INVESTIGATING THE CHARACTERISTICS OF A DIGITALLY AGILE ORGANIZATIONAL STRUCTURE FOR CONSTRUCTION COMPANIES

by

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DEDICATION

To the most agile organizations I have ever known:

My Family and Friends.

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ABSTRACT

INVESTIGATING THE CHARACTERISTICS OF A DIGITALLY AGILE ORGANIZATIONAL STRUCTURE FOR CONSTRUCTION COMPANIES

As the architecture, engineering, and construction (AEC) industry embraces digital transformation, the need for digitally agile construction organizations (DACOs) becomes more tangible. According to the literature, the structure of a company's organization may have an impact on its digital agility. However, no studies have been conducted to investigate the relationship between construction firms' organizational structures and their business models' digital agility. This study seeks to fill this gap by conducting exploratory sequential mixed-method research, beginning with the collection of qualitative data from the literature and continuing with in-depth semi-structured interviews with experts. Following that, directed content analysis is conducted on the qualitative data to identify recurring themes in the context of construction companies' digital transformation, provide a hypothetical definition for digitally agile organizational structure, create a hypothetical model based on defined latent variables, and define measurement factors. Then, a questionnaire is created to put the hypotheses to the test. Partial least squares structural equation modeling (PLS-SEM) is used for this test. According to the findings, a digitally agile organizational structure is less formalized, complex, and highly integrated, and it fosters the digital agility of a construction company's business model while also providing a fertile environment for agile leadership. Furthermore, construction companies must develop a digital organizational culture through educational programs in order to reduce employee resistance to digital transformation and communicate the change to them. This study adds to the body of knowledge in the field of organizational studies in the contexts of construction management and digital transformation by providing insights into DACOs and paving the way for future research on the subject.

ÖZET

İNŞAAT FİRMALARI İÇİN DİJİTAL OLARAK ÇEVİK BİR ORGANİZASYON YAPISININ ÖZELLİKLERİNİN İNCELENMESİ

Mimarlık, mühendislik ve inşaat (MMİ) endüstrisi dijital dönüşümü kucakladıkça, dijital olarak çevik inşaat organizasyonlarına (DOÇİO'lar) duyulan ihtiyaç daha somut hale geliyor. Literatüre göre, bir şirketin organizasyon yapısının dijital çevikliği üzerinde etkisi olabilir. Ancak inşaat firmalarının organizasyon yapıları ile iş modellerinin dijital çevikliği arasındaki ilişkiyi araştıran herhangi bir çalışma yapılmamıştır. Bu çalışma, literatürden nitel verilerin toplanmasıyla başlayan ve uzmanlarla derinlemesine yarı yapılandırılmış görüşmelerle devam eden, keşfedici sıralı karma yöntem araştırması yaparak bu boşluğu doldurmayı amaçlamaktadır. Ardından, inşaat şirketlerinin dijital dönüşümü bağlamında tekrar eden temaları belirlemek, dijital olarak çevik organizasyon yapısı için varsayımsal bir tanım sağlamak, tanımlanmış gizil değişkenlere dayalı varsayımsal bir model oluşturmak ve ölçüm faktörlerini tanımlamak için nitel veriler üzerinde yönlendirilmiş içerik analizi yapılır. Ardından, hipotezleri test etmek için bir anket oluşturulur. Bu test için kısmi en küçük kareler yapısal eşitlik modellemesi (PLS-SEM) kullanılmıştır. Bulgulara göre, dijital olarak çevik bir organizasyon yapısı daha az resmi, karmaşık ve yüksek düzeyde entegredir ve bir inşaat şirketinin iş modelinin dijital çevikliğini desteklerken aynı zamanda çevik liderlik için verimli bir ortam sağlar. Ayrıca inşaat şirketleri, çalışanların dijital dönüşüme karşı direncini azaltmak ve değişimi onlara iletmek için eğitim programları aracılığıyla dijital bir organizasyon kültürü geliştirmelidir. Bu çalışma, DOÇİO'lara içgörü sağlayarak ve konuyla ilgili gelecekteki araştırmaların önünü açarak inşaat yönetimi ve dijital dönüşüm bağlamında organizasyonel çalışmalar alanındaki bilgi birikimine katkıda bulunmaktadır.

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LIST OF ACRONYMS / ABBREVIATIONS

AEC	Architecture, Engineering, and Construction
AVE	Average Variance Extracted
BIM	Building Information Modelling
BSc	Bachelor of Science
CB-SEM	Covariance-Based Structural Equation Modeling
CDO	Chief Digital Officer
CEO	Chief Executive Officer
CIO	Chief Information Officers
DACO	Digitally Agile Construction Organization
DAO	Decentralized Autonomous Organization
DT	Digital Transformation
Ed.	Education
Ex.	Experience
H.	Headquarters
IT	Information Technology
MSc	Master of Science
PBO	Project-Based Organization
PhD	Doctor of Philosophy
PLS-SEM	Partial Least Square Structural Equation Modeling
QV	Qualitative Variable
R&D	Research and Development
SEM	Structural Equation Modeling
SME	Small and Medium-sized Enterprise
SMO	Self-Managing Organization
UAE	United Arab Emirates
UK	United Kingdom
USA	United States of America

VUCA	Volatile, Uncertain, Complex, and Ambiguous

1. INTRODUCTION

The digital world in which today's businesses operate has become more volatile, uncertain, complex, and ambiguous (VUCA) [1]. Organizations need to develop and improve organizational flexibility, accountability, and agility to gain competitive advantage and use a common business vocabulary across the whole organization to survive in a digital vortex [2]. So, the digital world complicates businesses and forces them to transform. To deal with these complexities, organizations must develop adaptable open systems. Systematic thinking manifests itself in the conception of organizational structure. Elements, relationships between elements, and structure collectively make up the organization. An organization's philosophy of existence is embodied in its structure, which is a complex combination of the relationships between its various elements. The division, organization, and coordination of organizational activities are all accomplished through the use of organizational structure. Organizations developed structures to coordinate the activities of various work factors and to regulate the performance of their members [3]. Organizational structure is crucial for any expanding business because it offers direction and clarity on particular human resource issues, like managerial authority. Organizational structure is therefore essential for making decisions. Additionally, organizational structure refers to how a business is set up to achieve its particular objectives [4].

The efficiency of work, employee enthusiasm, and coordination between upper management and deputies are all influenced by organizational structure, which helps to sketch out future plans. Therefore, organizational structure is a means by which authority and responsibility are distributed among organizational members and work processes are carried out. A construction organization is temporary since it is project-based and requires flexibility because of the uniqueness of each project [5]. This is what distinguishes construction organizations from manufacturing or technology organizations and makes them a unique case for study. As a result, any type of transformation carried out in these organizations must be conducted in a series of projects and in accordance with a long-term strategic plan [6]. In this study, I attempt to understand the relationship between construction

companies' organizational structures and the digital transformation process they are undergoing.

1.1. Statement of the Problem and Importance of the Study

Through omnipresent infrastructure and adaptable platforms, digital technology is allowing businesses to create new products and services and increase the scope and variety of social interactions [7]. Digital technologies have the potential to transform established business models and evoke organizational change [8-10]. From an evolutionary perspective, a firm's long-term performance and survival likely depend on its ability to adapt to unexpected changes in its environment caused by digital technologies [11, 12]. Studies show that as a consequence of digitalizing its core business processes, a firm may gain a competitive edge [13]. In this regard, corporate agility is directly related to the rapidity with which a firm's environment changes and has been a major issue for many firms. However, drastically changing a company strategy to take advantage of new technologies is neither effortless nor simple [14].

The AEC industry is not considered a technology-friendly sector, and it has lagged behind other industries such as manufacturing and technology in adopting new digital technologies [15-17]. This is contradictory to the fact that the construction sector is of key importance to the development of the world economy, and the prospects of intensive development of the sector in the future related to rapid urbanization and investment based on it plus the construction of smart cities and all related infrastructure should also be taken into account [18]. According to some researchers, construction is also the true manifestation of economic growth in any nation [19, 20]. It is assumed in the literature that this industry, like all other industries, will undergo digital transformation if it wants to survive in the digital vortex of the future world [21].

There is substantial documentation and modeling of change and transformation management in the construction industry, but only a few relate to the changes brought about by digitalization since the sector has clung to its conventional techniques and has been

reluctant to change [22, 23]. The impact of digitalization on the construction industry must be investigated in order to understand how to reduce or avoid the negative impacts of traditional techniques in the form of a maturity model [24].

To undergo digital transformation, organizations need to use knowledge management as a lever [25]. Construction firms, however, are confronted with significant difficulties in terms of knowledge sharing and management. This is because construction organizations are project-based organizations, and they do the majority of their work in the form of projects (PBOs) [26]. This makes them a unique case because projects force organizations to perform in novel ways, which results in the generation of knowledge. Construction organizations have been doing a poor job of capturing knowledge benefits, and it was discovered that modifying existing processes and procedures occurred much more frequently in projects with a knowledge strategy [27]. The issue may be traced back to the organizational structures that construction businesses are used to [28]. On the other hand, the concept of digital functional areas or transformed IT departments has emerged as a critical contributor to organizations' efficiency and agility in the digital era [29]. The IT function is inextricably linked to knowledge management [30, 31], and its contribution to the digital world must be studied.

Moreover, it is important to notice that only when an organization decides how it wants its members to behave, what attitudes it wants to encourage, and what it wants its members to accomplish can it design its structure and encourage the development of cultural values and norms to obtain these desired attitudes, behaviors, and goals [32]. Because communicating change to employees and creating organizational culture is such an important part of the change as it resolves staff resistance, communication management may play an important role here [33]. According to research, future IT departments in organizations may be able to assist with communication management [34].

One other important factor when studying digital transformation and its effects is leadership. Organizational agility in a digital world can be attained through effective leadership. Leaders must be able to adapt to change, think for the benefit of the entire organization, and be willing to share resources for innovative projects or particular initiatives that are not always tied to the strict key performance indicators [28]. The characteristics of

agile leadership and its effects on the digital transformation process through valuing digital agility have not yet been studied in the context of construction organizations.

Overall, digital transformation introduces numerous new concepts to organizations across all industries. The construction industry is not immune, and studies indicate that, sooner or later, construction organizations will be affected by digitalization waves and forced to implement organizational changes to survive in a digital world. This study aims to provide practitioners and construction management researchers with information on this critical topic. This work explores the unknown in the context of organizational studies in the construction industry. In this regard, as studies suggest that digital agility is a core characteristic of organizations pursuing digital transformation [35], and there is no study investigating the relationship between organizational structures and digital agility of company business models [29], particularly in the context of AEC organizations, this study attempts to touch on this missing link and contribute to the literature by taking the first step towards this subject. Furthermore, this research tries to see if construction companies can benefit from changing the role of IT departments to more integrated ones, which could help with knowledge and communication management by stimulating ambidexterity. This study also attempts to define agile leadership in the context of organizational structures and digital agility.

1.2. Research Aims and Objectives

This study aims to provide insights into the characteristics of an organizational structure that suits digitally agile business models and assists construction organizations in navigating digital transformation with minimal intra-organizational friction. The main question this study wants to answer is whether there is a meaningful relationship between a construction company's digitally agile organizational structure and the digital agility of its business model. The objectives of this study are:

1. Investigating the relationship between the structural elements of digitally agile construction organizations and the digital agility of their business model using SEM.

2. Examining the role of agile leadership in the development of an effective relationship between a digitally agile organizational structure and digital agility using SEM.
3. Examining the role of digital functional areas (transformed IT departments) in the relationship between a digitally agile organizational structure and digital agility using SEM.
4. Defining the role of change management in construction firms in order to accelerate the digital transformation process using a content analysis on the literature and interview data.
5. Paving the way for future research on the role of organizational elements in the digital transformation of construction companies and proposing new research avenues and agendas.
6. Discussing the possibility of using flatter organizational structures such as holacracies for construction companies.

1.3. Research Methodology

Because this study is exploratory in nature, I use an exploratory sequential mixed-method approach to collect, interpret, and analyze data. I conduct in-depth, semi-structured interviews with AEC industry experts to investigate their concerns and understand their points of view. The qualitative data is recorded, transcribed, and analyzed using a directed content analysis methodology. After collecting data via questionnaires, I use SmartPLS 3 to perform a PLS-SEM analysis on the data and test my hypotheses. Finally, the findings from both the qualitative and quantitative stages are discussed and interpreted.

1.4. Scope and Limitations

The scope of this research is to look into the relationship between the digitally agile organizational structure of construction companies and the digital agility of their business model. This study focuses on project-based organizations (PBOs), which are temporary

organizations formed by construction companies to manage their projects. It also attempts to shed light on the importance of concepts such as digital organizational culture, digital functional areas, and agile leadership that have not been studied in the context of digital transformation in the construction industry. The findings of this study are primarily applicable to small to large construction organizations with headquarters in North America, Europe, and the Middle East. The qualitative portion of this study's findings are advised not to be generalized because the qualitative information was primarily obtained through interviews with Middle Eastern specialists.

Digital transformation is in its early stages, and the construction industry has only recently been introduced to it. As a result, the literature on digital transformation in the construction industry is limited. Furthermore, few works address the organizational aspects of this transformation in the AEC industry. So, the questionnaire items and hypothetical model of this study are derived from business administration, management, and organizational studies, as well as expert knowledge gathered from construction professionals. Because the study relies on expert judgment and literature to develop and analyze hypotheses, it is subjective and should be categorized as a perception-based study.

1.5. Organization of the Thesis

This dissertation is divided into six chapters. The first chapter (introduction) briefly states the significance of the study and the problem for which it seeks a solution. Following that, I define the goals and objectives and briefly discuss the methodology, scope, and limitations of this study. The second chapter (background) examines the existing literature on a wide variety of topics ranging from organizational structures to digital transformation and change management in the construction industry. This chapter identifies the gaps in the literature that this research tries to fill. The third chapter (methodology) presents and explains the study's research methodology. This chapter describes in detail the research methodology flowchart, hypotheses, semi-structured interviews, questionnaire design, data collection, and qualitative and quantitative analysis methods. The fourth chapter (results and findings) presents data analysis and findings, while the fifth chapter (discussion) discusses

the results. The fifth chapter also discusses the limitations and future research directions. Finally, chapter six (conclusions) summarizes the study's findings. The study's contributions are also included in the conclusion section. The semi-structured interview form, questionnaire, and tables used in the discussion chapter are included in the appendices.

2. BACKGROUND

2.1. Organizational Structure: Definition, Elements, and Design

It is a social unit with clearly defined boundaries that works together to accomplish a shared objective or set of goals on a regular basis. In this definition of an organization, it is acknowledged that the interaction patterns of members must be officially coordinated. An organization's structure determines how duties are assigned, who reports to whom, and the protocols for formal coordination and communication within the company [36].

The concept of an organization acknowledges the need for formal coordination of the interactions of its members. The structure of the organization provides the framework for the various mechanisms that will be used to manage the tasks and interactions of its members. The complexity, formalization, centralization, and integration of an organization's structure are the three components used to define it based on the literature.

Before discussing the elements of an organizational structure, one must first define another essential term: organizational design. A well-designed organization is one that can achieve its goals and build a strong foundation for its future; like building a house, which usually begins with a goal, constructing an organization is similar to creating a blueprint for a project. The designer then creates a plan that explains how the organization will achieve its goals. Contrary to what many executives appear to believe, there is significantly more to an organization's design than simply altering its structure. As Tom Peters puts it, "structure is not organization." [37]

Although structure is a central component of organizational design, it is not the only aspect of the design process. Other factors such as the culture and leadership of an organization are also taken into account. Organizations have developed various ways to structure their work units in order to divide them up. As the Information Age continues to evolve, more forms of organizational design are likely to emerge [38].

The various divisions of a company are organized into systems that try to coordinate their efforts. An organization's structure is like a skeleton, which defines its various power relationships and spatial relationships. Its skeleton helps organize the body's resources to accomplish its task. An organization's systems are similar to the systems of a body, which move and engage in activities around the skeleton. They include various tasks and activities such as recruitment, management development, reward, and information processing. Some of the other systems that are part of an organization include finance, production, and sales. The structure of an organization is very important to its success. It determines the overall performance of the company and its various systems. If the structure does not align with the company's strategy and the various systems that are part of it, then its effectiveness will be compromised [38].

In the following subunits, I first introduce the four elements of an organizational structure. Then, I talk about the importance of systems perspective and define its characteristics. For this background to be elaborate, I then discuss some of the most important factors affecting an organization's structure, such as strategy and industry, size of the organization, technology, environment, and power control. I continue my discussion by introducing different organizational structures used by companies over time. Finally, I review the literature on project organizations and the history of organizational design in the construction industry to round out this section.

2.1.1. Elements of Organizational Structure

Formalization generally refers to the codification of the rules and procedures that an organization uses to direct the behavior of its employees. Some companies have strict guidelines that prevent employees from doing certain activities, while others have more flexible regulations that allow employees to do certain things.

The complexity of an organization is measured by the various levels of specialization and division of labor it has. This includes how many levels there are in its hierarchy and how widely spaced out its units are. The organization process becomes more complicated as the number of tasks and levels of specialization rise. As a result, the term "complexity" is a relative one.

The centralization of decision-making authority occurs when the authority to make decisions lies somewhere in an organization. In some cases, this can be as high as the top executives. In other cases, it can be as decentralized as the decision-making process is. As with the formalization and complexity, organizations are not necessarily either decentralized or centralized. On the other hand, decentralization and centralization are two extremes that can be represented by a continuum. The placement of an organization on this continuum is very important to determine if it has the right type of structure.

The concept of organizational integration refers to the ability of various organizational components to effectively respond to each other and pursue common goals [39, 40]. The term “component” refers to an organization’s various sub-systems, such as functions, external partners, and organizational units. In today’s knowledge age, organizational integration is more important than ever before. For instance, if a company has an integrated supply chain, its marketing function can work with its R&D department and its key supplier to develop new products [41].

Two major types of enterprise integration problems are usually distinguished: intra-enterprise integration and inter-enterprise integration [42]. Intra-enterprise integration can be achieved by imposing company standards on the enterprise. Inter-enterprise integration concerns have emerged with the concepts of extended enterprise or networked organization. The key to success is to build networks of enterprise entities to control the entire supply chain to serve the customers better worldwide [43].

