.2.a	The architects are stimulated to use seminars, trainings, consultants, and other opportunities to enhance their skill-set	0.66	0.83
5.2.b	The exchange of best practices with architects or EA experts from outside the firm is supported		
5.3.a	The architects share a common perspective on architecture	0.63	0.74
5.3.b	There is structural interaction between the architects		
5.4.a	The architects have sufficient time to do their assigned tasks well	0.55	0.77
5.4.b	The organization has hired enough architects to maintain and improve the architecture		
5.5.a	The architects have good communication skills	0.73	1.00
5.5.b	Most architects have good listening skills and are effective in sharing their ideas		
	Innovation-focused enterprise architect behavior		
6.1.a	The enterprise architects have articulated a clear ambition of how they want to contribute to the firm's innovation	0.77	0.81
6.1.b	The role and mandate of the architects is clear with regards to digital innovation		
6.2.a	The enterprise architects ensure the link between the organization's different innovation ambitions	0.97	0.98
6.2.b	The cohesion between the numerous innovation projects is safeguarded by the enterprise architects		
6.3.a	The enterprise architects are involved in innovation strategy discussions	0.71	0.79
6.3.b	Enterprise architects are part of the strategic discussions about the firm's innovation strategy		
6.4	The enterprise architects are involved in analyzing the impact of proposed innovations on the organization's performance		
6.5.a	The enterprise architects actively identify external opportunities and trends, such as better software systems or new IT-related innovations	0.92	0.92
6.5.b	The architects proactively bring trends and developments in the market to the attention of business management		
6.6	The architects assess whether the organization has the required capabilities of delivering the innovation		
6.7.a	The architects adapt the target architecture (to-be architecture; envisioned architecture) based on new innovation projects taking place	0.84	0.86
6.7.b	The architects integrate new innovations in the enterprise architecture		

Table F.10: EA factor questionnaire for pilot 2

As can be seen in Table F.10, the number of reflective constructs having an insufficient Cronbach's alpha (< 0.6) is significantly lower than for the first pilot test.o The constructs that still have an insufficient Cronbach's alpha value are either split up into two separate constructs or reduced to the item that best captures the essence of the construct. The results are shown in Table F.11. I also verify again if there are constructs whose Cronbach's alpha exceeds 0.95 (which would be too high, as explained in Section E.0.1) and find that this is only the case for item 6.2. However, because this Cronbach's alpha is just barely higher than 0.95, was significantly lower in the first pilot study, and is susceptible to minor deviations in the input data, I leave the construct as it is.

Item #	Old item	Action
1.1.a	The enterprise architects typically allow shadow IT systems to run alongside the established IT systems as temporary, small-scale experiments	**Item 1.1.a is removed.** This item was intended to measure the ease of running a small experiment, while a few experienced respondents noted that the question did not make sense from an EA perspective: with proper test environments, it is easy to run small experiments without allowing any shadow-IT. Additionally, allowing shadow-IT does not necessarily make running small experiments easy.
1.1.b	Pilots of new IT systems are allowed and supported by the enterprise architects	
1.2.a	The IT systems are usually loosely coupled components	**Item 1.2.a is removed.** To investigate the inconsistency between the responses between 1.2.a and 1.2.b, I asked several respondents to explain their motivation. Some respondents interpreted the first question as "the software that they use consists of other software modules" (almost always true: practically all software uses libraries, packages, and external modules to make it easier/faster to develop the software). Because 1.2.b captures the essence of the construct correctly, I decided to remove item 1.2.a.
1.2.b	The IT landscape within the firm is largely modular	
1.4.a	The organization has a data lake that provides easy access to most of the data available	**Both items kept.** At first sight, items 1.4.a and 1.4.b look quite similar, but by investigating why their Cronbach's alpha was insufficient, I found one significant outlier: one respondent had filled in a 1 for 1.4.a and a 5 for 1.4.b. After removing this outlier, the Cronbach's alpha increased to 0.79, which is very decent. I guess that the respondent either misunderstood the question or tried to click the "I don't know" option, which was one more option to the right.
1.4.b	The firm has a storage repository containing almost all data available at the firm	

Table F.11 continued from previous page

Item #	Old item	Action
1.5.a	The organization makes extensive use of low-code IT systems	**Item 1.5.b is removed.** Asking respondents about the difference in their response to item 1.5.a and 1.5.b showed that many respondents considered low-code IT systems not something to be used by employees without a programming background because they often still require you to know how the IT systems in the organization work. Therefore, they often gave a higher score to 1.5.a than to 1.5.b. Because 1.5.a captures the essence of the construct best, I dropped item 1.5.b.
1.5.b	Employees without a programming background are able to experiment with new initiatives by using low-code solutions	
2.1.a	The architectural models are developed in collaboration with all relevant parties, such as the business managers, administrators, developers, and line staff	**Both items kept.** At first sight, items 2.1.a and 2.1.b look quite similar, but by investigating why their Cronbach's alpha was insufficient, I found one significant outlier: one respondent had filled in a 1 for 2.1.a and a 4 for 2.1.b. After removing this outlier, the Cronbach's alpha increased to 0.74, which is quite decent. I guess that the respondent misunderstood the question because all other responses were quite consistent.
2.1.b	The interests of all stakeholders are addressed by the architecture	
3.4.a	The enterprise architecture is continuously adjusted based on suggestions from a wide range of employees (such as developers and administrators)	**Item 3.4.b is removed.** After asking respondents about the difference in their responses to item 3.4.a and item 3.4.b, it turned out that some respondents understood item 3.4.b as "the programmers give direct feedback to the enterprise architects instead of first talking to the solutions architects" (which is in large organizations rarely the case; feedback about the applicability of the architecture is given indirectly through the solution architects). Because item 3.4.a better captures the essence of the construct, I removed item 3.4.b.
3.4.b	The architectural process is regularly provided with feedback by the software implementation teams	
4.3.a	As soon as a project is started, architects are involved in the execution	**Item 4.3.a is reformulated and item 4.3.b is removed.** After asking respondents about the difference in their responses to item 4.3.a and item 4.3.b, it turned out that the role of "enterprise architects" sometimes overlaps with other roles such as "solution architects" (see also Section 9.4.3).

Table F.11 continued from previous page

Item #	Old item	Action
4.3.b	The architects help coordinate projects during the entire existence of these projects	Whereas in small organizations, enterprise architects are often involved in the execution of projects, this is the task of the solution architects exclusively in large corporations. Therefore, I decided to remove item 4.3.b and reformulate item 4.3.a to "Every software project needs to gain approval by the enterprise architects before it can be executed".
5.4.a	The architects have sufficient time to do their assigned tasks well	**Both items kept.** At first sight, items 5.4.a and 5.4.b would result in the same response, but by investigating why their Cronbach's alpha was insufficient, I found one significant outlier: one respondent had filled in a 5 for 5.4.a and a 2 for 5.4.b. After removing this outlier, the Cronbach's alpha increased to 0.84, which is excellent. I guess that the respondent misunderstood the question because all other responses were quite consistent.
5.4.b	The organization has hired enough architects to maintain and improve the architecture	

Table F.11: Reformulated items based on an insufficient Cronbach's alpha after Pilot test #2

The fact that the AVE of all constructs is above 0.5 indicates convergent validity.

Discriminant Validity

The Fornell-Larcker criterion for the second pilot test is shown as a matrix in Table F.12, and the HTMT criterion is shown similarly in Table F.13. In these tables, the constructs that are going to be changed due to an insufficient Cronbach's alpha value (see Section F.3.1) are colored blue. The squared Pearson correlations in Table F.12 and HTMT values in Table F.13 that are insufficient are colored blue when they are calculated based on one of these constructs. I cannot reliably derive information from these numbers because they are based on constructs that will be changed anyway. The values that are insufficient and not calculated based on these blue-colored constructs are colored red. These values can give me valuable information about how the discriminant validity can be improved.

In both tables, the number of colored cells, indicating an insufficient discriminant validity between the constructs, is significantly smaller than in the first pilot test. This means that I was correct in my approach after the first pilot test to collect more data before drawing conclusions, see Section F.2.1.

As indicated in Section E.0.2, the first step to handle discriminant validity is establishing content validity (which was already established in Section F.1), followed by scrutinizing the measurement model and re-evaluating the sampling design. Due to time constraints and the availability of interviews with enterprise architects, 40% of the pilot interviews happened to be with large financial organizations, resulting in a bias in the sampling design. Despite this bias, the measurement instrument can probably be improved by evaluating the results, but gaining more samples from other organizations operating in other industries would be beneficial to enable further improvements (K. A. Bollen, 1989; Rönkkö & Cho, 2022). Underneath, I evaluate every value indicating insufficient discriminant validity one by one. Every value is referred to with two subsequent numbers, where the first number denotes the row and the second number denotes the column.

Fornell-Larcker.