Also, three levels of integration are differentiated in the literature [42]: physical system integration, application integration, and business integration. Physical system integration involves system interconnection and message passing using computer communications networks, while application integration involves interoperability and distributed cooperative applications. This last characteristic of the organizational structure is what organizational theorists find necessary to create a system.

2.1.2. Systems Perspective

Systems perspective is a widely used concept among organizational theorists to gain deeper insight into the workings of an organization [44]. It shows how interconnected and interdependent parts of the system are arranged. The unique characteristic of this concept is how the parts of the system are interrelated. The concept of systems refers to two forces that are responsible for the development and maintenance of a system: differentiation and integration. The former involves the creation of specialized functions that are differentiated from the rest, while the latter involves the integration of all parts. In organizations, the goal of integration is usually achieved through the establishment of appropriate levels of hierarchy and supervision. This can be achieved through the use of rules, procedures, and policies. Systems also require integration to ensure that the various parts of the system are not separated.

Systems are typically classified as either open or closed [44]. The latter is the result of the philosophy of the physical sciences, which focuses on the system's self-contained nature. The former, on the other hand, is more practical, as it assumes that the environment does affect the system. Ideally, a closed system would be one that doesn't require energy from outside sources. The open system takes into account how the system and its surroundings change over time. Clearly, no one can argue that organizations are closed systems [44]. The environment provides raw materials and human resources to organizations. They also rely on the environment's clients and customers to absorb their output. Figure 2.1. shows an easy-to-understand picture of the open system.

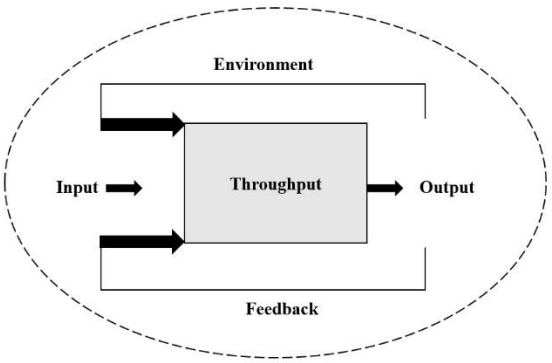

Figure 2.1. Basic open system.

Daniel Katz and Robert L. Kahn discuss the characteristics of an open system in their book [45]. As these concepts will be utilized repeatedly in the following chapters, I wish to mention them briefly here. The components of an open system are understood to be dependent on one another and the surrounding environment. This feature is referred to as environmental awareness [45]. This should be noted that there is always a boundary that limits the extent to which changes in the environment can affect the system's attributes. Through the continuous flow of information from its environment, an open system can adjust its settings to take into account the changes brought about by the environment. This process is called environmental feedback, and it allows the system to modify its outputs in order to get the most out of them. An open system also is a cycle of events that can be repeated. Its outputs provide the necessary inputs to allow the cycle to continue. For instance, if a company's revenue is insufficient to meet the wages and salaries of its employees and repay loans, its survival might be threatened.

The term "entropy" describes a system's tendency to deteriorate or fail [45]. As previously mentioned, a closed system will eventually come to an end because it is unable to import fresh energy or acquire fresh inputs from its surroundings. On the other hand, an open system can maintain its structure and avoid death due to its negative entropy. The energy that is used to arrest the entropy contributes to a steady state, as it does so in exchange for energy. Despite the continuous flow of new inputs and outputs, the system's character remains the same. The reason for this is that an open system tends to preserve its own state over time even as it processes inputs to produce outputs.

The steady-state characteristic refers to the state of a primitive or simple open system. As an open system becomes more complex, it expands and grows while maintaining its survival. The steady-state thesis is not in conflict with this. Large and complex systems are designed to acquire a certain level of safety to ensure their survival. It is also worth noting that expansion has no direct effect on the fundamental system. The most typical growth pattern is one in which the same type of cycles or subsystems are multiplied over and over again. The system's quantity fluctuates while its quality remains constant.

An open system seeks to reconcile two conflicting activities. One involves maintaining the system's balance, while the other involves adapting to changes in its environment. This

is done to prevent rapid changes that could unbalance the system. On the other hand, adaptive activities are needed to allow the system to adapt to changes in its external and internal demands. The latter is what I will emphasize recurrently throughout this dissertation. While one aims to maintain the status quo by purchasing, overhauling, and training new employees, the other focuses on developing new products and procedures. This process involves planning and implementing strategies and procedures that will allow the company to compete in the market [45].

Maintaining and adapting to changes in the environment are two of the most important factors that a system needs to survive. Stable organizations that are well-equipped to handle the changes in their environment will last long. On the other hand, an organization that is unstable and incapable of adapting to changes will not be able to survive. According to the notion of equifinality, there are various strategies for achieving organizational objectives [45]. It suggests that an organization can achieve its goals through a variety of transformations and inputs. This allows it to reach the same final state regardless of its initial conditions. As I talk about the managerial implications of the organization theory in Section 2.6, it is important that one keeps in mind the concept of equifinality. This will allow managers to think of various solutions to a given problem instead of settling for a single strategy.

Although the systems perspective can be considered a tool for solving organizational problems, it should not be viewed as a cure-all. Instead, it should be viewed as a framework that can be used to guide managers in making informed decisions. This is because its abstractness makes it difficult to provide managers with suggestions on what actions to take next. Nonetheless, this perspective will benefit the objectives of this academic work and provide the concepts necessary for further discussion.

2.1.3. Strategy and Industry

The concept of structure was first presented as a rational means to achieve goals. However, over the years, various factors, and on top of them strategy, have emerged that are vying for the title of “major determinant of structure.” [46] One of the most common factors that has emerged is the concept of strategy. It refers to an organization’s long-term goals and

a course of action that will allow it to achieve them [47]. Some view it as a strategy that's planned in advance, while others believe it is a pattern that is evolved over time [48]. Chandler [47] looked at over a hundred of America's biggest corporations and came to the conclusion that "structure follows strategy." While this thesis has a lot of support [49-52], the limitations of his research prevent any broad generalization of his findings. Through a four-category structure typology, Miles and Snow [53] were able to provide a framework for structural predictions. Their findings revealed that major tobacco companies were able to use this strategy to their advantage.

According to Porter, there are four distinct strategic paths that organizations can take: "cost leadership, differentiation, focus, or stuck-in-the-middle." For the first two procedures, specific structural predictions could be made [54, 55]. The purpose of cost leadership is to generate efficiency through tightening controls, lowering overhead, and taking advantage of economies of scale. High levels of complexity, formalization, and centralization in the structure are ideal for achieving this goal. However, a differentiation strategy focuses on developing distinctive offerings. This calls for flexibility and adaptability, which can be achieved through informal structures and distributed authority [56, 57].

In his study, Miller presented a framework that combines the work of Porter, Miles, and Snow. It features four dimensions that are focused on marketing differentiation, innovation, cost control, and breadth [58]. In general, critics of the strategy imperative have centered on three points: managerial leeway in adjusting strategy may be significantly lower than assumed [36]; due to the time lag, the relationship between strategy and structure may seem distant in environments with low levels of competition [59-61]; and instead of the opposite, structure may dictate strategy [59].

Concepts of strategy and industry are tightly connected to each other. The industry in which an organization operates was identified as a significant factor determining its strategy and, consequently, its structure [62]. Different industries have different development prospects, regulatory restraints, entrance barriers, etc. The majority of companies within an industry share these traits. Consequently, firms within the same industrial category have comparable organizational structures [62].

2.1.4. Organization Size

As an organization recruits more operational workers, it will want to capitalize on the cost savings that come with expertise. As a result, there will be more horizontal differentiation. Similar functions should be grouped together to improve intragroup efficiencies, but this will come at the expense of intergroup interactions, which will deteriorate as each does its own activity. To coordinate the horizontally differentiated units, management will need to increase vertical differentiation. This increase in size will almost certainly result in spatial differentiation. The ability of top management to supervise the operations directly within the business would be harmed as a result of this increased complexity. As a result, the adoption of official legislation and requirements will take the place of the control attained through direct observation. This increase in formalization may be followed by even more vertical differences as management establishes new units to coordinate the diversifying and expanding activities of organizational members. Finally, it becomes more challenging for senior executives to make quick and informed decisions as top management distances itself from operations. Decentralized decision-making should take the place of centralization as the solution. It can be understood how variations in size lead to large structural changes following this logic. The relationship between size and structure, however, is not clear [63]. The lengthy and convoluted discussions regarding the relationship between size and organizational structure elements are beyond the scope of this thesis, so I will not engage in them.

J. R. Kimberly, along with 80 percent of organizational theorists who use size as a variable, define it as the total number of employees [64]. This definition of size works mostly for businesses composed solely of full-time employees. Despite the consensus among researchers, there are dissenting opinions around this definition. Nina Gupta, in her 1980 article, “some alternative definitions of size,” argues using a count of the total number of employees as the measure of organizational size inherently mixes size with efficiency [65]. Is one company twice as large or only half as efficient as another if one hundred individuals are required to do the same tasks as fifty persons in another? These questions do not have straightforward answers, and I will not be discussing them in this dissertation.

Although it is possible to argue that size measurements cannot be compared across different scales [66], considering that the total number is closely related to other measures of size, the majority of studies point to the total number of employees being as useful as many other measures. As a case in point, researchers discovered a 0.78 correlation between the number of employees and the company's net assets [67]. In hospitals and colleges, the number of staff appears to be valid. The average daily patient load and the total hospital labor force have a correlation of greater than 0.96 [68], while the correlation between full-time and part-time faculty size and enrollment of students is greater than 0.94 [69]. From these studies, one can conclude that the total number of employees appears to have a strong correlation with other prominent measures of size. As a result, it ought to be a reasonably reliable measurement across enterprises.

2.1.5. Technology

Technology is another consideration that affects organizational structure. The information, equipment, procedures, and processes required to transform inputs into outputs in an organization are referred to as technology. That is, technology examines how inputs are transformed into outputs. There is also agreement that, despite its mechanical or manufacturing meaning, the concept of technology applies to all types of organizations [36].

The concept of technology as a determinant of organizational structure was first introduced during the 1960s. This was the work of Joan Woodward [70], who focused on production technology. Her research was the first attempt to look into the structure of organizations from a technological perspective [70]. In the south of England, Woodward selected about a hundred manufacturing firms. These ranged in size from around two hundred to over a thousand employees. She gathered data that allowed her to calculate various measures of structure. Her research question was simple: Is there a link between structural form and effectiveness?

Her attempts to link common structures to efficacy failed miserably. Because the structural variation among the organizations in each of her effectiveness categories was so considerable, it was impossible to draw any valid conclusions or establish any relationship between what was considered sound organizational structure and effectiveness.

Relationships between structure and effectiveness were apparent only after Woodward categorized the enterprises according to their normal mode of production technology.

In order to study the various structures of companies, Woodward put them into three categories: mass production, unit, and process production. She found unit producers to be the least complex, while process producers were the most complex. Woodward discovered that these technological classifications had distinct correlations with the firms' eventual structure and that the efficiency of the organizations was connected to the "fit" between technology and structure.

According to Woodward [70], the administrative component of an organization changes with the complexity of its technology. This was because the number of supportive and administrative staff members increased as the complexity of the technology became more apparent. The investigation conducted by Woodward revealed a link between technology, structure, and effectiveness. The companies that most closely resembled the typical structure for their technology were the most successful. Firms that deviated from their ideal structure in either direction were less successful. As a result, Woodward argued that effectiveness was dependent on a good fit between technology and structure. Organizations that developed structures that matched their technologies fared better than those that did not.

Woodward's findings have been supported by several follow-up studies [71], but she has also faced criticism. Edward Harvey [72] believed that technical specificity formed the basis of Woodward's scale. In other words, he assumed that specific technologies pose fewer problems requiring novel or innovative solutions than diffuse or complex technologies. Harvey discovered a link between technical specificity and structure, which is congruent with Woodward's technological imperative. Organizations that used specific technology had more specialized subunits, greater authority levels, and higher manager-to-total-staff ratios than those that used diffuse technologies.

A study conducted by W. L. Zwerman [73] on manufacturing firms also supported Woodward's claims that there is no such thing as a universally ideal structural form. The researcher found that there was no evidence that the various forms of production that are

commonly used in the industry result in a single optimal structure. His findings support Woodward's claim that proper fit within a category can increase the likelihood that an organization will be successful.

The arguments made by Woodward about technological necessity were not entirely correct. Her claims have been criticized in a number of ways [74]. One of the main issues with Woodward's approach to technology is that it is focused on the manufacturing industry, which only accounts for about half of all organizations. This means that it is not feasible to implement the concept in a more general manner if it is to have a meaningful impact on all organizations. Such an alternative has been offered by Charles Perrow [75].

Rather than looking at manufacturing technology, Perrow focused on knowledge technology. He defined technology as "the action that an individual performs upon an object, with or without the aid of tools or mechanical devices, in order to make some change in that object." [75] According to Perrow, the different methods of controlling and coordinating technology should vary depending on the type of technology being used. For instance, if a company has a routine technology, then it should have more structure. On the other hand, if a nonroutine technology is used, then it should have greater flexibility.

To elaborate more, according to Perrow's view, the most routine technology is best achieved through uniform coordination and control. These technologies should be used in conjunction with systems that are highly formalized and centralized. Nonroutine technologies, on the other hand, necessitate flexibility. They would be decentralized, have a high level of contact among all members, and be classified as having a low level of formalization. Moreover, craft technology necessitates problem-solving by people with the most knowledge and experience. Decentralization is what this entails. Engineering technology, with its many exceptions but analyzable search procedures, should have decisions centralized but low formalization to retain flexibility.

Perrow then determined the essential structural characteristics that could be changed to accommodate the technology. These include the amount of autonomy that the technology can provide, the extent to which groups can control the unit's goals, the extent to which they can coordinate with one another, and the extent to which they can use feedback and the

planning of others. Later on, several studies backed up Perrow's theory in manufacturing firms [76], health and welfare agencies [77], and state employment-service agencies [78]. In conclusion, Perrow's views appear to have a lot of support: Organizations and organizational subunits that use routine technologies tend to be more formalized and centralized than those that use nonroutine technologies. The original theory by Perrow went beyond what I have presented. He proposed various relationships between technology and structural aspects, such as the types of coordination and hierarchical discretion. However, these relationships have been found to be weak in empirical studies [79].

James Thompson has made a significant contribution to the literature on technology-structures [80]. Unlike Perrow and Woodward, Thompson is not a part of the technological-imperative school. Instead, he focuses on demonstrating that technology can help reduce uncertainty. He contends that certain structural arrangements can aid in reducing uncertainty. Thompson's observations can be generalized into structural terminology. He argued that the demands placed on decision-making and communication by technology increased from low (mediating) to medium (long-linked) to intense (high). Coordination of mediating technologies is most effective when governed by rules and processes. Long-linked connections require planning and scheduling. Intensive technologies necessitate mutual adaptation.

Unfortunately, there is a scarcity of evidence against which Thompson's forecasts can be measured. The sole research of consequence that used Thompson's dimensions looked at the relationship between technology and organizational effectiveness rather than structure [81]. Due to Chaudhari et al. [5], technology is a factor that affects public organizations more than private organizations. Private organizations need to innovate to attract customers, which requires them to adopt new technologies.

To recapitulate the studies around technology and organizational structure, we saw that job-level research could best support a technological imperative; small organizations and structural arrangements at or near the operating core are the most likely to benefit, and "routineness" is the common denominator in most technology research. There is conclusive evidence that regular technology is associated with low complexity and high formalization. Only in the case of minimal formalization is routine technology linked to centralization.

2.1.6. Environment

I talked about how organizations work in an open-systems framework earlier. I said that recognizing that organizations interact with their environment was the key to understanding them as open systems. Here, I want to talk about environment and its impact on the organization.

There is a wide range of definitions for environment, and their common thread is that it considers factors that are outside an organization's control. For instance, most researchers think of the environment as everything that's outside an organization's boundary. Robert H. Miles [82] has proposed that one can easily determine an organization's environment by subtracting the subset that represents the organization from the universe. My focus, however, is on the organization-relevant portion of the environment. The management wishes to reduce the uncertainty caused by this environment [83].

Burns and Stalker [71] claimed that a company's structure should be mechanical in stable, predictable environments and organic in tumultuous ones. Emery and Trist [84] established four types of environments: placid-randomized, placid-clustered, disturbed-reactive, and turbulent field. The implication is that diverse environments necessitate unique structural configurations. Lawrence and Lorsch's [85] biggest contribution was realizing that there are different levels of uncertainty in different environments, that successful organizations have subunits that meet the needs of their sub-environments, and that the level of uncertainty in the environment is the most important factor in choosing the right structure. All in all, the studies around environment could be synthesized into three dimensions: capacity (abundant-scarce), volatility (stable-dynamic), and complexity (simple-complex) [36].

The relationship between the environment and an organization's structure is complex, but it can be explained by several factors. Firstly, how dependent an organization is on its environment determines how the environment affects it [86]. Secondly, structure is affected more by a dynamic environment than by a static one [87]. Studies also indicate that there is a direct link between complexity and environmental uncertainty [71]. Moreover, formalization and uncertainty in the environment go in opposite directions [36]. Finally, the

more complex the environment, the greater the decentralization, and extreme hostility in the environment leads to temporary centralization [87].

2.1.7. Power-Control

Strategy, size, technology, and environment can only account for about 50 to 60% of the variation in structure [63]. A large amount of the remaining difference may be explained by the power-control view of structure, which says that the structure of an organization at any given time is mostly the result of those in power choosing a structure that will keep and improve their control as much as possible.

The other thing that determines structure is the assumption of rationality [88]. But for rationality to win, an organization must either have a single goal or agree on all of its goals [89]. In most organizations, neither of these is true [90]. Because of this, decisions about structure are not rational. The decision about structure is a power struggle between special-interest groups or coalitions, each of which wants a structure that meets its own needs best. Strategy, size, technology, and environment set the minimum level of effectiveness and the parameters within which decisions will be made that benefit the self-interest of those making them [86].

The power-control point of view is all about power. Those in power, the group called the dominant coalition, will make decisions about how things will be set up. Most of the time, this is the top management, but it does not have to be. Power can be gained by being at the top of the organization's hierarchy, controlling scarce but important resources, or being in the middle of the organization [91].

The concept of power-control is tightly connected to two other determinants of structure discussed before: technology and environment. In the literature, it is argued that those in power will choose technologies and environments that make it easier for them to stay in charge. As a result, organizations should be defined by routine technologies and environments with low levels of uncertainty. Those in positions of power will seek out structures with a low level of complexity and a high level of formalization and centralization in order to increase their control [86].

2.1.8. Organizational Structures

I feel obligated to propose an introductory review of different views on organizational structures because this dissertation aims to provide practitioners and researchers with insights into the characteristics of an organizational structure that meets the needs of the digital age (discussed later in the text). Basically, all structures could be placed on a continuum from bureaucracy to adhocracy. This concept will be explored in the following paragraphs.

To begin, let me define the lower end of the spectrum. As a sort of organizational structure, bureaucracy is characterized by clear divisions of work, strict hierarchies of power, an emphasis on formality over informality, and an emphasis on meritocratic hiring practices and career paths for employees. Max Weber, a German sociologist, is credited with coining this term [92].

Weber thought that capitalism and bureaucracy were the two most powerful forces of rationalization [92], and rationalization made modernity what it was [93]. He thought of bureaucracy as a way to organize that grows when “instrumental” rationality becomes the most common way for people to act in organizations and in business. When instrumental rationality is the norm, the reasons for doing something are given and not up for discussion.

In contrast, value-rational conduct is founded on a commitment to some ultimate ideal and entails careful consideration of the concrete meaning to be ascribed to that value in the particular context. These two types of activity based on logic can be contrasted with affectual action, which is based on emotion, and traditionalistic action, which is based on habit and respect for customs. Weber depicts bureaucracy as an organization based on instrumental rationality within a framework of legally sanctioned authority [92].

Routine and predictable actions in a stable and predictable environment are the strengths of bureaucracy. With its well-defined chain of command, regulations, and rigidity, bureaucracy is ill-equipped to deal with today’s rapidly changing world. While a bureaucratic pyramid may theoretically have no natural limit to its height, complexity is nearly always generated as the size increases significantly. As a business grows in size,

bureaucracy tends to become more impersonal, more expensive, and more riddled with archaic laws. These are all signs that progress is being stymied [94].

In this regard, Bennis [94] argues that today's activities need people with a wide range of specialized skills. Bureaucracy's well-defined chain of command, inflexible rules and processes, and impersonality are incompatible with fast development, quick change, and growing specialization. The structure we have today was built to cope with stable situations, but the structure we need today is one that can adapt to change. Many people have followed this argument about the flexibility and dynamism of bureaucracies up to the present day [95-98].

The relationship between bureaucracy and innovation [99-101], bureaucracy's efficiency rationale and its cultural il/legitimacy [102-104], and the impact of new technologies as either strengthening or obsoleting it [105-107] are all areas where scholarship is divided. Uncertainty exists regarding whether bureaucracy has a positive or negative impact on alienation and satisfaction [108-110]. The extent to which new organizational forms have replaced bureaucracy remains a controversial issue [111-114]. The role of bureaucracy in addressing the various challenges of our time is also under debate [115-117].

Even though many scholars in different fields tend to hate bureaucracy these days [118, 119], most big companies are bureaucratic in form, and for the majority of these organizations, bureaucracy is the most effective method to organize [120]. It is evident that bureaucracy works, even if we exclude the elements that can lead to nonbureaucratic systems. Bureaucracies are successful in a wide variety of organized activities, including industry, service businesses, hospitals, schools and colleges, the military, and voluntary groups, regardless of technology, environment, and so forth. According to one advocate, bureaucracy is a kind of organization that is "superior to all others that we know or can expect to afford in the near and intermediate future." [121]

Successful and enduring organizations often expand to a considerable size. And literature indicates that bureaucracy is more efficient when it is huge [36]. Due to the increased likelihood of failure of small organizations and their nonbureaucratic structures,

small organizations may come and go throughout time, whereas massive bureaucracies remain. Additionally, it is possible that size is the major criteria defining structure and that greater size results in bureaucracy [122].

Robert Merton [123] put up a basic case against bureaucratic systems. According to him, despite the fact that bureaucratic norms and impersonality create high levels of dependability and predictability, conformity may be counterproductive since it inhibits the capacity to change. Bureaucracies, according to Merton, get so enamored with their rules that members become mindlessly repeating acts and choices that they have taken previously, ignoring the fact that circumstances have changed. So, bureaucracy has the unfortunate side effect of alienating workers.

People in power want a high degree of uniformity, particularly in the hands of the ruling coalition. That is what bureaucracy is for, of course. Because it is the most effective structural mechanism for sustaining control of big organizations, bureaucracy is the preferable structure from a power-control standpoint. This conclusion is supported by the fact that all organizations have a reasonable degree of routineness [121]. Those in power are logically obligated to pick technologies (and corresponding structural forms) that will help them retain and increase their hold on the resources they command [36]. Researchers assert that bureaucracy is inescapable as a result of all of these factors coming together. It is the predominant structural form in North America, and it is quite unlikely that it will be greatly altered or eliminated within our lifetimes [36].

From a knowledge-management viewpoint, according to Drucker [124], knowledge is a resource, but it may also be seen as a creative force. From the knowledge-based viewpoint, the emphasis is on the production of value rather than extracting value from an intangible resource. An organization is considered an interconnected system by the systems or contingency theory of management, which supports the knowledge-based approach [125]. While it is critical to examine the components of an organization, it is as crucial to keep an eye on the system as a whole. All of an organization’s intangible assets work together to make up its intellectual capital.

When it comes to knowledge management, a bottom-up strategy is preferable to a top-down one, in which individuals drive the management process. Organizations are complex social processes that depend significantly on creative people [126, 127], and this approach advocates open and adaptable organizations in which the learning process is actively fostered [126]. In this regard, most technology companies these days try to use a flatter organizational structure to cope with the challenges of the digital world. This organizational structure can be described as the systematic process of delegating power and authority among the employers.

There is another organizational structure where groups of strangers with varied professional backgrounds work together to solve issues in an adhocracy, which is generally short-lived. This term, adhocracy, was coined by Toffler [128] as an antithesis to bureaucracy in 1971. Adhocracy is different from bureaucratic structures in that it is not fixed, formal, or hierarchical. Instead, it is characterized by the use of staff expertise and lateral relations. This concept highlights the importance of having a flexible and adaptable work environment.

Adhocracies are made up of experts who have been formally trained in certain abilities and who are in charge of critical decisions and actions. These professionals coordinate their skills to operate on a project-by-project basis, integrating domains of knowledge in a time-based manner [87]. The exact composition of these experts is not fixed, and it can be adjusted to meet the needs of the organization. In adhocracies, the control over the activities and decisions is given to the professionals through their lateral relations. This type of structure is more flexible than traditional hierarchical structures [129].

The advantages of adhocracies are that they provide an environment that encourages creativity and analytical problem-solving. They are also beneficial in today's dynamic and complex work environment due to their ability to accommodate the varying needs of the organization [130]. Adhocracy is also commonly used in high-risk organizations, temporary setups, and newly developing industries. Its horizontal management structure enables employees to share ideas and improve collaboration. This type of management structure can also overcome the weaknesses of traditional bureaucratic structures [129].

For adapting to change, fostering creativity, and bringing together disparate groups of people in one place, adhocracies are ideal. This, however, may lead to internal strife and is less productive than a bureaucratic structure [36]. Moreover, despite the advantages of adhocracy, it can still cause issues such as lack of continuity and slow decision-making. This type of management structure can also lead to frustration and a lack of clarity regarding the direction of the organization [129]. These traits indicate the fact that adhocracy lacks the attributes of traditional stable systems. It also means that adhocracies are fertile ground for study into knowledge management, new kinds of control, and professional management [131].

Adhocracy's value is not diminished by the fact that the circumstances that need its adaptability do not exist every day or in most businesses. The adhocracy, or a variation of it, is anticipated to become more important as businesses take on more demanding, innovative, and complicated projects [36].

One practical variation of adhocracy, which holds the middle ground and benefits from both bureaucracy's stability and adhocracy's flexibility, could be achieved through self-management, self-organizing [132], virtual organization [133], holonic enterprise [134], or "holacracy." [135] I use these terms synonymously throughout this dissertation. Many studies in academia [136-138] and business [139, 140] showed interest in self-managing organizations (SMOs) in recent years. "SMOs are organizations that have radically and systematically decentralized authority throughout the whole organization, almost to the point of getting rid of the middle management layer and the relationships between supervisors and subordinates." [98] When it comes to running a business, a holacracy is a framework of "roles" that everyone on the team fills to ensure smooth operations. Every aspect of the team's process is under constant scrutiny and revision. In this definition, self-organizing teams are business entities that must communicate with one another to cooperate and execute business processes. They manage the various flows of the enterprise (physical material flows, information flows and decision flows) [141].

In holacratic organizations, a hierarchical pyramid structure is replaced by a structure of circles and sub-circles. Each person can take over multiple roles and therefore belongs to more than one circle [142]. Holacracy describes a system of clear decision-making processes

and meeting structures to guarantee a coordinated course of function within the circles and the organization as a whole [143]. Based on Puranam et al.'s theory [144] about new organizations, the novelties and differences between holacracies and two previously discussed organizational structures will be discussed. Puranam et al. [144] argue that an organization needs to find four solutions in order to function: assigning tasks, rewarding employees for their efforts, and informing employees about the organization's goals.

In this regard, SMOs are characterized by three features [135]: (1) radical decentralization of power as opposed to gradual decentralization; (2) the decentralization of authority takes place across the entire organization; (3) there is a formal and systematic decentralization of authority. Moreover, employees at SMOs need to be proactive and comprehend the organization's overarching purpose to find new tasks that can advance those broader goals. This requires high levels of work engagement and motivation.

Decentralization of decision-making authority, which extends to task allocation, characterizes SMOs, unlike bureaucratic and adhocratic systems that follow a top-down task allocation model. Also, unlike bureaucracies where monetary compensation is the primary incentive system, and promotions are decided by supervisors, in holacracies, mechanisms for rewards and compensation among peers are expected to be the most popular approach to addressing the issue of employee recognition, because they make it possible for those who are directly involved in evaluating an employee's performance to determine the appropriate compensation levels [139].

As opposed to classical bureaucracies, SMOs are built on the assumption that people are active and willing to perform well when given a chance and an intrinsically motivational task. [137, 145]. In a bureaucratic organization, supervisors monitor employees' output and actions to ensure compliance with the goals and tasks. They also use explicit methods to monitor employees' whereabouts and to eliminate the possibility that they could avoid doing the work for which they are paid [140]. In a matrix organization, a more flexible variant of bureaucratic organizations, two different managers hold employees accountable for their performance, and on a team level, peer control could take the place of supervisor control [146]. In self-organizing organizations, the emphasis is on monitoring performance using quantitative metrics, and the monitoring is done by one's peers. This means that one must

be able to deal with circumstances in which one party is unable to fulfill their obligations [139, 147].

Key information is centralized at the top of bureaucratic organizations, and task division aims to be so detailed that individual agents do not need to be aware of the big picture in order to complete their tasks [92]. In adhocracies, teams frequently deal with distinctive and complex problems and have access to the best knowledge to decide how to address these issues. However, organizations often use the same mechanisms as bureaucracies at higher levels [85]. In self-organizing organizations, employees have the power to decide independently about matters and purchases that, in a bureaucratic or adhocratic organization, would require prior approval from a manager at a higher level. To make wise decisions, employees need enough information about organizational wholeness [137, 139].

To ensure employees have clarity over the current organizational situation and goals, SMOs typically make all information transparent. Consequently, employees must have the necessary analytical and decision-making skills to understand and analyze the data they are provided with [148]. Formal communication is generally employed by bureaucracies to implement a set of directed procedures. These procedures and steps ensure that employees' actions align with those of others [144]. Operating adhocracies do not need cross-team coordination, and in administrative adhocracies, the administrative component functions as an adhocracy while the operating part functions as a bureaucracy [149]. In SMOs, coordination between teams is achieved through adjacency, frequent meeting sessions, and consistent electronic communication. IT systems, like Glass Frog at Zappos, take care of a lot of the tasks that managers used to do, like coordinating, keeping track of progress, and sharing information.[34]. Figure 2.2. is a depiction of how holacracy differs from hierarchy [150].

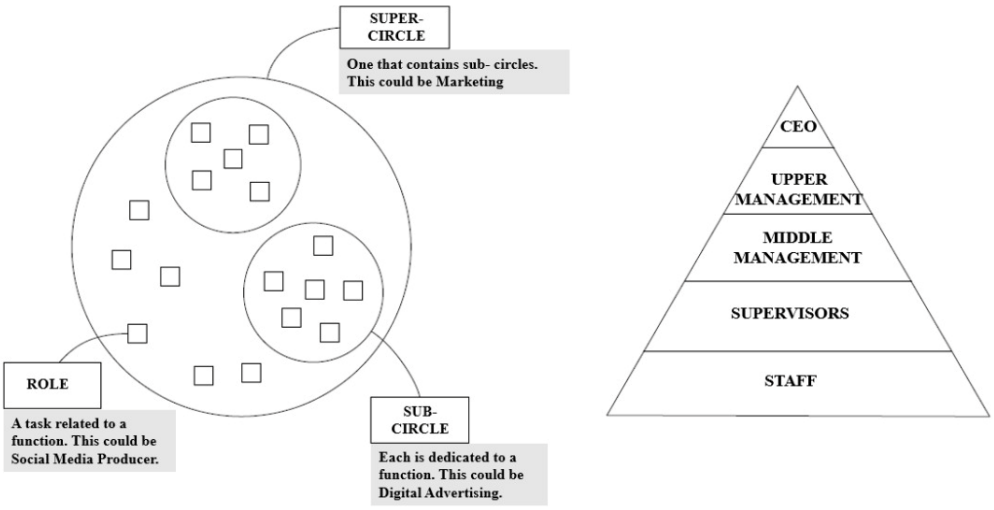

Figure 2.2. Holacracy vs. hierarchy.

So, one could say that holacracy replaces artificial hierarchy with a fractal “holarchy” of self-organizing teams, where each circle joins to its sub-circles through a double-link, making a tow-side flow of information and fast feedback chains [151] (Figure 2.3.). Holacracy increases organizational speed by helping managers make decisions rapidly and incrementally with maximal information and encourages us to take individual action using our best judgment [152]. Holacracy’s core practices include regular circle meetings for both governance and operations. Add-on practices include employing, budgeting, and project management [142].

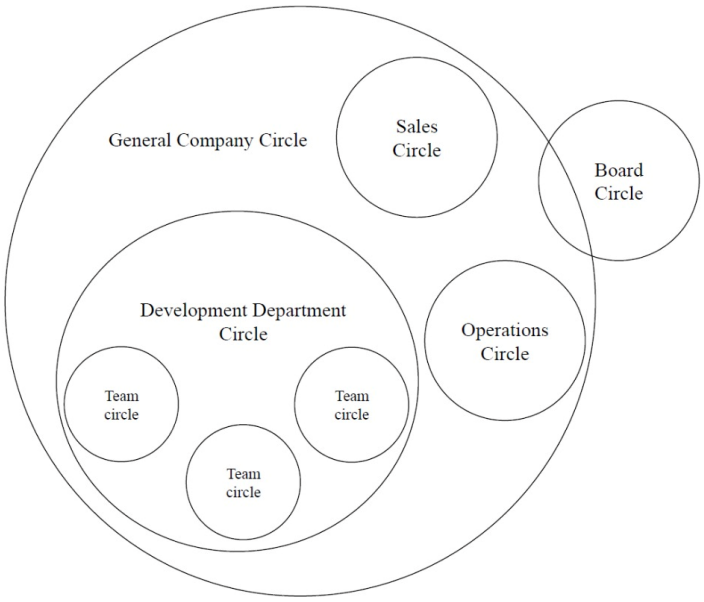

Figure 2.3. Example of a circle structure.

Holacracy does not abolish the traditional organizational chart but has a skillfully different meaning within holacracy cultural context [153]. Figure 2.4. shows the circle structure of the organization overlaid on top of the traditional organizational chart [151].

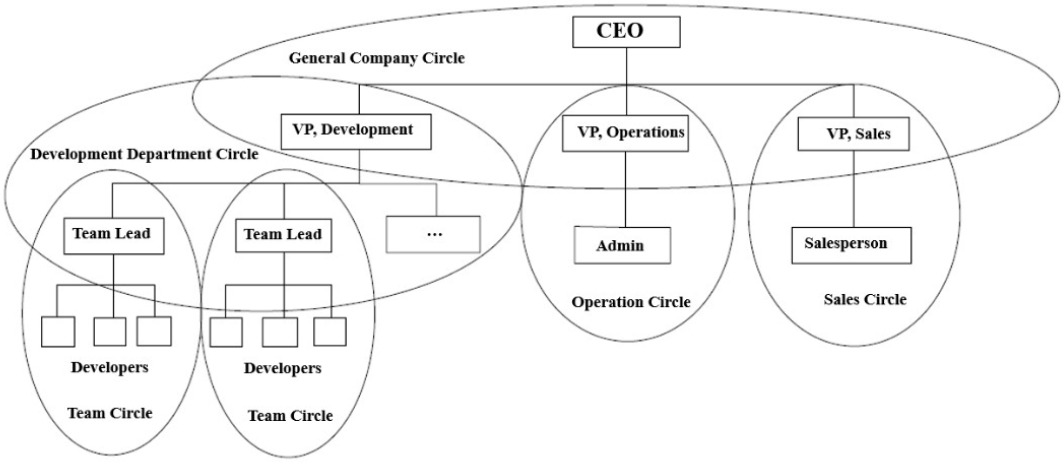

Figure 2.4. From hierarchy to holarchy.

SMOs appear to offer a different organizational structure than the more conventional options, but under what circumstances is it a more practical choice than other organizational

structures? Martela [135] suggests that in sectors where groups can operate independently, where each customer's output is customized, and where employees are highly dedicated, motivated, and skilled, SMOs are more likely to succeed than bureaucracies.