The Fornell-Larcker criterion is not applicable for construct "Innovation impact analysis" and "Innovation feasibility analysis" because these only have a single reflective item after the other one was removed in Section F.2.2

- **8.7.** After discussing the finding with an EA expert, the reason why these constructs correlate highly has probably to do with a latent variable (such as "structured way of practicing EA") that significantly influences both the extent to which EA deliverables are consistent with each other and the extent to which the EA deliverables are consistent with the business objectives. Because the content validity seems correct, I reformulate the items to make the difference between the items more explicit.
- **11.10., 13.10., 13.11.** These constructs form, together with 12.10 and 12.11., a cluster of highly correlated responses that seem to be capturing the same latent variable. The constructs "Continuous EA quality improvement" and "Continuous EA process improvement" are, upon closer examination, essentially derivatives from the "Feedback-driven EA design" construct. After all, when the design is driven by feedback, the enterprise architecture is also continuously improved. Therefore, I choose to remove these two constructs from the measurement instrument.
- **13.3., 13.6.** These constructs seem to be measuring distinct concepts (using the cloud and working agile are unrelated practices), and these correlation values are almost negligibly higher than the threshold value. Combined with the notion of (Hair et al., 2011) that the criterion has a high false-positive rate and its reputation for being "a very conservative test" (Voorhees et al., 2016), I decide not to change these constructs yet.
- **30.9., 30.29.** The "Innovation feasibility analysis" and "Innovation-driven To Be Architecture" constructs correlate highly with the "Roadmap" and "Innovation impact analysis" constructs. Together with an EA expert, I decide to gather more samples before eliminating these constructs.

HTMT.

The HTMT criterion only works when the correlation of the two items within the same construct is positive (otherwise, you have to take the square root of a negative number, which is not possible with non-imaginary numbers), see the HTMT formula in Section E.0.2. Due to the negative correlation for the "Support for pilots" and "Program / project consultation" constructs, which has been addressed in Section F.3.1, the HTMT values were not calculated for these constructs.

- **11.10., 13.10., 13.11.** See explanation for *11.10., 13.10., 13.11.* from the Fornell-Larcker criterion description above

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.
1. Support for pilots	0.69																													
2. Modular design	0.03	0.71																												
3. Cloud usage	0.11	0.15	0.85																											
4. Data lake usage	0.08	0.21	0.49	0.69																										
5. Low-code usage	0.03	0.74	0.04	0.06	0.72																									
6. EA stakeholder collaboration	0.27	0.21	0.54	0.21	0.04	0.64																								
7. EA cohesion	0.39	0.14	0.55	0.26	0.09	0.35	0.81																							
8. EA alignment with objectives	0.32	0.25	0.56	0.34	0.2	0.36	0.88	0.92																						
9. Roadmap	0.22	0.33	0.33	0.07	0.22	0.46	0.66	0.63	0.85																					
10. Continuous EA quality improvement	0.48	0.32	0.21	0.15	0.09	0.11	0.4	0.08	0.33	0.68																				
11. Continous EA process improvement	0.52	0.3	0.33	0.11	0.2	0.17	0.51	0.05	0.39	0.79	0.65																			
12. Feedback-driven EA design	0.52	0.19	0.15	0.1	0.19	0.41	0.54	0.46	0.69	0.88	0.8	0.56																		
13. Agile EA working method	0.29	0.16	0.85	0.4	0.1	0.65	0.65	0.61	0.48	0.79	0.81	0.45	0.86																	
14. EA visibility	0.36	0	0.02	0.01	0	0.09	0.48	0.32	0.26	0.28	0.35	0.3	0.06	0.72																
15. Strategy consultation	0.02	0.66	0.17	0.21	0.29	0.46	0.15	0.31	0.42	0.33	0.22	0.24	0.16	0.04	0.9															
16. Program / project consultation	0.39	0.12	0.2	0.15	0.3	0.24	0.42	0.47	0.26	0.51	0.55	0.58	0.5	0.11	0.07	0.52														
17. Compliancy verification	0.26	0.13	0.01	0.14	0.07	0.04	0.38	0.31	0.31	0.23	0.31	0.46	0.05	0.62	0.17	0.13	0.88													
18. Escalation / exception handling	0.02	0.59	0.07	0	0.65	0.21	0.12	0.18	0.37	0.19	0.28	0.17	0.12	0.02	0.37	0.17	0.01	0.86												
19. Architect recruitment	0.03	0.03	0.06	0	0.03	0.11	0.14	0	0.36	0.3	0.38	0.47	0.2	0.05	0.05	0.1	0.06	0.05	0.83											
20. Architect development	0.06	0.03	0.07	0	0.03	0.06	0.2	0.1	0.45	0	0.06	0.01	0.03	0.01	0.04	0.02	0.05	0.01	0.15	0.66										
21. Architect time	0.54	0.42	0.01	0.01	0.19	0.06	0.06	0.03	0.03	0.24	0.28	0.05	0.07	0.12	0.25	0.25	0.02	0.09	0	0.22	0.77									
22. Architect communication	0.1	0.16	0.49	0.27	0.17	0.36	0.55	0.37	0.61	0.65	0.63	0.6	0.75	0.04	0.01	0.51	0.05	0.15	0.59	0.09	0.03	1								
23. Architect bonding	0.41	0.2	0.38	0.11	0.12	0.24	0.37	0.22	0.39	0.41	0.44	0.51	0.45	0.03	0.07	0.49	0.06	0.09	0.39	0.33	0.41	0.55	0.75							
24. Clear innovation ambition	0.04	0.14	0.14	0	0.02	0.1	0.05	0.01	0.3	0.07	0.1	0.05	0.1	0.01	0.08	0.05	0	0.09	0.29	0.47	0.34	0.1	0.51	0.81						
25. Linkage different innovations	0.01	0.45	0.03	0	0.3	0.09	0.15	0.12	0.58	0.18	0.21	0.24	0.05	0.08	0.3	0	0.2	0.45	0.27	0.54	0.67	0.07	0.55	0.58	0.98					
26. EA involvement innovation	0	0.31	0.02	0	0.15	0.05	0.12	0.13	0.53	0.1	0.11	0.2	0.02	0.05	0.36	0.01	0.26	0.15	0.03	0.48	0.74	0	0.6	0.53	0.79	0.79				
27. Innovation impact analysis																														
28. Active EA opportunity scouting	0.09	0.17	0.74	0.31	0.03	0.51	0.48	0.36	0.51	0.55	0.61	0.3	0.72	0.03	0.17	0.08	0.05	0.05	0.31	0.25	0.02	0.52	0.41	0.54	0.23	0.22		0.92		
29. Innovation feasibility analysis																														
30. Innovation-driven To Be arch	0.25	0.21	0.34	0.06	0.13	0.39	0.79	0.63	0.93	0.51	0.58	0.64	0.47	0.43	0.25	0.22	0.39	0.26	0.45	0.51	0	0.59	0.49	0.3	0.53	0.43		0.54		0.86

Table F.12: Matrix mapping of the Fornell-Larcker criterion for the second pilot, where the diagonal cells contain the AVE value of each reflective construct, the non-diagonal cells contain the squared Pearson correlation between the two constructs, and the red-colored cells indicate squared correlations that exceed the AVE value

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.
1. Support for pilots																														
2. Modular design																														
3. Cloud usage		0.51																												
4. Data lake usage		0.59	0.71																											
5. Low-code usage		0.98	0.26	0.3																										
6. EA stakeholder collaboration		0.69	0.79	0.54	0.11																									
7. EA cohesion		0.41	0.67	0.53	0.27	0.6																								
8. EA alignment with objectives		0.53	0.64	0.54	0.37	0.59	0.76																							
9. Roadmap		0.69	0.52	0.28	0.33	0.69	0.69	0.65																						
10. Continuous EA quality improvement		0.58	0.7	0.51	0.31	0.71	0.71	0.73	0.71																					
11. Continous EA process improvement		0.63	0.66	0.55	0.33	0.67	0.68	0.76	0.77	0.88																				
12. Feedback-driven EA design		0.65	0.5	0.5	0.36	0.94	0.97	0.82	1.05	0.95	0.87																			
13. Agile EA working method		0.42	0.85	0.64	0.32	0.76	0.73	0.66	0.59	0.88	0.90	0.87																		
14. EA visibility		-0.01	0.15	0.13	-0.22	0.35	0.69	0.5	0.5	0.84	0.82	0.9	0.29																	
15. Strategy consultation		0.93	0.37	0.43	0.34	0.66	0.35	0.47	0.55	0.51	0.45	0.59	0.31	0.15																
16. Program / project consultation	0.44																													
17. Compliancy verification		0.37	0.08	0.36	0.06	0.22	0.54	0.45	0.47	0.82	0.87	0.92	0.23	0.78	0.34															
18. Escalation / exception handling		0.9	0.24	0.02	0.73	0.51	0.31	0.38	0.54	0.50	0.47	0.55	0.28	0.15	0.53		0.09													
19. Architect recruitment		0.25	0.21	0.06	0.15	0.31	0.28	0.04	0.43	0.61	0.57	0.77	0.35	0.26	-0.14		0.19	0.15												
20. Architect development		0.28	0.24	-0.01	0.28	-0.26	0.35	0.24	0.51	0.17	0.19	0.04	0.16	0.12	-0.09		0.15	-0.05	0.34											
21. Architect time		-0.76	0.1	-0.07	-0.38	0.22	0.21	0.1	-0.14	0.30	0.27	0.25	0.24	0.48	-0.43		-0.14	-0.13	-0.05	-0.46										
22. Architect communication		0.4	0.56	0.26	0.22	0.36	0.23	0.37	0.3	0.31	0.36	0.5	0.07	0.03			-0.5	0.45	0.5	-0.26	0.7									
23. Architect bonding		-0.2	0.44	0.25	0.02	0.58	0.46	0.37	0.39	0.57	0.55	0.54	0.48	0.23	-0.12		-0.33	0.1	0.24	-0.32	0.56	0.44								
24. Clear innovation ambition		0.59	0.36	0.01	0.1	0.35	0.2	0.12	0.52	0.32	0.29	0.3	0.26	-0.04	0.24		0.06	0.21	0.53	0.71	-0.52	-0.01								
25. Linkage different innovations		0.8	0.14	-0.01	0.38	0.29	0.3	0.28	0.6	0.44	0.37	0.56	0.15	0.26	0.44		0.35	0.51	0.42	0.64	-0.68	-0.42	-0.53	0.65						
26. EA involvement innovation		0.74	0.08	0.03	0.21	0.23	0.28	0.3	0.66	0.43	0.43	0.63	0.1	0.21	0.53		0.48	0.33	0.18	0.63	-0.7	-0.67	-0.65	0.71	0.75					
27. Innovation impact analysis		0.99	0.14	0.25	0.51	0.35	0.23	0.32	0.5	0.4	0.36	0.53	0.14	0.08	0.64		0.38	0.53	0.1	0.23	-0.66	-0.73	-0.71	0.39	0.59	0.67				
28. Active EA opportunity scouting		0.52	0.76	0.49	0.12	0.7	0.56	0.47	0.59	0.71	0.71	0.64	0.69	0.19	0.33		0.19	0.18	0.45	0.42	-0.1	0.65	0.22	0.66	0.36	0.38	0.25			
29. Innovation feasibility analysis		0.55	0.24	0.3	0.53	0.03	0.53	0.51	0.5	0.44	0.49	0.56	0.29	0.36	0.29		0.51	0.29	0.07	0.6	-0.32	-0.33	-0.38	0.22	0.44	0.51	0	0.24		
30. Innovation-driven To Be arch		0.55	0.53	0.27	0.24	0.61	0.76	0.66	0.82	0.81	0.84	1.01	0.59	0.68	0.43		0.54	0.45	0.46	0.6	-0.02	0.46	0.26	0.49	0.56	0.58	0.39	0.59	0.26	

Table F.13: Matrix mapping of the HTMT criterion for the second pilot where the red-colored cells indicate that the value of the HTMT is above the 0.85 threshold

F.3.2. Reliability & Validity of the Formative Constructs

As with the first pilot test, the multi-collinearity is evaluated by calculating the VIF and the discriminant validity by calculating the PCA factor loading for each formative construct. The results are shown in Table F.14.

Item #	Item name	VIF	PCA factor loading
	Innovation-focused Enterprise Architecture design		
1.1	Support for pilots	1.27	0.12
1.2	Modular design	1.95	0.85
1.3	Cloud usage	3.1	0.89
1.4	Data lake usage	2.34	0.89
1.5	Low-code usage	1.52	0.3
	Enterprise Architecture Capability => Innovation-focused alignment of To-Be architecture with business objectives		
2.1	EA stakeholder collaboration	3.25	0.77
2.2	EA cohesion	11.06	0.95
2.3	EA alignment with objectives	11.06	0.93
	Enterprise Architecture Capability => Innovation-focused development of the architecture		
3.1	Roadmap	7.97	0.93
3.2	Continous EA quality improvement	6.18	0.85
3.3	Continous EA process improvement	6.70	0.86
3.4	Feedback-driven EA design	6.28	0.92
3.5	Agile EA working method	4.14	0.84
	Enterprise Architecture Capability => Innovation-focused usage of the architecture		
4.1	EA visibility	1.87	0.73
4.2	Strategy consultation	2.33	0.72
4.3	Program / project consultation	1.62	0.8
4.4	Compliancy verification	2.45	0.85
4.5	Escalation / exception handling	1.87	0.75
	Enterprise Architecture Capability => Innovation-focused implementation of the enterprise architect role		
5.1	Architect recruitment	2.57	0.88
5.2	Architect development	1.33	0.39
5.3	Architect bonding	5.84	0.52
5.4	Architect time	1.14	0.57
5.5	Architect communication	3.06	0.92
	Innovation-focused enterprise architect behavior		
6.1	Clear innovation ambition	2.42	0.85
6.2	Linkage different innovations	6.46	0.92

Table F.14 continued from previous page

Item #	Item name	VIF	PCA factor loading
6.3	EA involvement innovation	3.19	0.88
6.4	Innovation impact analysis	3.30	0.95
6.5	Active EA opportunity scouting	1.88	0.81
6.6	Innovation feasibility analysis	2.64	0.94
6.7	Innovation-driven To Be arch	2.86	0.89

Table F.14: VIF and PCA values of the formative constructs of pilot 2

Reliability

Table F.14 shows that there are several constructs of which the VIF exceeds the threshold value of 5.0 (see Section E.0.1). For each of these constructs, I take action based on the four options described in Section E.0.1.

- **2.X - Innovation-focused alignment of To-Be architecture with business objectives.** I already noted that the ”Innovation-focused alignment of To-Be architecture with business objectives” constructs had very high VIF values and considered to collapse the associated constructs into a composite index in Section F.2.2.o Given that the VIF values are still too high after the second pilot study, I apply this change, making ”Alignment of To-Be architecture with business objectives” a reflective construct. The Cronbach’s alpha of this new reflective construct is 0.85, which is excellent. Applying PCA on the dimensions of this construct shows no significant differences between the influence of these dimensions on the final value. Therefore, in theory, I could remove several items to make the measurement instrument a bit shorter without compromising too much of its reliability, but choose not to do so because the length of the questionnaire is still reasonable.
- **3.X - Innovation-focused development of the architecture.** The VIF values of almost all dimensions of this construct exceed the 5.0 threshold. However, constructs 3.2 and 3.3 will be entirely removed anyway due to insufficient discriminant validity, as discussed in Section F.3.1. After removing these constructs, the VIF value of the three remaining constructs drops below the threshold.
- **5.3 - Architect bonding.** The VIF value of the ”architect bonding” construct is too high, indicating too much overlap with other constructs. This overlap is most significant with the ”Architect communication”, ”Architect recruitment”, ”Clear innovation ambition”, and ”EA stakeholder collaboration” constructs. Therefore, in consultation with an EA expert, I decide to remove this construct from the measurement instrument.
- **6.2 - Linkage different innovations.** Because changing the wording of the items in the first pilot test did not result in a sufficient decrease in the VIF value, I choose to use the second option and remove item 6.2.b. When calculated based on the existing samples, removing this item indeed pushes the VIF below the threshold (namely to 2.80).

Validity

In this section, I use the same approach as in Section F.2.2.

- **1.1 - Support for pilots.** The PCA factor loading of ”Support for pilots” is only 0.12, which is very low. However, because item 1.1.a was dropped due to insufficient Cronbach’s alpha (see Section F.3.1), its PCA factor loading increases to 0.7 which is well above the 0.5 threshold.
- **1.5 - Low-code usage.** Similarly as for construct 1.1, item 1.5.b was dropped due to insufficient Cronbach’s alpha (see Section F.3.1). After dropping this item, the construct’s PCA factor loading increases to 0.54 which is sufficient.

- **5.2 - Architect development.** The PCA factor loading of ”Architect development” is 0.39, which is below the 0.5 threshold. However, because item 5.3 was dropped due to a VIF that was too high (see Section F.3.2), its PCA factor loading increases to 0.88 which is excellent.

F.3.3. Removed

Constructs 2.1, 2.2, and 2.3 are collapsed into a composite index. Because the measurement instrument does not change (but only the structural model), they are not included in the table below.

Item #	Old item	Problem
1.1.a	The enterprise architecture typically allows shadow IT systems to run alongside the established IT systems as temporary, small-scale experiments	Cronbach’s alpha too low
1.2.a	The IT systems are usually loosely coupled components	Cronbach’s alpha too low
1.5.b	Employees without a programming background can experiment with new initiatives by using low-code solutions	Cronbach’s alpha too low
3.2.a	Attempts are made to review the architectural models and principles in some way or other with regard to quality	Insufficient discriminant validity, established by both the Fornell-Larcker and HTMT criterion
3.2.b	Quality standards have been formulated for the architecture	
3.3.a	The architectural process is evaluated according to a regular cycle	Insufficient discriminant validity, established by both the Fornell-Larcker and HTMT criterion
3.3.b	Improvement proposals regularly results in actual modifications to the architectural process	
3.4.b	The architectural process is regularly provided with feedback by the software implementation teams	Cronbach’s alpha too low
4.3.b	The architects help coordinate projects during the entire existence of these projects	Cronbach’s alpha too low
5.3.a	The architects share a common perspective on architecture	VIF too high
5.3.b	There is structural interaction between the architects	

Table F.15: Removed items after Pilot test #2

F.4. Final EA factor Questionnaire

The items resulting after the validation process described above is shown below and included in the final measurement instrument shown in Section 7.2.