Overall, it appears that the literature on organizational structure is shifting toward holacracy. In this regard, Mosamim et al. [153] contend that today's organizations can benefit more from a bottom-up approach to management than they can from a top-down one. Zappos, a multibillion-dollar retailer, announced in December 2013 that they would be switching to holacracy in 2014. The subsequent interest in holacracy has skyrocketed since. Tony Hsieh, the Zappos CEO, agreed to accept holacracy based on research showing that when organizations get bigger, innovation or productivity per employee decreases [154]. To date, many organizations have adopted the holacracy model to achieve performance efficiency [155]. Technological advances make studying the holacracies even more interesting. The advent of DAOs (Decentralized Autonomous Organizations) and all the capabilities that blockchain technology could provide with companies bespeak of new organizations that are more decentralized and, in the meantime, more efficient [144].

Holacracy is a self-organizing team concept that focuses on doing clear projects, managing a department, and overall business operations. Although the literature warns us that the holacratic model may not be suitable for every business [153], I think construction organizations could benefit from what this model has to offer. Furthermore, the findings of this study may provide useful insight into the possibility of this matter. In the following section, I will go over project-based organizations and why construction firms fall into this category.

2.1.9. Project Organizations and Organizational Structures in the Construction Industry

Regardless of the nature of the business or project, researchers have found that organizational structure is crucial to project success or failure [156-159]. As a result, it should be taken into consideration as a different direction to investigate when examining the project successes that have been carried out by various researchers. Hyvari [159] looked into the efficiency of various elements, such as management systems in various business

organizations. He came to the conclusion that the efficiency of project management is directly related to organization design. Hyvari [158] investigated the relationship between crucial organizational parameters and project success factors in another study. He reached the conclusion that organizational factors, such as the size and structure of the organization, alter the crucial success factors for projects undertaken by them The relationship between the structure of project management and project success was examined by Lechler and Dvir [156]. They used 600 samples from the USA and Germany for their dataset. They made clear that the type and scale of the projects have no bearing on the relationship between the project management structure and project success.

The use of different project management methodologies and project success were investigated by Joslin and Muller [157]. They asserted that project management methodologies act as a stand-in for organizational structure because they establish the management hierarchy and command structure of the project. Joslin and Muller [157] claimed that these methodologies contribute to about 22% of successful projects. Additionally, they came to the conclusion that project-based methodologies outperform complementary methodologies in terms of effectiveness for project success.

Gazder and Khan [160] focused on the factors related to project failures in the construction industry. They found that organizational structures affect the percentages of factors related to the project team, and the nature of construction also affects the percentages of factors related to planning processes and mechanisms.

Researchers' quest to find an organizational structure that suits companies that deal with projects resulted in the concept of project-based organizations (PBOs). Project-based modes of organizing and controlling work are becoming more common in new industries and are also being used in more established sectors. In such organizations, people with different skills are brought together to develop innovative products and services within fixed periods of time [161, 162].

Mintzberg [149] suggests that the Adhocratic organizational form is similar to the PBO in its emphasis on novelty and that it requires the combination of different bodies of existing knowledge and skills. He mentions that task coordination in both organizational forms

requires much more face-to-face mutual adjustment than in professional bureaucracies, which rely predominantly on standardized skills.

Gareis [163] describes a PBO as an organization that manages projects, has permanent project-oriented structures, applies project management methodology, and perceives itself as being project-oriented. Mitsuru [164] considers a PBO to be an organizational structure specially formed for a temporary period. Hobday [165] defines PBOs as fully project-based organizations (PBOs) with no ties to other organizational functions. He identifies six distinct organizational structures, ranging from the purely functional to the purely project-based. PBOs, as defined by Thiry [166], "conduct the majority of their activities as projects and/or privilege project over functional approaches, and they can include: departments within functional organizations; matrix organizations; projectized organizations, and other forms of organizations that privilege a project approach for conducting their activities."

Many researchers have addressed the PBO, but they report that there is little knowledge on how PBOs actually operate in practice [163, 165-170]. Most PBOs still have hierarchical-functional structures [171] (Figure 2.5.), and their managers adapt project management to the classic organizational structure [172-175].

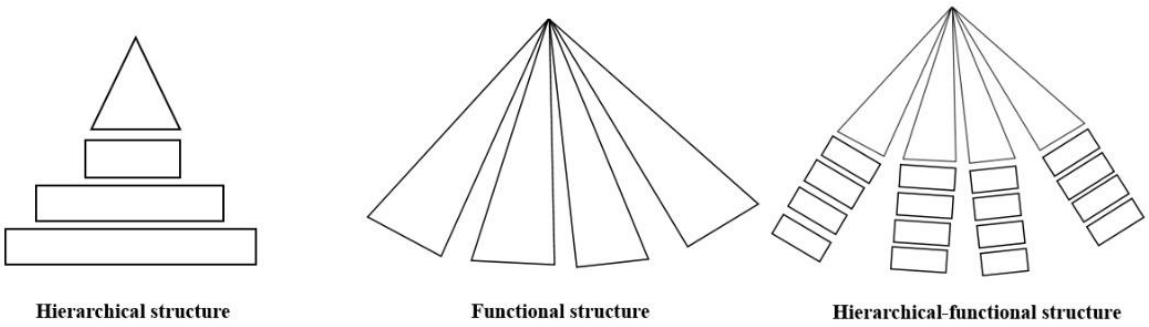

Figure 2.5. From hierarchical, functional, and hierarchical-functional organizational structures.

In the 1960s, project management only started to be useful in businesses where the work was extremely complex. More organizations switched to formal project management in the 1970s and early 1980s, abandoning informal project management [171]. The most

sophisticated high-tech and multinational corporations changed their formerly hierarchical organizational structures to flatter, quicker, and more flexible ones based on teams and projects in the 1990s [176].

This journey began with hierarchies and progressed to functional structures. Differences between hierarchical levels are a drawback of the hierarchical structure, whereas disagreements between functional departments are a drawback of the functional structure. A synthesis of these two (hierarchical-functional structures) has the downside of having a series of operational "islands." The project manager's role is thus defined as ensuring "transversal and longitudinal communication between these operational islands." [171] Figure 2.5. shows these three structures.

The concept of PBO was shaped by companies starting to adopt a structure that included an R&D department and functional departments. This structure was used in areas with high degrees of innovation. From this point on, the importance of autonomy, cooperation, aggregation, and self-organization has become more prevalent in organizations [177].

Organizations have used matrix structures (Figure 2.6.) to address the needs generated by projects within the organization [171]. The project-based matrix structure, according to Rozman [178], is made up of cross-functional teams that collaborate on projects across the organization. Cross-functional teams help to improve business-IT collaboration and facilitate continuous change [179, 180]. Some research scholars consider the matrix structure a great leap forward in the structure of PBOs [181]. Others [182] believe that the matrix approach is a marginal change since functional managers still hold great power and influence, hindering development projects.

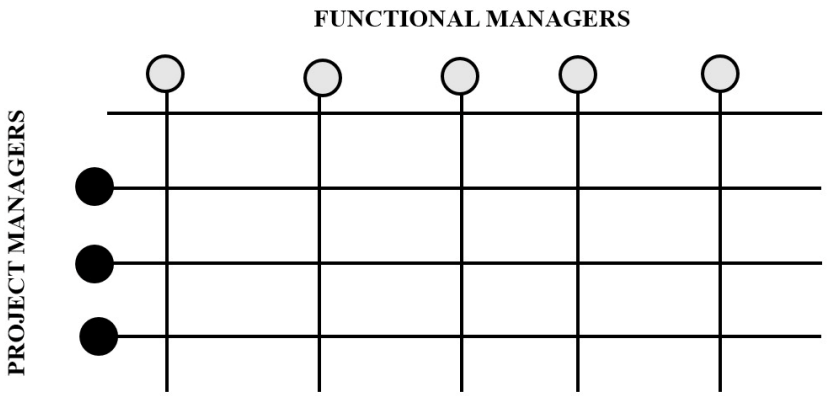

Figure 2.6. Matrix structure.

The next trend in PBOs structuring will consist of running processes within organizations through projects, with functional managers coordinating employees under the authority of the project manager [177]. Further studies tried to reveal the characteristics of an ideal PBO structure. Due to Cheng et al. [183], the optimal project organization structure is defined based on three assumptions: (1) the project network is determined, (2) the maximum number of organizational layers is limited to three, and (3) the construction teams are classified into three types: the main contractor, intermediate contractor, and specialty contractor.

The success of the project depends on the team members' ability to coordinate effectively. The leveling and adequate simplification of the organizational structure are not too far from the ideal organizational structure and could improve team member coordination effectiveness. The best layer relationship should be derived from the mutual reliance relationship on the project network because the flattest structure is not always the most ideal one [183].

PBO differs from a classical organization. It is challenging to move from a traditional organization that runs projects to a project-based organization. Nevertheless, addressing this issue becomes more crucial due to the high failure rate of projects and increased customer dissatisfaction. There are multiple organizational changes required during the transition.

Employees will delegate their competencies to various project teams within the organization so that structural departments and hierarchical lines become less important.

Eliminating strict hierarchy and thinning departmental and divisional limits face increased resistance from departmental managers. PBO needs to decrease the authority of hierarchical departmental managers so that project managers can exercise their cross-functional authority and expertise. The success of the organization depends on autonomous project teams.

The classic organization also needs to develop a mechanism for prioritizing projects and activities in its transition to the project-based organization. Without a prioritization system, resources are used excessively, some projects fail, and both customer activities and the profit of the organizations suffer.

Recently, studies [171] tried to give an integrated model for PBOs based on continuous quality improvement cycles that could address some of the issues mentioned above. Although it is obvious that holacracy concepts could be developed in PBOs, there appears to be a gap in the literature addressing this link.

Construction projects are highly complex organizations operating inside exceptionally complicated institutional settings [184]. As already discussed in depth, companies that do most or all of their work in the form of a project are known as “project-based” organizations (PBOs) [165], or in short, project organizations. As stated by researchers, construction companies are mainly PBOs [26].

The structure of a project organization is important. Integrity and formalization are two characteristics of the organizational structure that help the project succeed, while centralization is a detriment [185]. Accordingly, whereas integration and project success are intertwined in an informal context when formalization is implemented, knowledge sharing acts as a mediator between these two variables. Public companies, on the other hand, seem to be more successful in their formalized knowledge management than their private counterparts. Project success and knowledge sharing are inversely correlated with high-level centralization, which is harmful to project management and success [185].

A project-based organization's structure is made up of a diverse spectrum of people from many cultures and backgrounds, including those in executive, managerial, and administrative positions. The construction sector operates in a highly dynamic environment where demand varies from project to project, making managing a diversified workforce more complex. As a result, in order to fulfill project goals, construction organizations require coordination among a broad collection of employees, contractors, and suppliers.

Complex technology savvy projects can fetch higher profit margins for construction companies as compared to low technology projects like road construction. Working capital requirements for any company depend on the order mix of the companies [186]. The scale and complexity of construction projects are increasing, and so the difficulty in project control also increases. A suitable project organizational structure can improve communication between different groups of project members [183].

The researchers had a difficult time arriving at the above-mentioned understanding. This section concludes with a summary of what researchers have done thus far to gain a better understanding of the best organizational structure for construction organizations.

Developing project organizations that are appropriate to the specific project environment is one of the most important responsibilities of senior management in construction organizations. Subcontractors and specialist contractors are often required to collaborate in construction projects, and the organizational structure of a project can influence the nature of these intrafirm relationships and how individuals are organized. Organizational theory, which dates back to the 1940s, represents the basis for developing an appropriate organizational structure.

Structuring tasks, authority, and workflow have been emphasized in recent organizational design advancements. The goal of this process is to establish systems of interaction between the firms operating within the project organization that is both efficient and stable. It results in an organizational structure that combines technology, tasks, and human components in a way that ensures project success. Position, superstructure, lateral linkages, and decision-making systems are the four main groups or design parameters that

Mintzberg [87] identified as essential to understanding organizational structure from an analytical perspective.

Researchers in the field of construction management, however, have cast doubt on the usefulness of such an approach. Morris [187] and Newcombe [188] argued that a systems perspective is superior for the construction industry. Also, it has become common for construction companies and construction projects to think about how they interact with their environment as an open system.

Due to Morris [189], managing the dynamic interrelationships between various organizations on a construction project has been identified as the key priority for increasing the efficiency of the construction process. He claims that when there is uncertainty and complexity, designing semi-autonomous organizational subsystems and focusing managerial attention on their interrelationships will be beneficial. However, this can result in highly fragmented subsystems on both sides of the interface, necessitating additional data processing for effective integration.

Morris [189] suggested two solutions. First, subsystems and their interrelationships should be rearranged. Second, different integrative methods should be used based on subsystem structure. Speed changes how design and construction overlap and how functions depend on each other. This changes coordination and control. To deal with the transition between the two stages, it is important to have contractual arrangements that encourage early contractor entry. This will help figure out how the design will affect the project schedule.

A decision theory-based prescriptive and descriptive model was used by Tatum [190] to analyze how managers design project organizations. He wanted to know if the current practice should be kept or changed. It is evident from the conclusions that past structures are frequently adapted, especially in urgent situations. The decision-making process involves more analysis and a contingency approach when data and time permits. Tatum [190] noted that the project life cycle, performance issues, and changes in project goals require decisions about structure. To tailor an organization to project requirements, Tatum [190] proposed an eight-step decision-making framework based on Thompson’s [80] ideas. In his remarks, the

operating core should be buffered from environmental disturbances and located near line segments so staff can interact directly with one another.

In 1980, Bennett et al. [191] addressed the complexity of the construction industry by focusing on the various characteristics of its fragmentation. These include the existence of temporary coalitions of specialized firms with varying economic and social interests. The authors then proposed the establishment of a unique organization composed of groups and individuals from different firms. This should be done using project delivery systems and contractual arrangements. Based on their theoretical understanding of the construction process, they proposed the establishment of a project organization that is based on the analysis of the various factors that affect the project's progress. This concept was carried out through the development of a simulation model that measures the effects of multiple factors such as the size, predictability, and cost of the tasks.

A shift toward situational or contingent design of organizations has resulted from the rise of open systems analysis. Construction organizations and projects cannot be managed or organized in one way, according to this view of contingency that emphasizes the complex interactions between environment, task, technology, human motivation, and organizational structure [192].

According to Bresnen [181], organizational structure is determined by a combination of external and internal factors. In competitive environments, construction companies tend to make their operational and administrative procedures more strict and effective. Moreover, Winch [193] argued that construction projects are sociotechnical systems, with technical systems serviced by social systems. He claimed that this leads to centralized project reporting systems and delegations of authority.

Organizational theorists, as previously discussed in depth, have identified some common factors in organizational design, including technical methods [70], environmental uncertainty [85], and how technologically advanced the project is [71]. In addition, The operating environment of the project and the technical system were two important factors that the researchers concentrated on when structuring construction project organizations [194].

Galbraith [195] argued that the amount of information processing required to complete a task increases when it is characterized by uncertainty (which can be characterized as a lack of certainty regarding the necessary resources or the technical difficulty). He made the point that the amount of data that needs to be handled affects organizational structure. As a case in point, when construction managers face uncertainty, organizational design creates self-contained tasks and ensures lateral relations. Management-based procurement uses these two strategies to deal with fast-track construction uncertainties. Using these strategies, companies can achieve the goal of decoupling management and production systems, as proposed by systems theory [196].

Earlier, I mentioned that the diversity of work items and the predictability of work activities serve as indicators for the uncertainty dimension. The system becomes more regulated and the structure more bureaucratic as technological certainty rises. As a result of the system's predictability, workers can participate in project supervision and workflow design early on, allowing for decentralized decision-making. In a non-regulating system, skilled operatives and their immediate supervisors retain authority over daily operations, leading to a more organic organizational structure.

The complexity of the organization increases with the number of subcontractors. To make decisions, the project organization needs a complex administrative framework and liaison mechanisms. There may be two distinct levels of interdependence between organizational functions and tasks. There are three different types of interdependence: reciprocal, sequential, and pooled. Depending on the level of overlap and the type of the interface, there is a great deal of reciprocal interdependence between the parties in the design and construction subsystems [197]. It may be hypothesized that there will be mutual adjustment by committees or liaison groups on a building project [197]. A greater degree of horizontal decentralization will be needed when multiple trade specialists are involved in a project in order to facilitate coordination through mutual adjustment. Cheng et al. [183] analyzed the organization of the construction team based on the differences and interfaces of the contracts in order to find the optimal structure for the project. Their analysis concentrated on the relationships and niche positions among different members of the project team.

The majority of the studies I mentioned here are from the pre-digital era, and no specific study attempts to address the problems that traditional organizational structures of construction enterprises face in the digital world. So, with this study, I hope to pave the way for future studies of this type.

2.2. Digitization, Digitalization, and Digital Transformation

Before I get into the meat of this dissertation, I need to define three key terms that is heard all the time while studying today's digital world, and it is critical that one understands their relationship and differences. As digital technology diffuses into the industry, the economy, and society, it becomes necessary to distinguish between digitization, digitalization, and digital transformation.

Digitization refers to changing from analog to digital form and is done by converting handwritten or typewritten text into digital form [198]. Digitalization, on the other hand, is the process of moving from analog technologies to digital ones. In the business world, it has been defined as the incorporation of digital technologies into the organization's day-to-day activities [199]. The word "digitalization" refers to the process of transitioning from conventional commercial operations to the conduct of business via the use of digital technology [200]. Gartner [201] defines digitalization as the process of employing digital technologies and information to transform business operations. The Brookings Institute [202] defines digitalization as the process of people's jobs changing as a result of the implementation of digital technologies. Whether it is the evolution of jobs or the revamping of business operations (to many, these are the processes most directly affected by digitalization), automation plays a crucial role in the digitalization narrative [198].

There is no commonly accepted definition for the term "digital transformation" [203], but it can be seen as an ongoing process of adoption to a significantly changing digital landscape [204, 205]. McKinsey defined "digital" as "creating value at the new frontiers of the business world" [206], Morakanyane et al. [207] defined "digital transformation as an

evolutionary process that leverages digital capabilities and technologies to enable business models, operational processes and customer experiences to create value."

All in all, there is consensus among researchers that the adoption of digital technology and its integration into an organization's external interface as well as continuous internal activities is what "digital transformation" entails [208]. In this definition, digital transformation is not a series of digitalization projects but a customer-driven strategic business transformation that requires cross-cutting organizational change as well as the implementation of digital technologies [198]. Figure 2.7. summarizes the definitions I have given for the three stages of turning a business into a digital one [209].

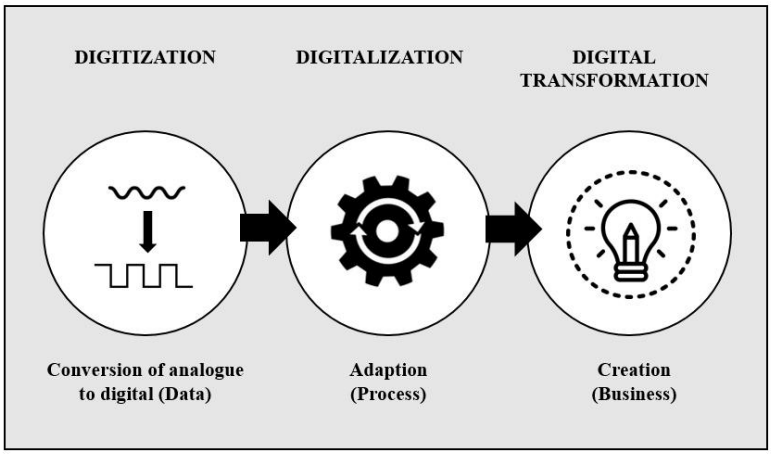

Figure 2.7. Definition of digitization, digitalization, and digital transformation.

Several practice-oriented publications about digital transformation exist, but academic research insights are limited [210]. Digital technology is integral to society and the economy [211, 212]. Digital transformation offers great opportunities and high risk for organizations [213], and those that do not react will suffer [214]. Companies need to embrace digital transformation to remain competitive and overcome several challenges, such as changing customer behavior, high regulatory requirements, and shrinking margins [13]. For many organizations, digital transformation is a strategic priority. However, managers are unsure about the process, topics, and setup of digital transformations. Due to Bughin et al. [214], executives are aware of the urgency of the situation and the need to take action, but they

have scant information to help them decide what to do. So, they are lagging behind the new digital reality [215].

The capacity of organizations to participate or be left behind in a digital society depends on the availability of broadband infrastructure, devices, training and support, and applications and online content that encourage self-sufficiency, participation, and collaboration.

In order to plan and execute digital transformation, organizations must place “digital” at the heart of their business strategies [216]. Companies’ digital transformation efforts are driven by the strategies they deploy and only secondarily by the technologies they adopt [217]. A company-wide overarching digital transformation strategy that addresses both opportunities and risks [218] is, therefore, a necessary component of a company’s business strategy [215, 218, 219].

This digital transformation strategy that every company should have alongside its functional and business strategies has been addressed by many authors in the form of digital maturity models or frameworks. Digital maturity is the degree to which a company’s digital transformation has been completed in comparison to the firms in the same industry [220]. In the literature, digital transformation and digital maturity are sometimes used interchangeably without regard for differences [221]. However, because digital maturity depicts how an organization steadily evolves over time, it is a more tangible concept than digital transformation [222]. Figure 2.8. shows the stages of digital maturity in companies.

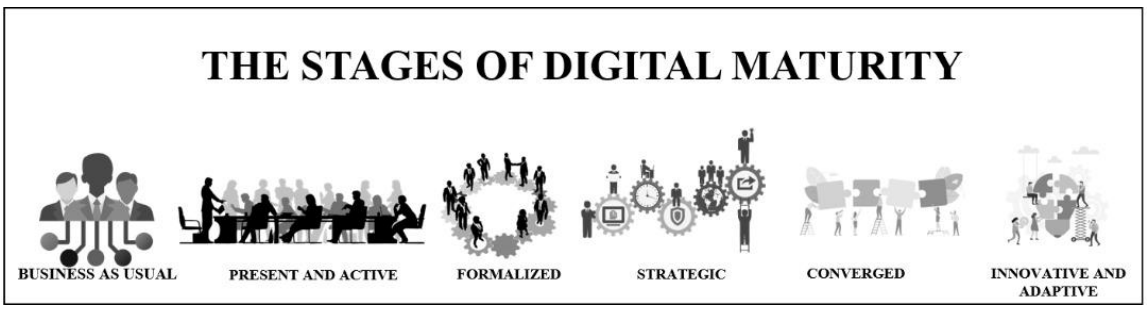

Figure 2.8. The stages of digital maturity.

A maturity model, when properly presented and implemented, may help to remove the confusion around what it means for a company to be digitally mature [24]. These kinds of models may also assist in identifying an organization's assets, liabilities, and growth potential [223]. Many scholars presented different maturity models for companies in different industries, and Bumann [216] has presented a holistic review of them. In this dissertation, however, my goal is to put finger on a concept that all these models share: agility.

Bumann [216], after reviewing many maturity models put forth by researchers, defined six action fields/dimensions for a potential digital transformation framework (Figure 2.9). I will make numerous references to these dimensions and their subdimensions in the following sections of this background. Figure 2.9 summarizes the findings of Bumann [216] about digital transformation action fields.

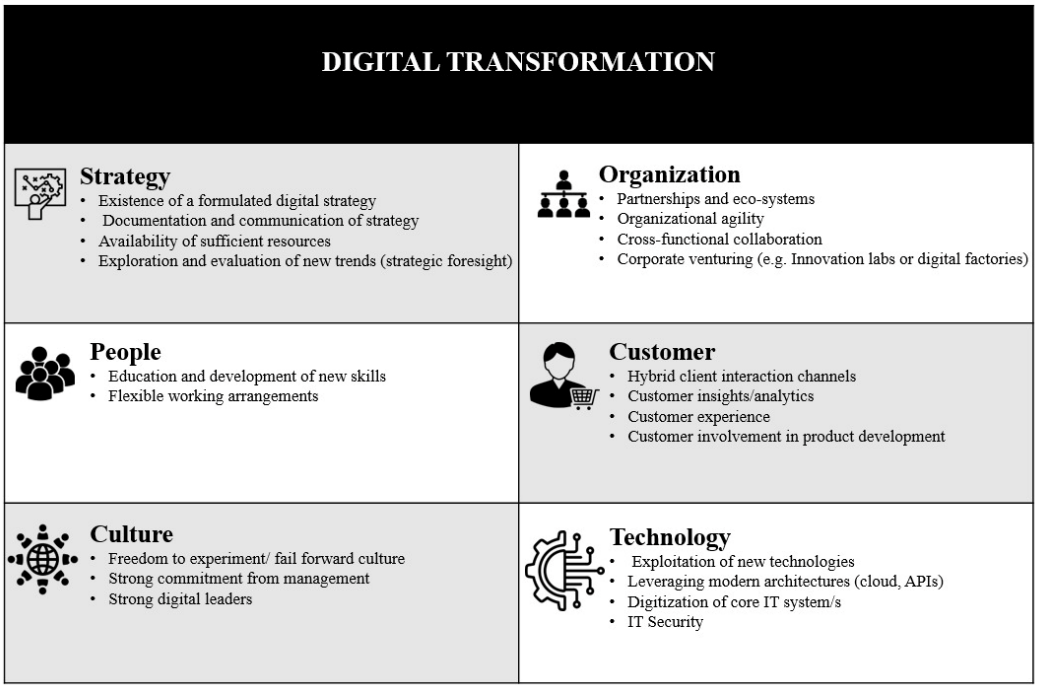

Figure 2.9. The action field/dimensions and sub-dimensions of digital transformation framework.

Researchers such as Gimpel et al. [212] emphasize the importance of agility in the organization dimension, which refers to an organization's ability to respond quickly to

changes in the technology or market environment. In the following section, I discuss agility and the importance of a digitally agile business model that enables digital maturity models to perform well at the organizational level.

2.3. Digital Transformation, Agility, and Digital Business Agility

So far, I discussed that digital transformation is the process of transforming an organization into a digital business. It consists of several steps that must be taken in order to achieve digital maturity [224]. As I mentioned earlier in 2.2., digital transformation, in contrast to digitalization, is not something that companies could implement as projects [198]. Digital transformation initiatives will typically include several digitalization projects, but executives that believe that there is nothing more to digital transformation are making a grave strategic mistake.

As the business evolves into a fully customer-centric operation, digital transformation necessitates an improved capacity for managing change across the board. This sort of agility will be helpful for ongoing digitalization efforts without being mistaken for them. Berman [225] asserts that organizations that can overcome the challenge of optimizing physical and digital elements by implementing new business models based on customer demand can win the first choice of talent, partners, and resources. Furthermore, this is the practical outcome of business agility. Imran et al.'s [28] findings show that cultural change can create agility for organizations. They point out that one of the most significant cultural change topics for the digital transformation is agility. But what exactly is agility, and why does it alter business models and organizational structures?

The term "agility" was introduced to manufacturing in 1991. It was popularized in agile project management in 2000 and is characterized by the ability to change the configuration of a system in response to unforeseen changes and unexpected market conditions [226-231]. Agility appeared in the project management area at the end of 1980 and early 1990, mainly in software development projects. In parallel, lean and design thinking approaches have been explored and adopted by scholars and practitioners [232-

238]. There is no precise definition and understanding of “agility” in the literature, which causes different interpretations, such as the ability to profit in a turbulent business environment [239].

Conforto et al. [240] suggested that agility could be characterized as a team performance indicator that could be influenced by a variety of internal and external organizational factors, including team and client characteristics, market conditions, business environment, product type, complexity, and novelty. Ergo, when applied to a diverse group of projects, such as different industries, types of products, and levels of innovation, the measured variables should indicate different levels of agility. To develop agility, the key element is velocity, which is obtained by performing the action quickly [240].

Recently, Perkins and Abraham [241] identified two additional pillars of agility: focus and flexibility. These three elements, velocity, focus, and flexibility, have three action fields: competence, company, and customer. Focus means “building organizational momentum through an enabling, agile and adaptive strategy with strong links to execution, and aligned to a curious, outwardly looking perspective and a clear vision and purpose.” [241] Flexibility means “creating the culture, environment, and structures to move fast through agile structures and small, multi-disciplinary teams, greater agility in decision-making and governance, productive and collaborative environments, and an empowering and engaging culture characterized by autonomy, mastery, and purpose.” [241] To balance these three in a digital world, companies need to have strategic alignment. Strategic alignment involves balancing the organizational, digital, and technological goals following the overarching strategic vision and the digital business strategy [242].

The literature summarizes various sources as customer or stakeholder needs, market or technological demands as the basic triggers for developing agility. Different demands and opportunities from these various sources are common in project environments, and they often raise the level of uncertainty, instability, and rapid rate of change in the project [240]. The literature emphasizes that organizations should harness the benefits of digital technologies by collecting customer data and using customer insights, for instance, to predict customer behavior and to provide tailored and personalized products and services with a better customer experience [212, 243-245]. Von Leipzig et al. [221] state that today’s

customers do not only expect organizations to react to their demands, but they even expect them to anticipate their future needs before they identify those themselves.

So, a form of agility that suits the digital world is known as digital agility by scholars [246]. Digital agility, as agility itself, outlines three pillars that a company must have in order to be digitally agile: hyperawareness, informed decision-making, and fast execution [246]. These terms are not well-researched yet, but they are digital jargon translations of focus, flexibility, and velocity, respectively, that I discussed earlier in the context of business agility (Figure 2.10.).

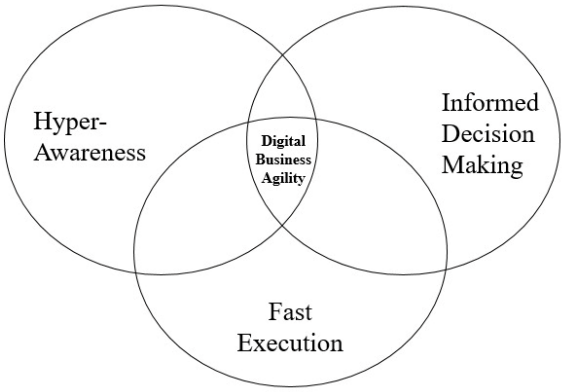

Figure 2.10. Three elements of digital agility: hyperawareness, informed decision-making, and fast execution.

What distinguishes digital agility from agility is that the former entails what researchers and practitioners call digital accelerators (Figure 2.11). Companies that are hyperaware of their business environment can gain insights from customers, partners, and competitors using digital tools. Hyperawareness has two accelerators: behavioral awareness and situational awareness. Their function is to gather data from internal and external environments, including the workforce, customers, and operational environment [246].

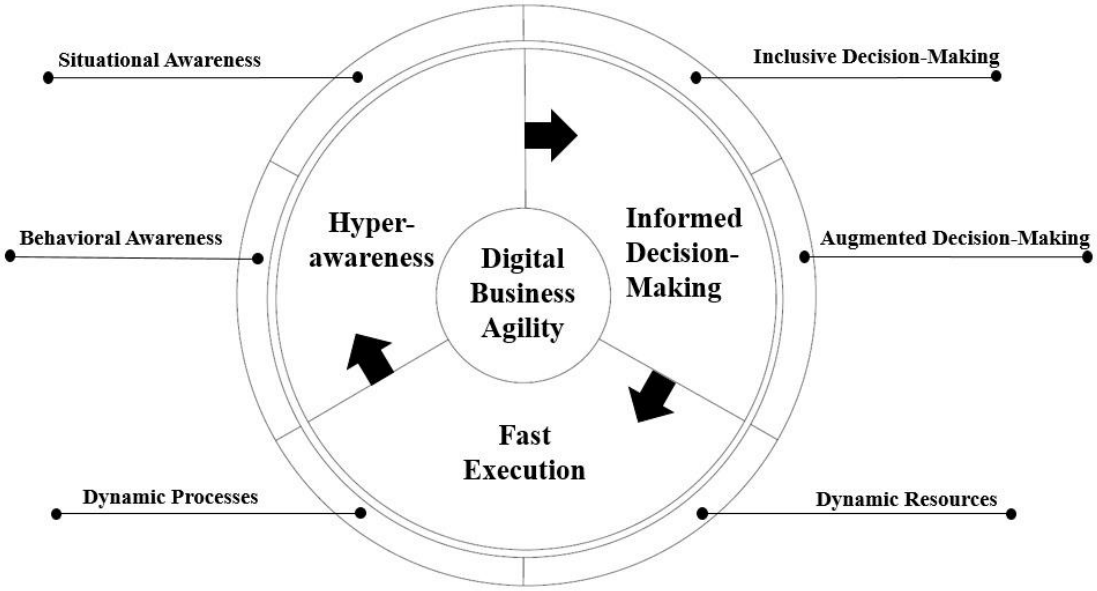

Figure 2.11. Digital accelerators.

Informed decision-making is about bringing experts and diverse perspectives into the decision-making process. It also includes ubiquitous analytics, automated or fast decisions, and connected meeting spaces equipped with intuitive data visualization walls enabling the use of real-time data during the decision-making process. Informed decision-making has two accelerators: inclusive and augmented decision-making [246].

By connecting and harnessing the collective intelligence of the workforce, the inclusive decision-making digital accelerator provides a voice to diverse viewpoints and expertise. Using augmented decision-making digital accelerator, managers and employees can make informed decisions based on analytics embedded directly into the work process. By automating and analyzing decision cycles, technology also enables faster decision cycles [246].

Agile accelerators that affect fast execution are dynamic resources and dynamic processes. Human capital, financial capital, and technological capital are dynamic resources, acquired, deployed, managed, and shifted rapidly based on business needs. Dynamic processes are the structured actions that help organizations achieve their objectives [246].

The literature on digital business agility is lacking and requires further investigation, particularly in the AEC industry. This study attempts to fill this gap by providing insights for researchers and paving the way for further research into digital agility elements that may affect or be affected by organizations.

2.4. Digital Transformation in the Construction Industry

Digital technologies are having a transformative effect on industrial organizations [247, 248]. Digital transformation allows companies to improve products and services, gain a competitive advantage, enhance customer experiences, innovate business models, and introduce new business processes [22, 35, 218, 249]. Due to Berman [225], digital transformation varies by industry, as do customer adoption and an organization's legacy environment. However, every industry is under pressure to change, and every organization needs to have a plan in place. In this section, I review the construction industry's journey toward digital transformation to identify the gaps needed to be filled.

Technology does not automatically bring added convenience or value unless firms carefully consider the context into which it is introduced and how to derive any practical or monetary benefits. By becoming digitally conscious, firms can become better equipped to take on new and transformative technologies [250]. Researchers assert that modern digital information technologies can enhance the capabilities of the construction industry by advancing project work coordination and allowing visualization of future construction investment in multiple dimensions [251, 252]. Construction is the least digitalized industry in the era of digital economies [15, 16], but digital transformation can revolutionize multiple segments of the industry, enabling efficient cost and time-saving operations [253, 254].

According to the literature, lack of experienced professionals, lack of training, unsupportive organizational culture, lack of management of digital transformation teams, IT security issues, lower results compared to digital investments, digital divide, and limited resources are the major challenges in the construction sector digital transformation [255].

Due to Koscheyev et al. [208], the construction industry has a great interdisciplinary influence and interaction. They claim that to improve competitiveness, construction companies must transform into digital organizations, integrate digital platforms into the existing ecosystem, rationalize and standardize technological and business processes, and ensure socio-psychological comprehension of digital transformations by all organization employees and business partners.

Construction organization employees spend 70% of their working time on commitments, materials transportation, construction site, and equipment preparation. Industrial robots and drones improve labor productivity by collecting and processing larger data scopes [208]. Digital marketing and sales channels are important at the initial stage of investment-construction project implementation. They provide access to consumers, decrease the costs of goods sold and improve the project's investment attractiveness [208]. Also, service digital tools allow companies to know more about clients' demands ahead of competitors and reduce the time for decision-making in regard to cooperation commencement [208]. So, increasing the use of digital technology has the potential to completely change the construction business [256]. Two techniques have been utilized to manipulate digital technologies in the construction industry: Industry 4.0 [257] and its companion Construction 4.0 [258]. As mentioned earlier, the term "digital" relates to the usage of electronic data sets, as opposed to analog data sets, and is used to distinguish between them [259]. There has been a substantial shift in the acceptability of digital technologies due to the growing usage of digital information in building projects [260, 261], and specifically Building Information Modeling (BIM) [262]. Companies' future seems to depend more on their adoption of digitalization and the change of their business organizations to include digital technology [200].