Item #	Items
Innovation-focused Enterprise Architecture design	

Table F.16 continued from previous page

Item #	Items
1.1	Pilots of new IT systems are allowed and supported by the enterprise architecture
1.2	The IT landscape within the firm is largely modular
1.3.a	Most IT systems run in the cloud
1.3.b	Cloud providers (such as Amazon or Microsoft) provide facilitating services such as the infrastructure, platforms, or applications
1.4.a	The organization has a data lake that provides easy access to most of the data available
1.4.b	The firm has a storage repository containing almost all data available at the firm
1.5	The organization makes extensive use of low-code IT systems
Enterprise Architecture Capability => **Innovation-focused alignment of To-Be architecture with business objectives**	
2.1.a	The architectural models are developed in collaboration with all relevant parties, such as the business managers, administrators, developers, and line staff
2.1.b	The interests of all stakeholders are addressed by the architecture
2.1.c	The enterprise architecture and project architectures are consistent with each other
2.1.d	The cohesion between the different architectural deliverables is effectively safeguarded during the development of the architecture
2.1.e	The relationship between the architectural choices and the organization's business objectives is clear
2.1.f	The architectural choices are in line with the business strategy and objectives
Enterprise Architecture Capability => **Innovation-focused development of the proper architecture**	
3.1.a	There is a clear roadmap on how to proceed from the existing As-Is situation to the desired To-Be situation
3.1.b	The architecture offers guidelines in the area of migration (how to proceed from an existing to a desired situation)
3.2	The enterprise architecture is continuously adjusted based on suggestions from a wide range of employees (such as developers and administrators)
3.3.a	The architects develop the architecture in an agile way
3.3.b	The architects work iteratively, where they regularly get and incorporate feedback about the deliverables they're working on
Enterprise Architecture Capability => **Innovation-focused usage of the architecture**	
4.1.a	The target architecture can be directly accessed by all relevant employees
4.1.b	Everyone in the firm who should know about the enterprise architecture knows where to find it
4.2.a	The architecture plays an integral role in the organization's decision-making process
4.2.b	If the business intends to change its strategic objectives, it automatically involves architects as a partner in the discussion

Table F.16 continued from previous page

Item #	Items
4.3	Every software project needs to gain approval by the enterprise architects before it can be executed
4.4.a	Compliance with the requirements set by the target architecture is a standard feature of a project's execution
4.4.b	Actions are taken to ensure that projects satisfy the requirements of the target architecture (e.g., communication session or trainings)
4.5.a	If a project does not comply with the target architecture, there is a system in place to ensure compliance or make an exception
4.5.b	Deviations from the target architecture are actively managed (e.g., in an architecture board)
	Enterprise Architecture Capability => Innovation-focused implementation of the enterprise architect role
5.1.a	The architects are generally sufficiently skilled to do their job well
5.1.b	The architects have the required knowledge and skills
5.2.a	The architects are stimulated to use seminars, trainings, consultants, and other opportunities to enhance their skill-set
5.2.b	The exchange of best practices with architects or EA experts from outside the firm is supported
5.3.a	The architects have sufficient time to do their assigned tasks well
5.3.b	The organization has hired enough architects to maintain and improve the architecture
5.4.a	The architects have good communication skills
5.4.b	Most architects have good listening skills and are effective in sharing their ideas
	Innovation-focused enterprise architect behavior
6.1.a	The enterprise architects have articulated a clear ambition of how they want to contribute to the firm's innovation
6.1.b	The role and mandate of the architects is clear with regards to digital innovation
6.2	The enterprise architects ensure the link between the organization's different innovation ambitions
6.3.a	The enterprise architects are involved in innovation strategy discussions
6.3.b	Enterprise architects are part of the strategic discussions about the firm's innovation strategy
6.4	The enterprise architects are involved in analyzing the impact of proposed innovations on the organization's performance
6.5.a	The enterprise architects actively identify external opportunities and trends, such as better software systems or new IT-related innovations
6.5.b	The architects proactively bring trends and developments in the market to the attention of business management

Table F.16 continued from previous page

Item #	Items
6.6	The architects assess whether the organization has the required capabilities of delivering the innovation
6.7.a	The architects adapt the target architecture (to-be architecture; envisioned architecture) based on new innovation projects taking place
6.7.b	The architects integrate new innovations in the enterprise architecture

Table F.16: Final EA factor questionnaire

F.5. Final Test

After the measurement instrument was improved using the two pilot tests, it was sent to many enterprise architects and used as a guideline for the interviews. More information about the data collection methodology and results can be found in Section 6. The reliability and validity of the instrument on the complete set of responses is investigated in this section.

F.5.1. Reliability & Validity of the Reflective Constructs

To evaluate the reliability, I calculate the Cronbach's alpha of each reflective construct again, and to assess the construct validity, I calculate the AVE value again and re-evaluate the Fornell-Larcker and HTMT criterion (see Section 7.1.

Internal Consistency & Convergent Validity

Item #	Items	Cronbach's alpha	AVE
	Innovation-focused Enterprise Architecture design		
1.1	Pilots of new IT systems are allowed and supported by the enterprise architecture		
1.2	The IT landscape within the firm is largely modular		
1.3.a	Most IT systems run in the cloud	0.62	0.62
1.3.b	Cloud providers (such as Amazon or Microsoft) provide facilitating services such as the infrastructure, platforms, or applications		
1.4.a	The organization has a data lake that provides easy access to most of the data available	0.59	0.67
1.4.b	The firm has a storage repository containing almost all data available at the firm		
1.5	The organization makes extensive use of low-code IT systems		
	Enterprise Architecture Capability => Innovation-focused alignment of To-Be architecture with business objectives		
2.1.a	The architectural models are developed in collaboration with all relevant parties, such as the business managers, administrators, developers, and line staff	0.88	
2.1.b	The interests of all stakeholders are addressed by the architecture		
2.1.c	The enterprise architecture and project architectures are consistent with each other		
2.1.d	The cohesion between the different architectural deliverables is effectively safeguarded during the development of the architecture		
2.1.e	The relationship between the architectural choices and the organization's business objectives is clear		
2.1.f	The architectural choices are in line with the business strategy and objectives		
	Enterprise Architecture Capability => Innovation-focused development of the proper architecture		
3.1.a	There is a clear roadmap on how to proceed from the existing As-Is situation to the desired To-Be situation	0.80	0.83
3.1.b	The architecture offers guidelines in the area of migration (how to proceed from an existing to a desired situation)		

Table F.17 continued from previous page

Item #	Items	Cronbach's alpha	AVE
3.2	The enterprise architecture is continuously adjusted based on suggestions from a wide range of employees (such as developers and administrators)		
3.3.a	The architects develop the architecture in an agile way	0.63	0.67
3.3.b	The architects work iteratively, where they regularly get and incorporate feedback about the deliverables they're working on		
	Enterprise Architecture Capability => Innovation-focused usage of the architecture		
4.1.a	The target architecture can be directly accessed by all relevant employees	0.67	0.76
4.1.b	Everyone in the firm who should know about the enterprise architecture knows where to find it		
4.2.a	The architecture plays an integral role in the organization's decision-making process	0.70	0.79
4.2.b	If the business intends to change its strategic objectives, it automatically involves architects as a partner in the discussion		
4.3	As soon as a project is started, architects are involved in the execution		
4.4.a	Compliance with the requirements set by the target architecture is a standard feature of a project's execution	0.75	0.79
4.4.b	Actions are taken to ensure that projects satisfy the requirements of the target architecture (e.g., communication session or trainings)		
4.5.a	If a project does not comply with the target architecture, there is a system in place to ensure compliance or make an exception	0.75	0.77
4.5.b	Deviations from the target architecture are actively managed (e.g., in an architecture board)		
	Enterprise Architecture Capability => Innovation-focused implementation of the enterprise architect role		
5.1.a	The architects are generally sufficiently skilled to do their job well	0.88	0.90
5.1.b	The architects have the required knowledge and skills		
5.2.a	The architects are stimulated to use seminars, trainings, consultants, and other opportunities to enhance their skill-set	0.83	0.90
5.2.b	The exchange of best practices with architects or EA experts from outside the firm is supported		
5.3.a	The architects have sufficient time to do their assigned tasks well	0.85	0.86
5.3.b	The organization has hired enough architects to maintain and improve the architecture		
5.4.a	The architects have good communication skills	0.88	0.90
5.4.b	Most architects have good listening skills and are effective in sharing their ideas		
	Innovation-focused enterprise architect behavior		
6.1.a	The enterprise architects have articulated a clear ambition of how they want to contribute to the firm's innovation		

Table F.17 continued from previous page

Item #	Items	Cronbach's alpha	AVE
6.1.b	The role and mandate of the architects is clear with regards to digital innovation	0.73	0.79
6.2	The enterprise architects ensure the link between the organization's different innovation ambitions		0.98
6.3.a	The enterprise architects are involved in innovation strategy discussions	0.85	0.86
6.3.b	Enterprise architects are part of the strategic discussions about the firm's innovation strategy		
6.4	The enterprise architects are involved in analyzing the impact of proposed innovations on the organization's performance		
6.5.a	The enterprise architects actively identify external opportunities and trends, such as better software systems or new IT-related innovations	0.86	0.88
6.5.b	The architects proactively bring trends and developments in the market to the attention of business management		
6.6	The architects assess whether the organization has the required capabilities of delivering the innovation		
6.7.a	The architects adapt the target architecture (to-be architecture; envisioned architecture) based on new innovation projects taking place	0.68	0.66
6.7.b	The architects integrate new innovations in the enterprise architecture		

Table F.17: EA factor questionnaire for the final test

As can be seen in Table F.17, almost all reflective constructs have a sufficient Cronbach's alpha value except for construct 1.4, which has a Cronbach's alpha value of 0.59, which is just below the 0.60 threshold. I considered splitting construct 1.4 into two separate dimensions or reducing it to the item that best captures its essence. However, because its Cronbach's alpha value is very close to the threshold and the items seem similar enough to produce together the concept that I intend to measure, I decide to keep the items as they are. I also note that there are no constructs whose Cronbach's alpha exceeds 0.95 (which would be too high, as explained in Section E.0.1).

The fact that the AVE of all constructs is above 0.5 indicates convergent validity.

Discriminant Validity

The Fornell-Larcker criterion for the final test is shown as a matrix in Table F.18, and the HTMT criterion is similarly shown in Table F.19. In both tables, the number of red cells, indicating an insufficient discriminant validity between the constructs, is significantly smaller than for both pilot tests. This means that I was correct in my approach after the second pilot test to collect more data before drawing conclusions, see Section F.3.1.

The Fornell-Larcker criterion does not have any red cells, which means that according to this criterion, discriminant validity is established.

The HTMT criterion shows two red cells, namely 25.19 and 25.23. However, these values are just barely above the 0.85 threshold (namely, with a difference of 0.01 and 0.02). Given the fact that also their content validity was already established (see Section F.1) and the constructs clearly have a different meaning, I decide to keep the constructs as they are.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.
1. Support for pilots	0.57																								
2. Modular design	0.11	0.7																							
3. Cloud usage	0.24	0.13	0.62																						
4. Central data access point	0.09	0.22	0.19	0.67																					
5. Low-code usage	0.01	0.02	0.1	0.13	0.57																				
6. EA alignment	0.19	0.06	0.06	0.14	0.04	0.66																			
7. Roadmap	0.11	0.09	0	0.16	0.08	0.17	0.83																		
8. Feedback-driven EA design	0.13	0.08	0.08	0.08	0.03	0.12	0.15	0.77																	
9. Agile EA working method	0.3	0.23	0.2	0.17	0.01	0.21	0.11	0.23	0.67																
10. EA visibility	0.09	0.12	0.05	0.21	0.05	0.09	0.23	0.1	0.17	0.76															
11. Strategy consultation	0.15	0.14	0.04	0.22	0.07	0.28	0.25	0.43	0.18	0.32	0.79														
12. Program / project consultation	0.1	0	0.04	0.06	0.02	0.09	0.15	0.03	0.01	0.17	0.1	0.71													
13. Compliancy verification	0.09	0.08	0.03	0.21	0.06	0.27	0.3	0.09	0.11	0.37	0.26	0.24	0.79												
14. Escalation / exception handling	0.1	0.08	0.01	0.12	0.05	0.34	0.23	0.08	0.09	0.29	0.31	0.37	0.58	0.77											
15. Architect recruitment	0.03	0.07	0.08	0.08	0.04	0.18	0.17	0.17	0.18	0.15	0.18	0.07	0.14	0.06	0.9										
16. Architect development	0.07	0.05	0.07	0.07	0	0.14	0.11	0.25	0.21	0.2	0.35	0.04	0.16	0.11	0.5	0.9									
17. Architect time	0.02	0.01	0.01	0.04	0	0.02	0.1	0.02	0.03	0.17	0.09	0.18	0.12	0.1	0.03	0	0.86								
18. Architect communication	0.03	0.1	0.25	0.15	0.07	0.08	0.13	0.09	0.07	0.16	0.16	0.04	0.15	0.06	0.56	0.34	0.03	0.9							
19. Clear innovation ambition	0.09	0.05	0.05	0.15	0.05	0.11	0.24	0.19	0.2	0.14	0.22	0.14	0.17	0.1	0.3	0.37	0.02	0.2	0.79						
20. Linkage different innovations	0.1	0.06	0.02	0.09	0.04	0.18	0.36	0.23	0.11	0.08	0.32	0.11	0.32	0.19	0.39	0.37	0.03	0.25	0.6	0.91					
21. EA involvement innovation	0.1	0.1	0.02	0.1	0.07	0.14	0.15	0.12	0.03	0.13	0.37	0.03	0.13	0.14	0.16	0.27	0	0.22	0.13	0.3	0.86				
22. Innovation impact analysis	0.05	0.13	0.05	0.12	0.23	0.13	0.24	0.14	0.04	0.13	0.33	0.04	0.2	0.12	0.16	0.2	0	0.24	0.37	0.48	0.38	0.81			
23. Active EA opportunity scouting	0.16	0.08	0.08	0.19	0.02	0.18	0.19	0.28	0.32	0.17	0.35	0.04	0.13	0.09	0.38	0.47	0.05	0.19	0.46	0.43	0.33	0.32	0.88		
24. Innovation feasibility analysis	0.22	0.17	0.12	0.09	0.04	0.07	0.25	0.11	0.21	0.19	0.26	0.04	0.15	0.06	0.31	0.39	0.01	0.4	0.3	0.41	0.38	0.33	0.4	0.82	
25. Innovation-driven To Be arch	0.23	0.09	0.14	0.2	0.09	0.26	0.35	0.32	0.32	0.26	0.37	0.12	0.29	0.16	0.47	0.37	0.1	0.26	0.37	0.61	0.25	0.35	0.48	0.35	0.66

Table F.18: Matrix mapping of the Fornell-Larcker criterion for the final test, where the diagonal cells contain the AVE value of each reflective construct, the non-diagonal cells contain the squared Pearson correlation between the two constructs, and the red-colored cells indicate squared correlations that exceed the AVE value

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.
1. Support for pilots																									
2. Modular design																									
3. Cloud usage																									
4. Central data access point			0.54																						
5. Low-code usage																									
6. EA stakeholder collaboration				0.39																					
7. Roadmap				0.51		0.34																			
8. Feedback-driven EA design																									
9. Agile EA working method			0.2	0.47		0.33	0.36																		
10. EA visibility			0.13	0.66		0.22	0.48		0.46																
11. Strategy consultation			0.16	0.53		0.43	0.42		0.49	0.62															
12. Program / project consultation																									
13. Compliancy verification			0.06	0.52		0.55	0.55		0.35	0.57	0.53														
14. Escalation / exception handling				0.53		0.51	0.45		0.27	0.63	0.53		0.85												
15. Architect recruitment			0.13	0.24		0.31	0.36		0.34	0.32	0.41		0.26	0.13											
16. Architect development			0.14	0.26		0.38	0.28		0.49	0.42	0.62		0.32	0.27	0.59										
17. Architect time			0.1	0.45		0.12	0.4		0.18	0.48	0.49		0.39	0.41	0.19	0.14									
18. Architect communication			0.46	0.33		0.19	0.29		0.07	0.33	0.36		0.29	0.15	0.58	0.45	0.19								
19. Clear innovation ambition			0.05	0.48		0.33	0.5		0.46	0.4	0.5		0.42	0.29	0.43	0.48	0.3	0.32							
20. Linkage different innovations																									
21. EA involvement innovation			0.16	0.46		0.36	0.28		0.26	0.37	0.58		0.36	0.41	0.39	0.46	0.22	0.5	0.35						
22. Innovation impact analysis																									
23. Active EA opportunity scouting			0.08	0.41		0.34	0.36		0.55	0.39	0.57		0.32	0.29	0.5	0.57	0.3	0.3	0.59		0.5				
24. Innovation feasibility analysis																									
25. Innovation-driven To Be arch			0.3	0.76		0.55	0.64		0.78	0.61	0.84		0.55	0.44	0.72	0.72	0.39	0.5	0.86		0.63		0.87		

Table F.19: Matrix mapping of the HTMT criterion for the final test where the red-colored cells indicate that the value of the HTMT is above the 0.85 threshold

F.5.2. Reliability & Validity of the Formative Constructs

As with the pilot tests, the multicollinearity is evaluated by calculating the VIF and the discriminant validity by calculating the PCA factor loading for each formative construct. The results are shown in Table F.20.