Despite the facts mentioned above, only 25% of construction companies hold digital transformation programs, and most spend less than 1% of the cash cycle on research and development [263]. The inertia of the industry, the resistance of employees, and the technical challenges specific to the construction industry are the major challenges in digital transformation that prevents managers from implementing it [35]. Some studies [264, 265] highlight possible issues due to digital transformation in the construction sector, such as data

misuse and information leakage, time-consuming meetings, and misinterpretation of information exchanged digitally.

McKinsey & Company indicates in a study that fragmentation, decentralization, and lack of system integration are some of the challenges in digital transformation in the construction sector [266, 267]. Although there are different challenges and barriers in the digital transformation process, some studies suggest possible solutions to overcome these challenges. These include government support [268], reskilling and restructuring the engineering teams [266], and considering the new business models and changes to different job roles due to digitalization [269].

Construction projects involve complex processes that require better project management solutions to deliver them on time within the estimated budget by utilizing the available resources fulfilling the stipulated quality requirements. However, the construction sector has been slow in adopting new technologies and, therefore, productivity is low [21]. Koeleman et al. [266] claim that digital transformation in the construction industry can cause 14% to 15% productivity gains and 4% to 6% cost reductions.

This needs attention that digital transformation of the construction sphere exerts influence on the whole product value chain, so companies must change their operational model to comply with digital transformation strategy, which, due to Koscheyev et al. [208], includes the following elements: focusing on cooperation with client, full package of digital advantages, new management system.

As it is defined earlier, digital transformation means rethinking current business operations in a new way where digital technology is enabled. And due to the literature suggestions, construction companies need to adopt the right process to achieve a smooth transformation [270]. This dissertation discusses the role of the organizational structure of construction companies in smoothing this transformation.

2.5. Digital Transformation, Digital Agility, and Organizational Structure of Construction Companies

So far, the importance of digital transformation in the construction industry has been discussed. It is also mentioned earlier that agility, specifically digital agility, is at the heart of any digital transformation effort. This section examines the literature that assists in developing the main hypothesis of this dissertation: the relationship between digital agility and digitally agile organizational structures.

Companies in today's business environment must deal with a multitude of new or altered challenges, including emerging technologies, shortened product life cycles, innovative business models, and a dynamic competitive environment. Therefore, companies often engage in an organization-wide digital transformation [180, 271]. Previous research has shown that digital technology creates both tangible and intangible value. To exploit the value of digital technology, a firm must entangle physical, technical, and social systems, ensure organization-wide commitment, and that technological development is grounded in strategy and practice [272].

In order to complete the tasks and contribute to the organization's goal as it undergoes digital transformation, the organization must inspire the agents, provide information about the environment, the other organizational agents, and coordinate their actions [135]. Without a strong knowledge management effort, hyperawareness, and informed decision-making, two pillars of agile businesses, would be impossible to achieve. For companies to meet customer expectations promptly, information and data availability, and accessibility are crucial [273]. Furthermore, knowledge of customers' business environments and the forces that create the need to initiate a new project is essential, and intelligence generation will be based on surveys, workshops, focus groups, and meetings [274]. IT department is at the heart of the knowledge management sector of a company [275]. Researchers claim that IT capability positively influences organizational agility [276]. In addition, other authors found that firms need to develop high IT capabilities in order to build agility [277-279]. In the following section, I will go over the role of the IT department in greater detail.

Research has found that learning is vital for organizational innovation capability and firm performance [280-282], and that learning can be expanded in management both externally and internally [283]. External learning is defined as the acquisition and creation of knowledge gained through joint problem solving with suppliers and customers [284]. This knowledge helps firms to become more agile and improve their responsiveness [285, 286]. Internal learning refers to employee training and the incorporation of employee suggestions that occur primarily during process or product development [284]. It is also emphasized that internal learning may help firms enhance their responsiveness and ultimately improve financial performance [287].

Knowledge management acts as a bridge between customer orientation and self-organizing teams by supplying them with data gathered both inside and outside the company [288]. In addition, the need for individual job profiles to perform more challenging tasks may contribute to the use of mixed, multidisciplinary teams for providing customer-oriented solutions. By increasing the degree of autonomy and decision-making power, the work design could eventually lead to the development of self-managed team structures [289-292].

Customer orientation is an important enabler of digital agility in organizations [293]. Anttila, et al. [294] found that more than half of the construction companies studied had not attempted to collect customer feedback. Smyth [295] argues that monitoring client needs is not a construction contracting tradition. However, businesses that want to continuously improve their products and services must recognize that customer needs and expectations change over time. To keep existing customers happy and attract new ones, businesses must constantly monitor and respond to changing market demands [274]. In their study of speculative house building, Roy and Cochrane [296] argue that changing most aspects of the business organization is required to develop and implement a customer-focused strategy.

It is important to understand the term “customer” as inclusive of all parties and individuals who may influence the character, scope, and nature of the product or service the business provides [274]. As described by Newcombe [297], construction projects are characterized by a coalition of forces, or stakeholder groups, which are by definition the customers of that particular project. As a result, construction firms, particularly in the digital age, are being pushed to become more customer-focused. As a result, senior management

must commit to radical change, develop customer-focused strategies and processes, and review and monitor their business strategies on a regular basis [274].

The organization is considered the holder of agility, as it is the principal agent affected by changes in the environment and would use this ability to respond to changes in customers and the market [298-300]. Literature informs us that there is a clear dominance of “agility” in organizational and manufacturing entities, and there is no hegemonic term for the management of new product development projects, which is a process or method. The solution is to develop a specific definition for the project management theory [240]. To respond to changes in customer needs, it would be necessary to change the manufacturing process and product development and to have an agile project team [240].

Imran et al. [28] present organizational structure as one of the key drivers of the digital transformation in industrial organizations. Some organizations develop whole new structures to support digital transformation; others assign business or functional heads the responsibility of creating new functional teams to back the digital transformation.

Many researchers assert that the traditional organizational structures are hard to transform, and the projects for digital transformation have not yet had an impact on the conventional organizational structures [301, 302]. It is also emphasized that organizations should move away from traditional hierarchies and embrace leaner and flatter organizational structures which empower employees and allow greater agility and faster decision-making [303]. So, digital transformation causes enterprises to rethink the very foundation of who and what they are. Reassessing existing skills and capabilities is one way to transition from functional silos to cross-functional teams that can accommodate the interdisciplinary nature of innovative products and services [35, 248].

According to studies, organizational structure significantly affects how well digital transformation works. According to some, successful organizational digital transformation calls for a de-layered or flatter hierarchy, decentralized power of command, less formalization, and greater cross-functional integration [148, 302, 304, 305]. B. J. Robertson [142] calls holacracy “the new management system for a rapidly changing world.” Digital transformation is a pathway towards success in a VUCA world. One might conclude that

companies could benefit from holacratic organizational structures in their journey towards digital transformation.

Despite the fact that it has been highlighted in the literature [29, 35], no study has been conducted to investigate the relationship between digital agility and firm organizational structure in the AEC sector. In this dissertation, I hope to take the first steps toward studies that link organizational design and digital business models.

2.6. Digital Functional Areas (Transformed IT Departments) and Agile Leadership

In the previous sections, I mentioned that digital transformation is the process of creating new products and business models based on data. The creation of data is an inescapable consequence of digital transformation and can have troubling implications [306]. While individuals may consent to share information with organizations with which they interact, this does not entitle any one actor to combine data from various firms or to compile a comprehensive image of consumers' activities. Data has considerable destructive potential should it fall into the wrong hands [14]. Furthermore, studies claim that in the age of digital transformation, companies should use knowledge management as a lever [25] which many, including construction firms, fail to do so [27].

So, the immanent opportunities and threats from digital business transformation significantly affect the role of the IT function. The Enterprise operation environment consists of a physical system, a management or decision system, and an information system. These entities are integrated by means of an integrating infrastructure [307]. In this section, I will see how the literature suggests that companies should transform their IT department into an integrating infrastructure, which is defined as a digital functional area, to solve the problems that arise due to digital transformation. In this regard, Koeleman et al. [266] claim that installing some IT solutions will not suffice, and companies should adjust their IT departments to prepare them for a new digital era.

IT agility and IT ambidexterity are key capabilities that help the IT function support digital transformation [308]. Lee et al. [309] define IT ambidexterity as the ability to pursue exploration and exploitation in the management of IT resources and practices. Contextual ambidexterity balances exploitative and explorative activities in the organization by encouraging individuals to decide for themselves how to allocate their time [310-312].

IT exploitation is the ability to manage existing IT assets well and improve their effectiveness and efficiency, while IT exploration is the ability to learn about emerging technologies, methodologies, and skills. The relationship between IT ambidexterity and organizational agility is limited, but a study by Lee et al. [309] provides empirical evidence that IT ambidexterity promotes organizational agility. Agility facilitates market arbitrage [313], but managerial competencies are required to implement these opportunities [314]. Furthermore, IT ambidexterity moderates the relationship between IT agility and digital transformation support [308].

The IT function's digitalization support includes the creation of IT-enabled innovation to improve the firm's competitive position and to react to or be at the forefront of digital technology-induced changes [315]. In recent years, many organizations have established the role of CDO (Chief Digital Officer) to spearhead the digital transformation journey [243, 316, 317]. It is also suggested by Schlaepfer [318] that companies should also enable and encourage cross-functional collaboration within the firm and create small innovative units.

IT sensing capabilities refer to the ability to identify changes in customer needs and markets, as well as emerging environmental opportunities that may affect the company's business. Strong sensing capabilities require established processes and dedicated resources to continuously acquire external knowledge [319]. Studies argue that IT agility is essential for successful digital transformation support from the IT function [309, 320]. Moreover, Leonhardt et al. [308] observed several CIOs (Chief Information Officers) struggling with their IT function experiencing immense pressure from the business side due to a lack of IT agility. A digitally agile IT function has the ability to scan the environment for relevant digital developments, has the appropriate resources to quickly launch change initiatives, and has a governance and process framework in place that allows for fast yet risk-controlled responses to digital business needs [276, 321].

The interplay of multiple concurrent digital transformation initiatives creates complexity and additional interdependencies within companies [215]. To ensure goal orientation, synchronization, prioritization, efficient structures, and collaboration among all digital transformation initiatives, companies must coordinate digital transformation initiatives across three coordination aspects: strategic alignment [215], governance [271], and communication and culture [322].

Research recommends that companies should use deliberate strategies for exploitation and emergent strategies for exploration. Deliberate strategies might impede exploration of new strategic possibilities [323, 324]. Governance mechanisms regulate the sharing of resources and responsibility for IT between business partners, IT management, and service providers. Communication and cultural aspects are also important in ambidextrous IT organizations, as they can help to reduce organizational barriers and inertia as well as to foster innovative capabilities [325-329].

IT strategy is often seen as a subordinate functional-level strategy that must be aligned with the firm's business strategy [330-332], but some researchers have argued in more recent publications that a digital business strategy is necessary instead, reflecting a fusion of IT and business strategy [315]. There are also those who argue that the many different factors that contribute to digital transformation need their own strategy that stands apart from other functional and organizational plans [215, 219].

Pelletier et al. [333] claim that due to different IT value creation and digital strategies, SMEs achieve mixed results in their digital transformation efforts. Lack of training and lack of digital culture are other major challenges in digitalization in the construction sector [334].

The increased reliance on IT and analytical functions is a key aspect of digital transformation. The IT function itself must change from being a line function primarily concerned with facilitating communication or data flows into a more proactive and orchestrating role supportive of digital value creation through quick and exploratory responses [308]. In addition to changing the functional role of the IT department, businesses frequently overlook the need to improve staff members' digital marketing and service operations skills [335, 336]. From the perspective of human resource management, digital

transformation implies the recruitment of workers with digital and analytical skills who could displace the current workforce.

As mentioned in 2.5., previous studies have suggested that the organizational structure should be adjusted to accommodate the changes brought about by digital transformation [337]. And as discussed here, this would entail the creation of distinct business units, agile organizational forms, and digital functional areas or transformed IT departments [29].

Researchers of digital transformation models claim that organizations that have successfully transformed do not just have well-documented digital strategies but also ensure that these strategies are communicated throughout the organization and internalized by employees at all levels. The strategy should be tested and updated on a regular basis, and adequate resources must be made available [243, 338]. Management must share the organization's new vision and strategy with employees and give them the resources they need to put the strategy into place [339]. Additionally, businesses should actively and systematically investigate and assess emerging trends (such as technological advancements and changes in customer behavior) in order to spot emerging business opportunities and contribute to the formulation of business strategies [340, 341].

Schlaepfer et al. [318] argue that a company's culture that is committed to digital transformation must foster an environment where employees are free to try new things and where innovation is encouraged on a regular basis. Some call this a "fail forward culture," which means that people are encouraged to try new things and grow from their failures. This kind of culture cannot be established without the full support of the board of directors and the C-level executives [316, 342]. Thus, successful digital transformation necessitates strong digital leaders who are not necessarily high-tech wizards but who can manage complexity, inspire and develop distinct digital cultures that are supportive of success, and promote the development of innovative digital solutions despite investment risks [316, 338, 340].

The question of company culture as a hurdle to digital transformation is moving more and more to the foreground and to the top of CEOs' agendas. Adaptive attributes of culture can positively influence the progress of digital transformation efforts [343, 344]. In order to foster a collaborative environment within the organization for an effective digital

transformation, leadership is crucial. To produce the desired results, leaders must strike the right balance between businesspeople and digital talent [28]. Agile leadership is at the heart of every digital transformation attempt because this transition is not an isolated routine technical project. In fact, digital transformation involves social and cultural elements that need to be led by leaders who value agility.

Organizational agility can be attained through effective leadership. Leaders must be able to adapt to change, think for the benefit of the entire organization, and be willing to share resources for innovative projects or particular initiatives that are not always tied to the strict key performance indicators [28]. To achieve customer centricity, leaders need to be committed to providing solutions to customers and driving value for them. They need to know what their customers want and where they're changing so they can create digital products that meet their needs. Researchers believe that leaders' roles in co-creation with customers are also important. Leaders should involve customers in testing and keep abreast of all technological advancements in the sector [28].

Digital transformation affects multiple areas of an organization and requires a common understanding of the relevant areas to be addressed and the prioritization of digital transformation activities. Consequently, managers need to systematically assess the current state of digital transformation in their organization [204]. In a nutshell, it appears that we require agile leaders in the digital age.

2.7. Change Management towards Digitally Agile Construction Organizations (DACOs)

When an organization transforms from a current state to another desired state, an organizational change occurs. Effective management of this change includes the planning and implementation of the change in a way that minimizes employee resistance and costs while maximizing the effectiveness of change management efforts [345]. As strategic and operating conditions become increasingly turbulent due to factors such as hyper-competition, increasing demands from customers, regulatory changes, and technological

advancements, the ability to change becomes an important determinant of firm success in a VUCA environment [11, 12].

Veldhoven and Vanthienen [346] identified key components of digital transformation and summarized them into three key transformations: business transformation, digital technologies transformation, and social transformation. Digital transformation pushes enterprises out of their comfort zones and forces long-term strategic choices about an unpredictable future [347]. Digital transformation involves fundamental and comprehensive change. It is the reinvention of the way in which a company operates [241]. Digital transformation also requires talent in four domains: technology, data, process, and organizational change capability [255, 348]. This could necessitate organizational changes in human resource management, as well as recruitment processes and criteria. Moreover, using digital technologies to generate value is becoming one of the decisive factors for companies to survive and compete in the digital economy [214]. The four dimensions of technology use, changes in value creation, financial considerations, and structural changes are the focus of business digital transformation strategies [349]. This dissertation's main emphasis is on the latter.

Earlier, it was discussed how cross-functional teams are crucial for agile businesses. This basically means that developers, IT specialists, designers, and stakeholders, among others, form cross-functional teams in a "digital factory" to create something new for the company using agile sprints and techniques like "design thinking." [318]

Studies have revealed that digital technology has changed the way we conduct business. Some perceive it as a catalyst for opportunity, while others see risks stemming from the scope and uncertainty associated with transformative change [14]. Operational studies also claim that digital technologies have changed the way industrial organizations operate and, therefore, require a company-wide transformation program [35].

The necessity of reskilling and restructuring the engineering teams for better digital transformation is highlighted in Koeleman et al.'s work [266]. Due to the fragmentation throughout the project lifecycle, coordination within the organization is necessary to manage

the change during the implementation of digital solutions for a construction project. That may be challenging, though, given how little time is allotted for a project's completion.

Despite the widespread adoption of the concept of digital transformation, organizational change is not fully understood in the earlier literature [23, 35, 350]. Digital transformation initiatives purposefully create organizational change and foster ambidexterity. However, the interplay of multiple concurrent digital transformation initiatives causes considerable organizational complexity [351], which can be overcome by combining structural (e.g., digital units) and contextual (e.g., cultural change programs) approaches [35].

By combining leadership with the appropriate set of competencies, modifications to established organizational structures, and revitalizing organizational culture, industrial organizations can successfully implement digital transformations. This leads to improved agility, customer centricity, and collaboration.

The combination of disruptive technologies makes it hard to change the existing structure of an organization, and it will take time and more effort to change the employees' resistance to change [352]. So, it is obvious that organizational culture plays a role in shaping transformation. The shift is influenced by people's work habits, mentalities, and social norms [353]. Jose [354] asserts that when a construction industry undergoes a rapid digital transformation, the change affects the business models, processes, and the way employees work throughout the value chain. The change management methodology should be based on emotional intelligence. He obviously considers the cultural aspects of change to be the most important.

Digital technologies and innovation require organizations to cope with continuous change. To handle this change, organizations must implement a digital transformation strategy that comprises strategic responses [215], structural changes [355, 356], and general cultural change [322]. Based on what I have been said so far, one could conclude that construction organizations require change involving leadership, structure, and culture to ensure the organization-wide impact of digital transformation. However, the literature on change management efforts in construction companies with digital transformation on their

agenda is limited. This dissertation attempts to fill the abovementioned gap by providing insights into leadership, structure, and culture relationships.