Item #	Item name	VIF	PCA factor loading
Innovation-focused Enterprise Architecture design			
1.1	Support for pilots	1.64	0.57
1.2	Modular design	1.95	0.7
1.3	Cloud usage	2.27	0.72
1.4	Central data access point	2.4	0.81
1.5	Low-code usage	1.49	0.57
Enterprise Architecture Capability => Innovation-focused alignment of To-Be architecture with business objectives			
Enterprise Architecture Capability => Innovation-focused development of the architecture			
3.1	Roadmap	2.28	0.67
3.2	Feedback-driven EA design	3.09	0.77
3.3	Agile EA working method	2.25	0.81
Enterprise Architecture Capability => Innovation-focused usage of the architecture			
4.1	EA visibility	2.73	0.81
4.2	Strategy consultation	2.25	0.74
4.3	Program / project consultation	2.08	0.71
4.4	Compliancy verification	3.23	0.88
4.5	Escalation / exception handling	4.05	0.91
Enterprise Architecture Capability => Innovation-focused implementation of the enterprise architect role			
5.1	Architect recruitment	4.14	0.92
5.2	Architect development	2.58	0.85
5.3	Architect time	1.32	0.38
5.4	Architect communication	3.1	0.85
Innovation-focused enterprise architect behavior			
6.1	Clear innovation ambition	2.67	0.84
6.2	Linkage different innovations	4.72	0.91
6.3	EA involvement innovation	2.3	0.72
6.4	Innovation impact analysis	3.11	0.81
6.5	Active EA opportunity scouting	3.2	0.86
6.6	Innovation feasibility analysis	2.91	0.82
6.7	Innovation-driven To Be arch	3.1	0.91

Table F.20: VIF and PCA values of the formative constructs

Reliability

Table F.20 shows that the VIF of all constructs is below the 5.0 threshold (see Section E.0.1), which indicates that the degree of multicollinearity of the model is acceptable.

Validity

In this section, I use the same approach as in Section F.2.2. The factor loading of each formative construct is above 0.5, which is excellent: it indicates discriminant validity for all constructs.

G

SEM Step 5: Assessing the Structural Model - Methodology

This Appendix contains more information about the methods and threshold values used to assess the structural model, as explained in Section 8.2.

To assist the reader, a copy of the original table showing an overview of the methodology used (namely, Table 8.3) is shown in Table G.1.

This appendix contains a dedicated section for each of the assessment types mentioned in this table.

For more information about the assessment of the structural model, see Section 8.2.

Type	Test	Condition	Reference
Multicollinearity	Variance Inflation Factor (VIF)	< 5.00	(Miles, 2014)
Strength of path coefficients	Path coefficient (β)	N/A	(Hair Jr, Sarstedt, et al., 2017)
Statistical significance of path coefficients	• t-value • p-value	< 5%	(Fisher, 1992)
Practical significance of path coefficients	Expert review	N/A	(Kraemer et al., 2003)
Explanatory power	Coefficient of determination (R^2)	• >= 0.67 (substantial) • >= 0.33 (moderate) • >= 0.19 (weak)	(Hair et al., 2019)
Importance / performance analysis	Importance-performance map analysis (IPMA)	N/A	(Ringle & Sarstedt, 2016)

Table G.1: A copy of the overview of the reliability and validity assessment methods used for the structural model (see Table 8.3)

G.0.1. Multicollinearity

Before assessing the structural relationships, I need to examine the structural model for multicollinearity. When the constructs exhibit too much collinearity, the path coefficients may be biased because they represent similar concepts (Hair Jr et al., 2021). The multicollinearity is assessed with the Variance Inflation Factor (VIF value) similarly as for the formative measurement model (see Section E.0.1) where the latent variable scores of the predictor constructs are used to calculate the VIF values (Hair et al., 2019). When the VIF values are lower than 5, the structural model is probably free from collinearity issues (Hair et al., 2019; Hair Jr et al., 2021).

G.0.2. Strength of Path Coefficients

The *path coefficients* denote the strength of the hypothesized relationships between the constructs of the structural model. They are defined as the standardized beta (β) coefficients of the result of a least-squares regression on the structural model (Hair et al., 2011). Their standardized values vary approximately between -1 and +1 (for strong negative / positive relationships respectively) (Hair Jr et al., 2021; Russo & Stol, 2021). Although β is also often used to denote the unstandardized path regression coefficients, I will use β to denote the standardized path coefficients because that seems to be in line with the literature (Ahmad et al., 2020; Müller et al., 2015). There is no threshold for the minimum strength of a path coefficient in the literature to accept a hypothesis, but path coefficients with a value close to 0 are usually statistically insignificant (see Section G.0.3), resulting in the rejection of the hypothesis (Hair Jr et al., 2021). In contrast, when the path coefficients are significant, they are often compared to understand which independent variables have the most significant influence on the dependent variable.

G.0.3. Statistical Significance of Path Coefficients

The *statistical significance* of a path coefficient shows the confidence in the fact that an exogenous construct really influences an endogenous construct and thus if the hypothesis about the relationship should be accepted (Russo & Stol, 2021). It does not contain any information about the strength of the relationship but only about the probability that it exists.

The statistical significance of a correlation is commonly calculated by computing the t-value and subsequently the p-value (Hair et al., 2011). The p-value is the probability of assuming a significant path coefficient when in fact it is not significant (Hair Jr et al., 2021). The maximum p-value for an observed effect to be statistically significant differs per discipline. In consumer research, researchers usually assume a critical significance level of 1%, in marketing 5%, and in exploratory research often 10% Hair Jr et al., 2021. Although I was unable to find a validated guideline specifically for the Enterprise Architecture discipline, a quick search for “ ”Enterprise Architecture” ”p-value” “ on Google Scholar showed only studies with a critical significance level of 5% on the first page (Ahmad et al., 2020; Foorthuis et al., 2020; Holm et al., 2014; Lange et al., 2012b, 2016; Plessius et al., 2014; Van Steenbergen et al., 2011). Therefore, I also use 5% as the critical significance level for the path coefficients.

P-values can be either one-tailed or two-tailed. *One-tailed* tests should be used for PLS-SEM when ”the coefficient is hypothesized to have a sign (positive or negative)” (Kock, 2015, p. 2), while *two-tailed* tests are recommended when ”no assumptions are made about the coefficient sign” (Kock, 2015, p. 2). Thus, in line with these guidelines, I use one-tailed tests for the hypotheses whose hypothesized sign is a ”+” and two-tailed tests for the hypotheses whose hypothesized sign is a ”+/-” (see Section 8.1). These two-tailed tests also apply for the moderation hypotheses specified without denoting the direction of the moderation effect.

G.0.4. Practical Significance of Path Coefficients

Based on the recommendation of Hair et al. (2019), I also evaluate the practical significance of the path coefficients. *Practical significance* can be considered as ”the magnitude of the observed effect and whether it is big enough to modify research conclusions” (Russo & Stol, 2021, p. 15). Assessing the practical significance is important because even though a correlation may be statistically significant, its strength might be too small to be useful for practical purposes. Because there is no consensus about the measurement of practical significance, I use expert judgments in line with the recommendation of Hair et al. Because this judgment boils down to a discussion of the results, the practical significance of the results is included in the discussion (see Section 9.3).

G.0.5. Explanatory Power

The *explanatory power* of a model is measured by the coefficient of determination, or R^2 (Hair Jr et al., 2021). It measures the variance explained in each of the endogenous constructs explained by the exogenous constructs linked to it (Shmueli & Koppius, 2011) and ranges from 0 to 1, where a higher value indicates a greater explanatory power (Hair et al., 2019). Acceptable R^2 values depend on the discipline, the model complexity, and the context (Hair Jr et al., 2021; Russo & Stol, 2021). For example, when predicting stock returns, an R^2 value of 0.10 is satisfactory (Raithel et al., 2012), in marketing research a value of 0.25 - 0.75 (Hair et al., 2019), and for inherently predictable physical processes a value of 0.90 (Hair et al., 2019). Due to the significant amount of noise present in the data (see Section 9) and the semi-exploratory nature of the research, I opt for the slightly more relaxed R^2 values proposed by Chin (1998), namely 0.19, 0.33, and 0.67, which are described by the author as weak, moderate, and substantial respectively.

G.0.6. Importance-Performance Map Analysis

An *Importance-Performance Map Analysis* (IPMA; also called priority map analysis, impact-performance map, or importance-performance matrix) relates the importance of each exogenous construct in increasing the endogenous construct to the average performance on these exogenous constructs of the respondents (Ringle & Sarstedt, 2016). Such a map is useful for understanding which EA factors should be prioritized in future research (namely those that are important for improving digital innovativeness but on which firms perform poorly). The map is created by following the four-step procedure proposed by Ringle and Sarstedt (2016) as shown in Figure G.1 (which is adapted from Figure 3 of the original paper (Ringle & Sarstedt, 2016)). The original paper splits creating a high-level IPMA map and a more detailed IPMA map into two separate steps while I consider them a single step.

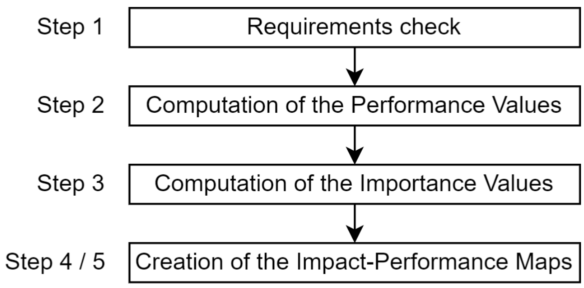

Figure G.1: Steps of an importance-performance map analysis, adapted from Figure 3 of the original paper (Ringle & Sarstedt, 2016)

Step 1: Requirements Check

The requirements of IPMA applications are as follows:

- All indicators must use a metric or quasi-metric scale
- All the indicator coding must have the same scale direction where the minimum value presents the worst outcome and the maximum value the best outcome
- The outer weight estimates must be positive

Given the research setup and the results I obtained, all requirements are satisfied.

Step 2: Computation of the Performance Values

The performance values are based on the indicator scores which are rescaled to a range between 0 (lowest performance) and 100 (highest performance) by the following formula:

$$x_{ij}^{rescaled} = \frac{E[x_{ij}] - min[x_i]}{max[x_i] - min[x_i]} * 100 \quad \text{(G.1)}$$

where x_i is the ith indicator in the PLS path model. $E[.]$ denotes indicator i's actual score of respondent j and $min[.]$ / $max[.]$ represent the indicator's minimum and maximum value, namely 1 and 5 respectively, in the case of the Likert scale used for this thesis.

Then, the standardized weight of each indicator is divided by its standard deviation to obtain the unstandardized weight. Subsequently, the unstandardized weights of the indicators that correspond to the same construct are rescaled such that their sum equals 1. The performance of a construct is then defined as the sum of the rescaled indicator scores times the rescaled unstandardized weight. A more elaborate explanation of this process, including an example, can be found in the original paper (Ringle & Sarstedt, 2016).

Step 3: Computation of the Importance Values

The original paper explains the calculation of the importance values for models where there are multiple paths from an exogenous to an endogenous construct. Because in my structural model, there is for each exogenous construct only a single path to the endogenous construct, the importance is defined as simply the unstandardized path regression coefficient (Ringle & Sarstedt, 2016).

Step 4 / 5: Creation of the Importance-Performance Maps

Based on the computed performance and importance values, the IMPA map can be created by scattering each construct's performance and importance value on a plot. The importance values are plotted on the x-axis and the performance values on the y-axis. To gain additional insights, I generate two IPMA maps, namely one for the impact of the statistically significant main constructs and one for its statistically significant formative dimensions.

H

SEM Step 5: Assessing the Structural Model - Extended Results

Whereas Section 8 presents the correlation of the EA constructs with the ”digital innovativeness” measure, this Appendix shows their correlation with each of the 8 components of the ”digital innovativeness” measure.

The components of the ”digital innovativeness” measure are - for the sake of conciseness - named β_1 until β_8, as illustrated in Table H.1.

The full mapping of the correlations between the EA factors and these components is shown in Table H.2.

The results are discussed in Section 9.3.

β	**Meaning**
β_1	The number of digital solutions introduced in the market is superior compared to our competitors’
β_2	The number of successful digital solutions is superior compared to our competitors’
β_3	The time to market for digital solutions is superior compared to our competitors’
β_4	The quality of our digital solutions is superior compared to our competitors’
β_5	The features of our digital solutions are superior compared to our competitors’
β_6	The applications of our digital solutions are totally different from our competitors’
β_7	Some of our digital solutions are new to the market at the time of launching
β_8	Some of our digital solutions serve new markets and customers

Table H.1: Matrix mapping of β, see next page

Main construct	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	Sub-construct	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8
Innovation-focused Enterprise Architecture design	0.29	0.29	0.29*	0.31	0.3	0.29	0.26*	0.22	1.1 - Support for pilots	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02
									1.2 - Modular design	0.25	0.25	0.25	0.27	0.26	0.25	0.23	0.19
									1.3 - Cloud usage	0.25	0.25	0.26*	0.27	0.26	0.25	0.23	0.19
									1.4 - Central data access point	0.23	0.23	0.24	0.25	0.24	0.24	0.21	0.18
									1.5 - Low-code usage	0.2	0.2	0.2	0.21	0.21	0.2	0.18	0.15
Innovation-focused alignment of To-Be architecture with business objectives	0.25	0.24	0.25	0.26**	0.26*	0.25	0.22	0.19									
Innovation-focused development of the proper architecture	0.37*	0.37*	0.37*	0.4**	0.39*	0.37	0.34	0.28	3.1 - Roadmap	0.14	0.14	0.14	0.15*	0.14	0.14	0.12	0.1
									3.2 - Feedback-driven EA design	0.37*	0.37	0.38*	0.4	0.39*	0.38	0.34	0.29
									3.3 - Agile EA working method	0.36	0.36	0.36*	0.38	0.37	0.36	0.32	0.27
Innovation-focused usage of the architecture	0.29	0.29	0.29	0.31**	0.3*	0.29	0.26	0.22	4.1 - EA visibility	0.26	0.26	0.27	0.28	0.27*	0.26	0.24	0.2
									4.2 - Strategy consultation	0.34	0.34	0.34	0.36*	0.35*	0.34	0.31	0.26
									4.3 - Program / project consultation	0.15	0.15	0.15	0.16	0.16	0.15	0.14	0.11
									4.4 - Compliancy verification	0.23	0.23	0.23	0.24*	0.24	0.23	0.21	0.18
									4.5 - Escalation / exception handling	0.16	0.16	0.16	0.17*	0.17	0.16	0.15	0.12
Innovation-focused implementation of the enterprise architect role	0.46*	0.46*	0.47**	0.5**	0.48***	0.47	0.42	0.36	5.1 - Architect recruitment	0.45*	0.45*	0.45*	0.48**	0.47**	0.45	0.41	0.35
									5.2 - Architect development	0.4	0.4*	0.41*	0.43**	0.42**	0.4	0.37	0.31
									5.3 - Architect time	0.18	0.18	0.18	0.19	0.18	0.18	0.16	0.14
									5.4 - Architect communication	0.35	0.35	0.36*	0.38*	0.37*	0.35	0.32	0.27
Innovation-focused enterprise architect behavior	0.32	0.32	0.32*	0.34**	0.33*	0.32	0.29	0.24	6.1 - Clear innovation ambition	0.38	0.38	0.38	0.4**	0.39*	0.38*	0.34	0.29
									6.2 - Linkage different innovations	0.29	0.29	0.29	0.31**	0.3	0.29	0.26	0.22
									6.3 - EA involvement innovation	0.1	0.1	0.1	0.11	0.11	0.1	0.09	0.08
									6.4 - Innovation impact analysis	0.2	0.2	0.21	0.22	0.21	0.2	0.19	0.16
									6.5 - Active EA opportunity scouting	0.37	0.37*	0.37	0.39*	0.38*	0.37	0.33	0.28
									6.6 - Innovation feasibility analysis	0.25	0.25	0.25*	0.26*	0.26	0.25	0.22	0.19
									6.7 - Innovation-driven To Be arch	0.28	0.28	0.28	0.3*	0.29	0.28	0.25	0.21
Digital innovation readiness	0.45	0.45*	0.45*	0.48**	0.47**	0.45	0.41	0.34*	7.1 - 7.3 - Resource readiness	0.3	0.3	0.3	0.32	0.31	0.3	0.27	0.23
									7.4 - 7.6 - Cultural readiness	0.28	0.28	0.29	0.3*	0.3	0.28	0.26	0.22
									7.7 - 7.8 - Innovation valance	0.34	0.34	0.34	0.36	0.35	0.34	0.31	0.26
									7.9 - 7.10 - Cognitive readiness	0.41	0.41	0.42	0.44**	0.43*	0.41	0.38	0.32
									7.11 - 7.13 - Partnership readiness	0.46**	0.46*	0.47	0.5*	0.48*	0.47	0.42	0.36

Table H.2: Matrix map of all correlations

I

Discussion - Interview Methodology

To gain more insight into the results and estimate their causality, I discuss with EA experts the findings of the thesis (as mentioned in Section 9). These experts are sampled as explained in Appendix L. In total, I conduct for the discussion of the findings 7 interviews with senior EA experts, all of whom have at least 10 years of EA-related consulting experience.

Based on evaluating the advantages and disadvantages of the various interview methodologies as outlined in Appendix K, I choose to use semi-structured interviews to discuss the findings.

Unstructured interviews would be unsuitable because I specifically want to discuss the findings of the research one by one.

Structured interviews would be unsuitable because I want the experts to think freely and not be bound too much by a specific conversation structure when thinking about the results; interesting digressions that add new perspectives to the interpretation of the results are more than welcome.

Semi-structured interviews allow me to steer the interviews in the right direction by asking specific questions and simultaneously gaining rich data for understanding the responses.

To this end, I use the protocol shown in Table I.1 as a guideline for the interviews.

The interviewees all got the results several days before the actual interview to be able to think about the content beforehand.

After interviewing the experts, the results are combined, synthesized, and added to the discussion in Section 9.