2.8. Identification of the Literature Gap

As discussed in this chapter, construction is known to be one of the least digitalized industries in the digital economy, but digital transformation has the potential to turn the table in favor of the construction industry [15, 16]. Many researchers have recently expressed an interest in the effects of digital transformation on the AEC industry. However, there is scant conceptual and empirical research on the digital transformation of industrial organizations, especially construction organizations [22, 23].

There is no empirical research that examines the position of construction companies along the digital transformation spectrum. Researchers agree, however, that given how increasingly digital businesses are becoming, change is unavoidable for the organizations in AEC sector [11, 12]. Although studies on change management in construction organizations have been conducted, most of these studies have not addressed organizational changes brought on by digital transformation.

Furthermore, organizational design of firms is thought to play a critical role in their success in a digital world [28], a world characterized by volatility, uncertainty, complexity, and ambiguity. According to studies, companies must be digitally agile in order to survive in such a world. However, no research has been conducted on the relationship between a company's organizational structure and the digital agility of its business model.

In this respect, Verhoef et al. [29] and Vial [35], defined research agendas for future studies on digital transformation in their recently published multidisciplinary review articles. They believe two main questions need to be pursued by future researchers:

1. Which organizational structures enhance firms' digital agility?
2. What organizational structures are most effective for digital transformation?

As discussed earlier, agility and organizational agility are broad concepts [357]. When studying digital transformation, these concepts must be redefined and tailored to the digital environment [241]. Recently, the concepts of velocity, focus, and flexibility as the elements of business agility [241] have been translated into hyperawareness, informed decision-making, and fast execution [246] that contain more practical implications for digital business agility. The latter concepts have yet to be used by researchers in organizational studies, and this academic work attempts to bridge that gap.

I also discussed three organizational structures in this section, namely bureaucratic, adhocratic, and holacratic organizational structures, and learned that future organizations may benefit from shifting toward more flexible organizational structures that foster digital agility. Through the manipulation of self-organizing teams, holacratic organizations appear to provide an opportunity for companies to be more agile and flexible [142]. However, due to the novelty of these subjects and a lack of cases that could be studied, the literature on holacratic organizations is limited and the concept has just recently put into practice by some organizations.

The literature also discusses how construction organizations should be classified as PBOs [26] and how any change that is required in these organizations should be implemented in a series of projects [6]. Furthermore, the use of SMOs in PBOs is a novel idea that has yet to be investigated in the construction industry.

As mentioned in the background, Bumann [216] has identified six action fields for the digital maturity of any company. I aim to look into these topics in the context of construction companies. Furthermore, little work has been done to understand the role of leadership in creating a digitally agile organization, and this study also attempts to shed light on this concept.

The concept of digital functional areas or transformed IT departments has emerged as a critical contributor to organizations' efficiency and agility in the digital era [29]. According to research, the IT function must transition from a line function primarily concerned with facilitating communication or data flows to a more proactive and orchestrating role supportive of digital value creation through quick and exploratory responses [29]. However,

no studies in the field of construction management have been conducted to investigate this viewpoint.

In this dissertation, I investigate the basic elements of organizational structures and their relationship to digital agility in order to provide insights into the characteristics of the most effective organizational structures for the digital transformation of construction companies. Furthermore, I want to take the first steps toward understanding the action fields. In order to achieve this, it is necessary to first determine whether there is a significant correlation between the organizational structure of a construction company undergoing digital transformation and the digital agility of its business model. Thus, this work's main contribution would be a solid foundation for future organizational studies in the context of digital transformation in the AEC industry.

3. METHODOLOGY

For this study, I designed an exploratory sequential mixed method approach [358] (Figure 3.1.) that includes a qualitative data collection and analysis phase that leads to a qualitative model and a quantitative data collection and analysis phase that tests the hypotheses developed in the qualitative stage. The interpretation of the results is based on the content analysis done on the interviews and the insights from the literature.

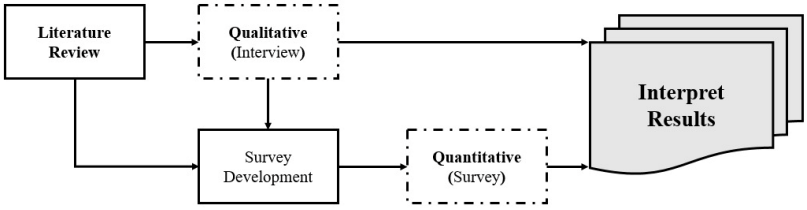

Figure 3.1. Exploratory sequential mixed-method approach.

First, a thorough literature review identified some of the themes and elements of a digitally agile organizational structure and digital agility. Because the topic of this study is novel, additional resources other than existing literature are required to provide me with insights. To address the scarcity of insightful qualitative data in the literature, I conducted in-depth, semi-structured interviews with AEC industry experts to investigate their concerns and understand their points of view. Content analysis is done on the interviews after transcribing them. Then, I hypothesized the relationships between the defined elements and developed my first qualitative hypothetical model based on my understanding of the trends in the literature and expert knowledge.

The interviews also assisted me in defining factors for measuring some of the qualitative variables. In the following phase, these factors were transformed into questionnaire items. Given the small sample size, I used SmartPLS 3 to conduct a PLS-SEM analysis (a non-parametric statistical method) on the data and test my hypotheses after collecting data via questionnaires. Figure 3.2. depicts all stages of this research project.

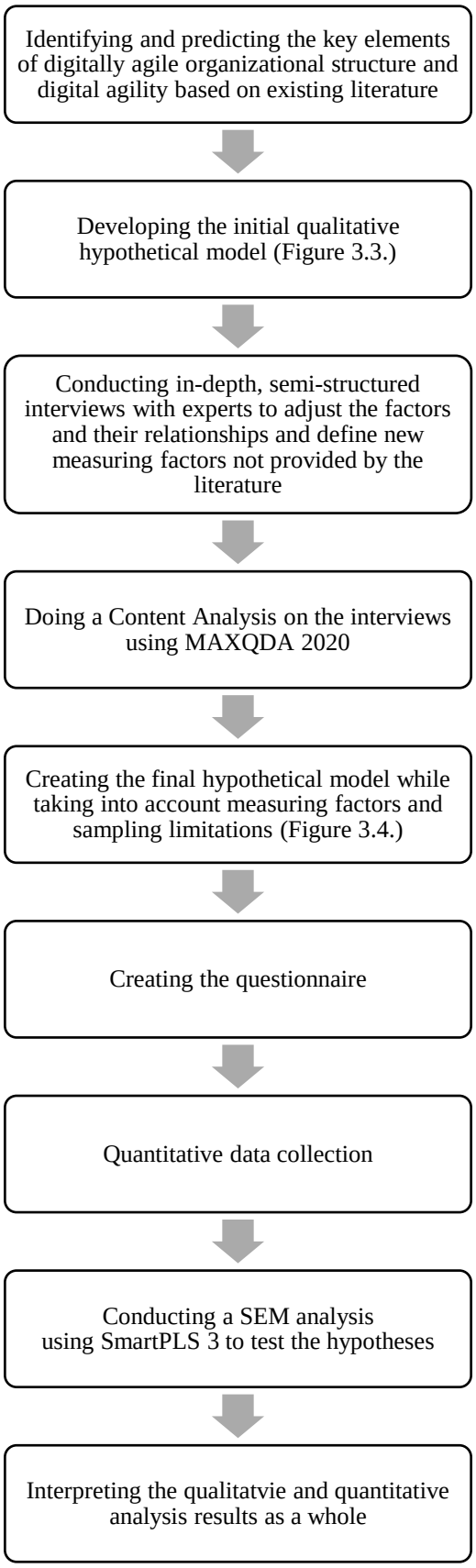

Figure 3.2. The research methodology flowchart.

This section is divided into four subsections. To begin, I develop hypotheses early on based on the literature and interview insights. The second part will discuss the research setting. The third subsection will be about data collection, in which I will go over the sampling methodology, criteria, interviews, and questionnaire design in depth. Finally, I discuss my data analysis method, structural equation modeling (SEM), and why I chose this analysis method.

3.1. Hypothesis Development

As mentioned in the background, different authors in various fields indicate different characteristics of a digitally agile organization. The topic of digital agility and its relationship to the organizational structure of construction companies is not well-researched. Nevertheless, some studies provide valuable insights into the different characteristics of organizational agility and how it relates to the company's organizational structure. There is a trend among most of these works to emphasize the importance of digital technologies and their adoption in organizations undergoing digital transformation. Additionally, these studies suggest that traditional organizations, of which most companies in the AEC sector are a part, require structural changes to remain relevant to digital transformation [359].

In the present study, I investigate the characteristics of a digitally agile organizational structure for construction firms. To do so, I need to start with a definition for a digitally agile organizational structure. This definition is based on existing research on organizational studies and digital transformation in other industries. I attempt to define this hypothetical definition using the earlier four organizational elements introduced in the background.

According to the literature, industrial organizations still have a rigid hierarchy, and formalization is high in these organizations [28]. Some researchers assert that process-oriented approaches (formalization) are one of the hurdles in attaining organizational agility [28]. It is known that a dynamic environment has a more considerable effect on organization structure than a static one [87]. Digitally agile organizations should have capabilities that enable them to be agile in the so-called VUCA environments [360]. Studies indicate that

there is a direct link between complexity and environmental uncertainty [71]. Moreover, formalization and uncertainty in the environment go in opposite directions.

The more complex the environment, the greater the decentralization [87]. Here, complexity refers to the extent to which a technical or social system's behavior is emergent, and agility refers to the capacity of a team to react quickly to change. Moreover, as I mentioned earlier in the background, the interplay of multiple concurrent digital transformation initiatives in a company causes considerable organizational complexity [351].

In today's business context, companies often engage in organization-wide digital transformation, which relies on the use of digital technologies to enable changes in value-creation paths [35, 361]. Digital transformation strategies often comprise multiple concurrent initiatives on different levels, including digital labs and units [362], incubators [363], and overarching cultural change programs [322]. Due to Imran et al. [28], organizations have adopted two different strategies for achieving digital transformation, including developing a separate organization that provides digital support to the main businesses and allocating digital transformation tasks to the business heads. These initiatives increase organizational complexity.

As previously stated in the background, centralization is detrimental in the context of PBOs, whereas integrity and formalization are two aspects of the organizational structure that help the project succeed [185].

As a result of the rise of digitalization, organizations are undergoing changes to become more agile. The ability of a company to better identify changes in their environment and to sense new opportunities is improved when decision-making is decentralized to lower levels of the organization [364]. This is because lower-level employees have objective functions that differ from the CEO and senior executives at corporate headquarters [365].

Due to Lehn [365], decentralization promotes corporate agility, which is directly related to corporate performance and survival during periods of rapidly changing environments. Also, Jensen and Meckling [366] note that knowledge should be co-located

with decision rights and that corporate headquarters can transfer decision rights to lower-level employees. Literature also asserts that if knowledge transfer costs increase relative to control costs during periods of rapid environmental change, then firms with more decentralized governance structures will perform better and have a higher likelihood of survival than firms with more centralized governance structures [365].

Organizational Integration can help companies to manage change by identifying opportunities for potential improvements, monitoring processes, and modifying them whenever required. This requires the use of pertinent performance indicators at all decision levels, as well as the development of a sound life cycle culture [307]. Organizational Integration is concerned with making the enterprise interoperable to improve efficiency and reactivity and is concerned with providing the right information at the right place at the right time [307, 367-369].

Shirazi et al. [370] make the following conclusions about the PBOs in the construction industry. The more complex the environment, the more decentralized the structure. The more complex the technical system, the more decentralized the structure. The more interdependent the range of activities, the more decentralized the structure and greater functional specialization.

Overall, one can define a DACO as a PBO with a less formalized, complex, decentralized, and integrated structure. These concepts will be expanded on in the following sections.

In order to design a qualitative model that could be controlled and adjusted based on interviews with construction industry professionals, I need to integrate knowledge gained from research conducted in other industrial sectors in addition to the AEC sector. I developed the following model (Figure 3.3.) that contains all my basic hypotheses.

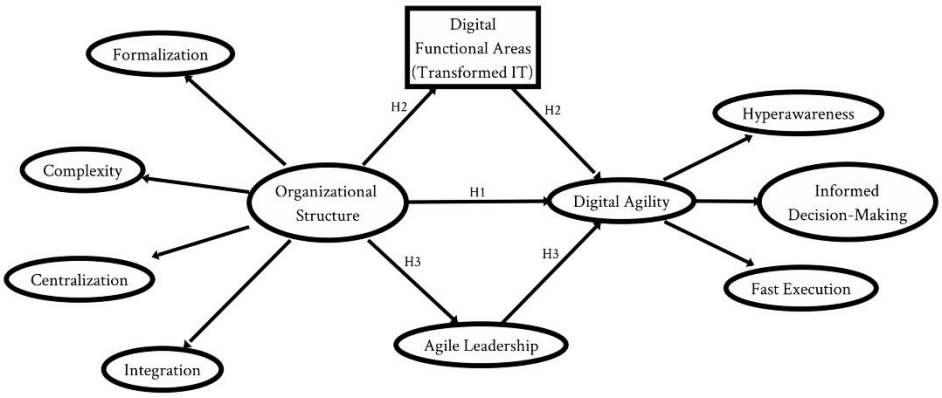

Figure 3.3. The initial hypothetical model.

3.1.1. Hypotheses

Many studies unanimously suggest the need for a digitally agile organizational structure to facilitate the process of going through digital transformation [337, 371]. In the meantime, many companies are still using a hierarchical, bureaucratic organizational structure [372]. Also, some large enterprises use a matrix structure to make their business more agile [373]. But, these are proven to belong to the pre-digitalized era [374].

Imran et al. [28] found that organizational structures play a key role in attaining organizational agility. Thus, an orchestrated change management is necessary for implementing structural and cultural changes to traditional organizations in order to make them ready for digital transformation [28]. One key capability that facilitates this process is creating digitally agile organizational structures [375]. So, based on what I have said, here is my first and main hypothesis:

- **H1:** Digitally agile organizational structure relates positively to digital agility.

Literature asserts that digital transformation initiatives seek to change companies' value-creation paths by utilizing digital technologies [376]. To achieve IT ambidexterity, companies can implement dual structures, i.e., a traditional IT setup for exploitation and an agile IT setup for exploration [356].

As I defined earlier, agility refers to the ability of a company to sense opportunities for business innovation and to rapidly take action and seize opportunities. IT is no longer limited to enabling innovation and new ways of value creation through increasing a firm's sensing and responding capabilities. Tiwana and Konsynski [329] define IT agility as the ability of the IT function to rapidly adapt to changing line function demands and opportunities.

Companies that are undergoing digital transformation can facilitate agility, and collaboration, abolish obstacles, and reduce costs [377] through shared language [378], shared knowledge [379], and shared understanding [378]. These can be created in a company through digital functional areas such as transformed IT departments [29].

As mentioned in the background, companies are increasingly integrating digital technologies, creating large and complex IT artifacts, namely, digital infrastructures [380, 381]. Yet, given their complexity, these affordances often remain invisible, preventing employees from leveraging their potential and thus, preventing effective use of digital infrastructures [382].

A flexible IT function is becoming more and more critical for companies' digital transformation. However, when combined with decentralized decision-making rights, excessive IT function flexibility leads to a complexity trap, which reduces organizational agility [364].

Moreover, Sklyar, et al. [337] assert that a flexible structure is composed of separate business units (in the form of self-organizing teams) and digital functional areas, which are transformed IT departments playing a more proactive and orchestrating role supportive to digital value creation via fast and explorative responses [308]. So, based on these, I hypothesize that:

- **H2:** The relationship between digitally agile organizational structure and digital agility can be moderated using digital functional areas (transformed IT departments), such that the relationship is stronger when these areas are used in the organization and weaker when they are not.

An organizational redesign alone will not provide the flexibility that today's global companies require in order to compete. Studies emphasize the necessity of having multidisciplinary, cross-functional, networked self-organizing teams with decision-making authority to enable flexibility [383]. There also seems to be an inherent correlation between agile leadership vision and flexibility in organizations because leadership talent supports the decision authority of teams [384].

As discussed in 2.6., leadership is a key enabler for successful digital transformation of industrial organizations [28]. In order to successfully implement digital transformation, industrial-organizational leadership must work on certain competencies, including adaptability, the right attitude, communication skills, data-driven decision-making, empowerment, failing fast, experimentation, open-mindedness, risk-taking, trust, and vision [28]. Moreover, the interviewees frequently emphasized the importance of leadership in fostering agility and saw leaders' agile vision as essential for digital transformation. So, my last hypothesis is:

- **H3:** The relationship between digitally agile organizational structure and digital agility can be moderated by agile leadership so that the relationship is stronger with agile leadership and weaker with traditional management styles.

3.1.2. Measuring Factors

To put my hypothetical model to the test, I need to define some measuring factors for each of the qualitative variables. I combine expert knowledge gained through interviews with what the literature has to offer. The factors defined in this section are direct questionnaire items (Appendix A) with which I measured the qualitative variables (Figure 3.4).

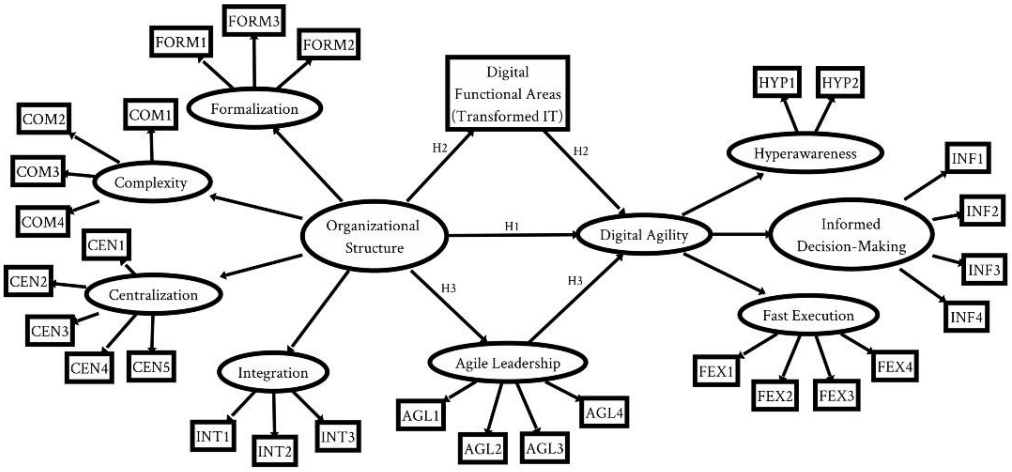

Figure 3.4. The hypothetical model with measuring factors/items.