Semi-Structured Interview Protocol
Introduction
General introduction • Thank the person for his/her time • Objective of the research • Objective of the interview • Agenda of the interview *Permission & Expectation Management* • Verify time expectations: "Is it correct that I scheduled 30 minutes to have this interview?" • Indicate the interview is completely anonymous and no information that could be traced down to the respondent is stored other than that the person works for Deloitte Consulting • Ask if the person would like to review the final report before being publicly disclosed
Main questions
• Would you expect the EA factors that were found to have a statistically significant correlation with digital innovativeness to correlate indeed with digital innovativeness? • Would you expect these correlations to be causal, reverse-causal, or both? (where reverse-causal means that an increase in a firm's digital innovativeness is likely to cause an increase in a particular EA factor) • Would you expect the EA factors that have not a statistically significant correlation with digital innovativeness to have no such correlation indeed? • Would you expect the results to be generalizable to other firms, despite the overrepresentation of financial and governmental organizations in this research? • What are the most important limitations of this research, in your opinion, and how can future research address these limitations?
Ending
• Summarize the main conclusion from the interview • Mention when the interviewee will hear from you when this person mentioned at the introduction that he/she would like to receive the final version of the report • Thank the person again for his/her time

Table I.1: Interview protocol used for obtaining expert insights on the results

J

Comparison Data Collection Methods

This appendix presents a comparison between various data collection methods based on their advantages and disadvantages. The information is synthesized from the work of Hair et al. (2007) and Paradis et al. (2016).

	Advantages	**Disadvantages**
Face-to-face interviews	• Can clarify doubts about the questionnaire • Can pick up non-verbal cues • Opportunity to establish rapport with the interviewees • Difficult things to articulate can be brought up	• Potential for introducing interviewer bias • Can be expensive if a large number of subjects are involved • Geographical limitations
Telephone interviews	• Number of calls per day could be high • Convenient when contact subjects are dispersed over various geographic regions • Efficient when one has specific, structured questions to ask	• The interviewer cannot observe the nonverbal responses of the respondents • Interviewee can block the call
Observational studies	• Can help to comprehend complex issues through direct observation • The data is rich and uncontaminated by self-report bias	• Expensive, since long periods of observation are usually required • Observer bias may well be present in the data
Personally administering questionnaires	• Can establish rapport with the respondents while introducing the survey • Can provide clarification on the spot • Can collect the questionnaires immediately after they are completed	• Administering questionnaires personally is expensive • Inconvenient when the sample is widely dispersed geographically
Electronic questionnaires	• Efficient when responses to many questions have to be obtained from a sample that is geographically dispersed • Very cheap	• Typically a low response rate • Might be biased since the nonrespondents may be different from those who did respond
Focus groups	• Can provide a rich, multidimensional perspective on a situation • Less time-consuming than observation or individual interviews	• Participants may share less information when they are in a group • Might be harder to conduct when topics are controversial or certain personalities are hard to manage • Transcription/note taking can be more challenging
Textual or content analysis (literature review)	• Many document are easily available online • Time and cost efficient • Access to information and previously gathered insights that would otherwise be hard to obtain	• All manually written sources, especially peer-reviewed articles, are not entirely up-to-date • Ability to gather information limited to the information contained in the documents

Table J.1: Advantages and disadvantages of the most common business research methods, synthesized from (Hair et al., 2007; Paradis et al., 2016)

K

Comparison Interview Formats

This appendix presents a comparison of three important interview formats based on their advantages and disadvantages. This comparison is quoted from Owen and Noonan (2013).

	Advantages	**Disadvantages**
Unstructured interviews *Starts with a broad question concerning the area of the study, with subsequent questions dependent on the participant's responses*	• Questions are not restricted • Useful when little is known about a topic or for collecting background data	• Processing can be difficult and time-consuming when participants talk about irrelevant issues • Requires excellent active listening and communication skills • Prone to researcher bias
Semi-structured interviews *Involves the use of predetermined questions, where the researcher is free to seek clarification*	• The open nature of the questions encourages depth, increasing the validity of the study • The researcher can explore new paths that emerge during the interview that may not have been considered initially	• Might be hard to identify where to ask prompt questions or probe responses
Structured interviews *Every participant is asked the same question in the same order and wording*	• Efficient with regards to time • Limits researcher subjectivity and bias • Easier to code, compare and analyse data because the researcher control the topics and format of the interview	• No room for elaboration • Recommended to be used only by qualitative researchers to elicit sociodemographic data (Holloway & Galvin, 2016)

Table K.1: Comparison of interview formats, quoted from Owen and Noonan (2013)

L

EA Expert Sampling Methodology

This appendix contains more information on how EA experts were sampled for interviews for this thesis. These EA experts were interviewed for three purposes:

1. To validate the structural model, see Section D
2. To validate the measurement model, see Section E.0.2
3. To validate the results and provide insights into potential cause-effect relationships, see Section 9

For each purpose, the EA experts are sampled along the same steps that are based on the guidelines from Martínez-Mesa et al. (2016):

1. **Define the population**
   All individuals who have sufficient knowledge about EA to be able to reflect on how mature EA capabilities are in companies in general and which ones are important.
2. **Determine the sample frame**
   A list of 37 EA consultants with at least 2 years of relevant work experience working for Deloitte Consulting
3. **Determine the sampling design**
   By following the sampling method decision tree of created by Hair et al. (2007) (see Figure L.1), I choose judgment non-probabilistic sampling. This is a type of purposive sampling specifically used for interviewing experts. Providing an extensive overview of the meaning of all terms in Figure L.1 is not included in this thesis for the sake of brevity, but these terms are explained in detail by Hair et al. (2007).
4. **Determine the appropriate sample size**
   Continue sampling until theoretical saturation
5. **Execute the sampling process**
   Based on the previous steps, experts are randomly selected to be interviewed.

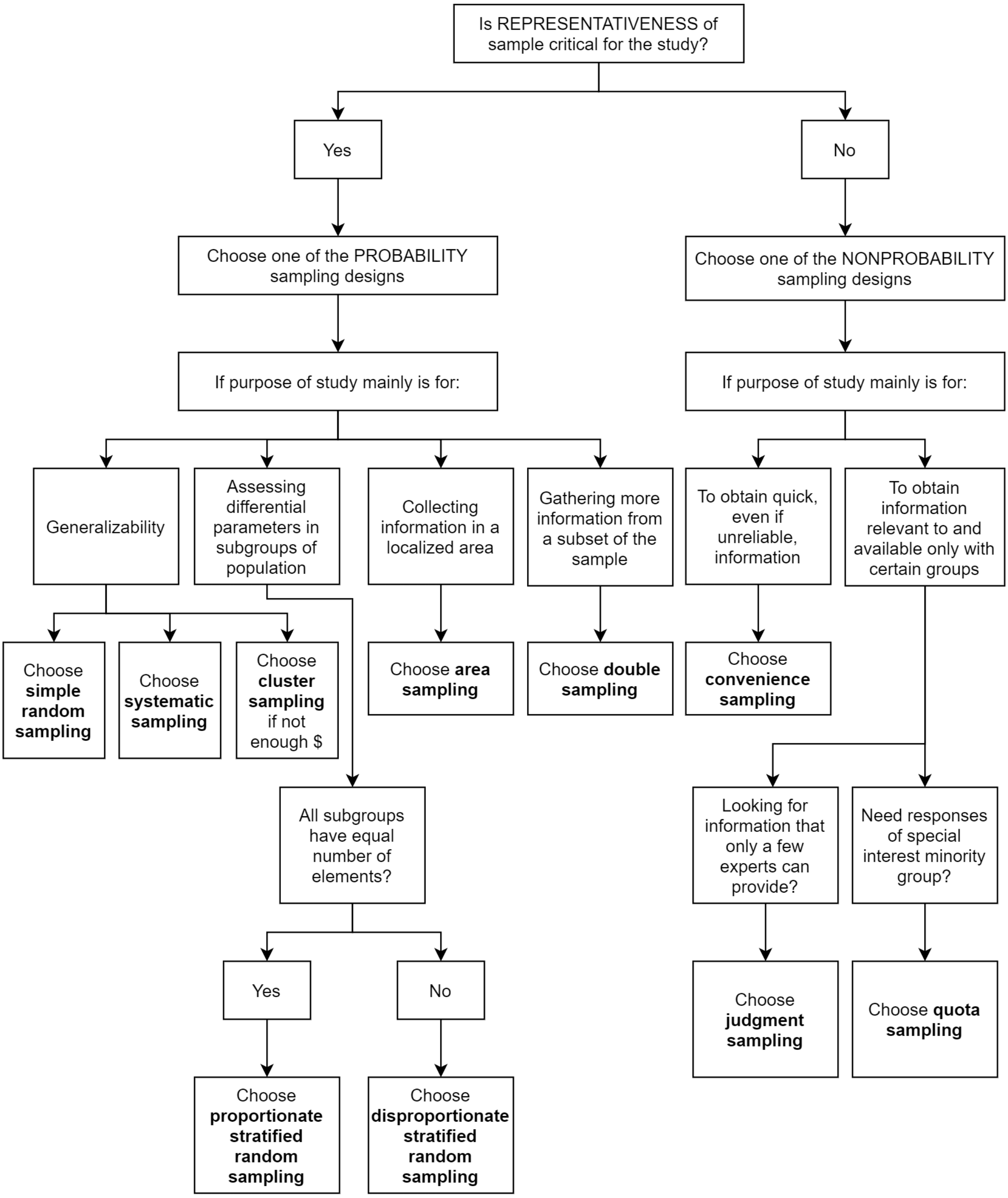

Figure L.1: Decision tree to choose the proper sampling method (Hair et al., 2007)

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