The measuring factors utilized in the questionnaire are summarized in Tables 3.1 through 3.3. The qualitative variables (QVs) of this research are organizational structure (a digitally agile organizational structure), digital agility, and agile leadership (Figure 3.4). The elements of organizational structure and digital agility are defined as clusters (also qualitative), each measured using a few measuring factors. The parameters used to measure the clusters have a direct or inverse connection with them. This is a conceptual connection that also aids in cross-checking questionnaire responses. The (+/-) column in Tables 3.1 through 3.3 depicts this connection.

As mentioned earlier, digital business transformation outlines three pillars that a company must have in order to be digitally agile: hyperawareness, informed decision-making, and fast execution [246]. Because these concepts are new to the literature, they have not been well investigated. However, I established certain measuring factors evaluating digital agility via a multidisciplinary literature review.

Three pillars of digital agility could be assessed based on their accelerators [246]. Due to existing literature, these accelerators have certain characteristics. Businesses need technical support to allow behavioral awareness (HYP1) and efficiently gather data from both workers and contractors [246]. Some applications, for instance, can make it simple for

workers to provide anonymous feedback in the present. This encourages a culture of listening, which may assist in surfacing useful negative input [246, 313].

Sensing the operational environment, monitoring changes in physical assets, manufacturing facilities, transportation fleets, and facilities that businesses utilize to provide the goods or services they offer are all part of situational awareness (HYP2). In this context, it is possible to use digital technology to ensure, for instance, worker safety on worksites [246, 385, 386].

By integrating the analytical process into the physical world, ubiquitous analytics (INF1) enhances human cognition and makes it possible to make sense of enormous data anywhere, at any time [387]. By giving managers and staff members the resources they need to choose wisely in particular situations, ubiquitous analysis aids in making well-informed choices in a VUCA environment [246, 388, 389]. Additionally, it contains fast or automated decisions (INF2), which use automation and analytics to speed up decision cycles [390]. As mentioned in the background, inclusive decision-making (INF3) provides a voice to diverse viewpoints and expertise by connecting and harnessing the collective intelligence of the workforce [246]. The use of new tools and unique algorithms allows for quick, data-based decision-making in a group setting, which is then driven by multicriteria voting [391]. Additionally, acquiring real-time task information is made easier by augmented reality programs that assist workers where they are needed [392]. This is known as augmented decision-making in the literature (INF4) [246].

As discussed earlier, fast execution is about dynamic resources and dynamic processes [246]. A company’s human, financial, and technical capital are considered dynamic resources, and they may be quickly acquired, deployed, managed, and moved depending on the needs of the organization. The two categories of resources that they fall under are agile talent and agile technology [246]. Agile talent (FEX1) is the capacity to quickly and accurately put together teams by identifying individuals with the required expertise [393]. Agile technology (FEX2) is the capacity to swiftly acquire technological resources and use technological infrastructure to address changing business requirements [394].

Dynamic processes are the systematic actions that help organizations achieve their objectives [246]. They also consist of two parts: rapid enablement and rapid intervention. Rapid intervention (FEX3) is the capacity to modify ongoing activities and acquire time-bound value [246]. The capacity to swiftly generate new organizational skills across a wide range of tasks, including marketing, customer care, commerce, and application development, is known as rapid enablement (FEX4) [395, 396]. Table 3.1 summarizes these factors, their corresponding codes used to model them, their relationship to the clusters, and the reference articles that I used to define them.

Table 3.1. Summary of measuring factors for digital agility.

QV	Clusters	Code	Measuring Factors	+/-	References
Digital Agility	Hyperawareness (HYP)	HYP1	Behavioral Awareness	+	[246, 313]
		HYP2	Situational Awareness	+	[246, 385, 386]
	Informed Decision-Making (INF)	INF1	Ubiquitous Analytics	+	[246, 387-389]
		INF2	Automated or Fast Decisions	+	[246, 390]
		INF3	Inclusive Decision Making	+	[246, 391]
		INF4	Augmented Decision Making	+	[246, 392]
	Fast Execution (FEX)	FEX1	Agile Talent	+	[246, 393]
		FEX2	Agile Technology	+	[246, 394]
		FEX3	Rapid Intervention	+	[246]
		FEX4	Rapid Enablement	+	[246, 395, 396]

Three indicators might be used to assess formalization in a digitally agile organization. One of the primary features of formal organizations is the presence of well-defined job descriptions (FORM1) [397]. Another strategy used by organizations to ensure power control is establishing specified standards and procedures (FORM3) [398]. Some firms allow

their staff to break from established restrictions and behave independently in order to develop flexibility and agility (FORM2) [399]. This component is inversely related to formalization.

An organization's complexity is determined by the number of job titles (COM1) [400], specializations (COM2) [401], and labor divisions it possesses, as was previously noted. This comprises the number of levels (COM4) [402] in its structure and the distance between its components (COM3) [403]. As the number of activities and degrees of specialty increase, the organizational processes get increasingly challenging.

Based on the existing literature, I defined two direct and two reverse measures to determine where digitally agile organizational structures fall on the spectrum between decentralization and centralization. Yardsticks against decentralization include using employee feedback (CEN1) [404] and giving employees decision-making authority (CEN2) [405] through the formation of self-organizing teams (CEN5) [406]. Also, Christie et al. [407] and Acemoglu et al. [408] use variables related to layers of management and the degree of autonomy managers have over investment and employment decisions to study the decentralization of firms. As measures of centralization, on the other hand, could be the extent to which managers submit to the central authority (CEN4) [409] and the control over employees (CEN3) [410].

The ability of various organizational components to effectively respond to one another and pursue shared objectives is referred to as organizational integration, as was previously mentioned [39, 40]. Due to interviews, one crucial measure of a company's integration is having educational programs (INT3) [411]. These programs not only help employees improve their digital skills but also provide opportunities for rapport building, which can help with organizational culture, collaboration, and communication (INT1) [412]. Furthermore, one of the objectives of digital transformation is for businesses to become more customer-centric. This requires the collaborative involvement of customers (INT2) [413] in projects which helps with organizational integration. Table 3.2 summarizes these factors, their corresponding codes used to model them, their relationship to the clusters, and the reference articles that I used to define them.

Table 3.2. Summary of measuring factors for digitally agile organizational structure.

QV	Clusters	Code	Measuring Factors	+/-	References
Organizational Structure	Formalization (FORM)	FORM1	Defined Job Description	+	[397]
		FORM2	Deviation Allowance to Employees	-	[398]
		FORM3	Defined Standards and Procedures	+	[399]
	Complexity (COM)	COM1	Job Titles	+	[400]
		COM2	Specialties	+	[401]
		COM3	Management Layers	+	[403], Expert Opinion
		COM4	Number of Vertical Levels	+	[402]
	Centralization (CEN)	CEN1	Using Employee Feedback	-	[404, 408]
		CEN2	Employee Authority	-	[405, 407]
		CEN3	Managers' Obeyance from Central Power	+	[410]
		CEN4	Level of Control over Employees	+	[409]
		CEN5	Self-Organizing Teams	-	[406]
	Integration (INT)	INT1	Collaboration and Communication	+	[412]
		INT2	Collaborative Involvement of Customers	+	[413]
		INT3	Educational Programs	+	[411], Expert Opinion

According to the experts who took part in this research, failing-fast (AGL2) and collaborative systems thinking (AGL4) are critical to attaining agility. This is in line with the findings of Imran et al. [28]. They said that the emergence of new leadership positions in the workplace is where digital transformation often begins. The most significant leadership abilities, according to their research, are flexibility, the correct attitude, communication skills, data-driven decision-making, valuing distributed decision authority

(AGL1), failing fast (AGL2), experimentation, open-mindedness, risk-taking (AGL3), trust, surface-level technical understanding, and vision. Other studies support these characteristics of agile leaders [406, 414-416]. Table 3.3 summarizes these factors, their corresponding codes used to model them, their relationship to the QV, and the reference articles that were used to define them.

Table 3.3. Summary of measuring factors for agile leadership.

QV	Code	Measuring Factors	+/-	References
Agile Leadership (AGL)	AGL1	Valuing Distributed Decision Authority	+	[28, 406, 414], Expert Opinion
	AGL2	Failing-Fast Mindset	+	[28, 416]
	AGL3	Risk-Seeking Behavior	+	[28, 415]
	AGL4	Collaborative Systems Thinking	+	Expert Opinion

3.2.Data Analysis

The data analysis is divided into two parts. In the qualitative section, I use content analysis to develop a good understanding of qualitative data gathered through semi-structured interviews. In the quantitative section, I use PLS-SEM to test my hypothetical model developed in this chapter.

3.2.1. Qualitative Data Analysis (A Directed Content Analysis)

I used qualitative content analysis techniques [417] to analyze qualitative data using MAXQDA. The aim of content analysis is to create systematic references and inferences based on meanings and contexts contained within texts, messages, or other forms of communication so that valid and replicable results can be generated for further study [418].

By examining the information contained in a message, content analysis enables the creation of conclusions and inferences about it [419].

Krippendorff [420] defines content analysis as “a research technique for making replicable and valid inferences from data to their contexts.” Kassarjian [421] calls it “a systematic method which identifies certain characteristics embedded within messages.” According to Weber [422], it is a technique for drawing conclusions about the message’s sender, content, and effects.

All in all, I can say that through objectively and systematically studying the meanings embedded in communications, the content analysis provides a set of interpretations that can be replicated due to their focus on objectivity, validity, and explicit rules. The content analysis method is used in this study to identify individuals’ views, interests, sentiments, and attitudes.

Three types of qualitative content analysis exist: summative, conventional, and directed [423]. Summative content analysis involves quantifying the number of words or content and interpreting the results. In conventional content analysis, categories develop naturally from the analysis rather than being imposed on the data. The use of conceptual categories in a new context is what directed content analysis is about.

When there is little existing theory or prior research on a phenomenon, and it would benefit from more description, directed content analysis is a good tool to use with the intention of conceptually validating or extending a theoretical framework or theory [423]. Because the present study was designed to explore the digital transformation of previously developed conceptualizations from one context (manufacturing and technology organizations) to a new context (AEC organizations), I used the directed content analysis method. The previously developed conceptualizations used in this study were the categorizations derived from the background literature review.

Deductive reasoning is a characteristic of directed content analysis. There are many who claim that only inductive qualitative research may be done, while others contend that qualitative research can be inductive, deductive [424, 425], abductive, and even a mix of the

three [424]. As will be discussed later, the qualitative analysis in this study can be thought of as both deductive and inductive.

Based what I said in the above, I applied a categorical coding system to the interview transcriptions using MAXQDA, which I initially developed based on the existing literature and content analysis theory [417]. Every time new topics emerged from the data during data analysis, I expanded my theoretically derived coding scheme. As a result, I produced new codes and assigned them to the appropriate category. When the coding scheme was too general, I carefully reviewed my codes and categories in the middle and at the end of the data analysis to condense codes and establish subcategories. By doing this, I made sure that the coding system was precise and clear.

3.2.2. Quantitative Data Analysis (Structural Equation Modeling and PLS-SEM)

Structural Equation Modeling, or in short SEM, is a statistical modeling technique. It can be seen as a synthesis of path analysis, regression analysis, and factor analysis. Theoretical concepts, which are represented by regression or path coefficients between the factors, are frequently of interest in SEM.

SEM has become a somewhat standard analysis method in management and marketing sciences for analyzing cause-effect relations between latent constructs [426]. It is also widely used in behavioral sciences [427]. In the field of construction [428-434] and project management [435], researchers have recently shown interest in using SEM to test, predict, and develop their theories.

As mentioned under 3.1.2, SEM enables the development of hypothetical models incorporating both latent and observed variables. Latent variables, which represent one of this method's key ideas, are measured through the use of associated observed variables. The measurement model and structural model are two models that are frequently used in the literature to assess whether the data support the model [436]. These two models offer a thorough confirmatory assessment of the construct [437]. The measurement model evaluates the measurement of hypothetical constructs and the reliability of observed variables, while

the structural model assesses the relationships between constructs and looks at hypothetical effects [438].

As shown in Figure 3.5, the final hypothetical model has three measurement models and one structural model. The latent variables in this model are:

1. Organizational Structure
2. Agile Leadership
3. Digital Agility

and the observed variables are:

1. Formalization
2. Complexity
3. Centralization
4. Integration
5. Digital Functional Areas (Transformed IT Department)
6. Valuing Distributed Decision Authority (AGL1)
7. Failing-Fast Mindset (AGL2)
8. Risk-Seeking Behavior (AGL3)
9. Collaborative Systems Thinking (AGL4)

One tangible difference between the hypothetical model in Figure 3.5 and the one in Figure 3.4 is that I turned six of the latent variables into observed variables. I decided to do this because the sample size was ended up being small. This causes several analytic challenges for a complex model as in Figure 3.4. One basic problem is the failure of the model in the chi-squared test. To resolve this issue, I decided to use the sum score method [439].

As Van der Ark [439] puts it, the sum score is sometimes used by researchers "to order respondents on the latent trait measured by the test." It has been discovered that the sum score can be used to order respondents on the latent trait safely for the majority of polytomous item response theory (IRT) models that do not imply stochastic ordering [439]. This is the case in this study, so using the sum score makes sense. This method has been used by researchers in organizational studies, such as Mahmoudsalehi et al.'s work [440] which attempts to identify the impact of organizational structure on knowledge management.

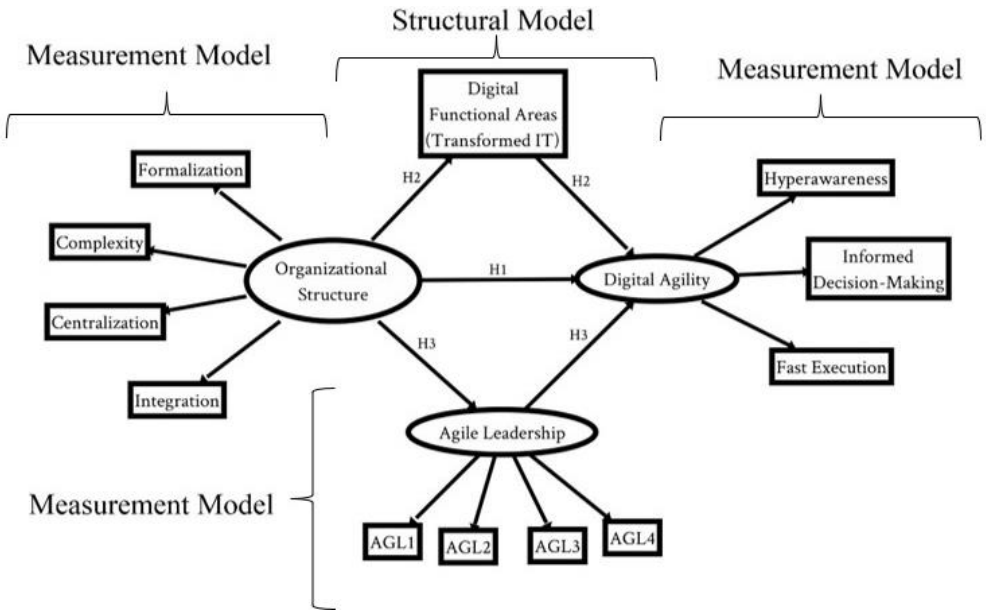

Figure 3.5. The final hypothetical model.

As mentioned earlier, there are two approaches to SEM: the covariance-based SEM (CB-SEM) and partial least squares SEM (PLS-SEM). It is simple to understand how CB-SEM and PLS-SEM differ philosophically. CB-SEM is the best method to use if the goal of the study is to test and confirm theories. On the other hand, PLS-SEM is the right approach if the goal of the study is theory development and prediction [426]. PLS-SEM is conceptually and practically equivalent to performing multiple regression analysis. The main goal is to increase explained variance in the dependent constructs, but a secondary goal is to assess the data quality using the properties of the measurement model.

PLS-SEM can handle a wider variety of issues than CB-SEM due to its effectiveness with a much wider range of sample sizes, increased model complexity, and less stringent data assumptions [426]. Furthermore, PLS-SEM allows for the use of constructs with fewer items than those that CB-SEM requires because the measurement properties of the constructs are less constrained. PLS-SEM is an appealing and frequently more appropriate alternative to CB-SEM when measurement or model properties prevent the use of CB-SEM or when the focus is more on exploration than confirmation [426].

Based on the rules of thumb presented in Hair et al.'s 2010 article [426] for choosing between CB-SEM and PLS-SEM, I chose the latter because it works better with small sample sizes, and my goal in this exploratory research is to identify key driver constructs and predict key target constructs rather than test an already developed theory.

There are two steps to the quantitative analysis. First, the PLS-SEM model is evaluated to see whether the measurement variables are correlated with their latent variables. Composite reliability and convergent validity and discriminant validity are tested in order to accomplish so. A short description of these concepts is provided below.

Cronbach's alpha values and composite reliability speak to the consistency of the model. They demonstrate the compatibility of measurement (observed) variables with latent variables. They specifically clarify the degree to which the latent item is explained by the related observable factors. The values vary from 0 to 1, and a trustworthy model requires a value of at least 0.7 [441, 442].

When measuring the positive correlations between measurement items that are related to the same concept item, convergence validity is considered [443]. Convergent validity may be determined by looking at the AVE value and factor loadings. A good model should have an AVE value greater than 0.5 [444]. Different thresholds are proposed by various scholars for factor loadings. For instance, Hulland [445] recommended using items with a factor loading of 0.5 or higher to achieve the requisite convergent validity, although other studies offered a 0.6 [442] or 0.7 [446] criterion.

Fornell-Larcker Criterion and Cross Loadings were evaluated to determine the discriminant validity of construct variables. A latent factor's discriminant validity is a measure of how different it is from other factors [445]. The square root of the AVE for each latent component is compared using the Fornell-Larcker criteria to examine correlations between latent variables. It is anticipated that the diagonal values, which represent the square root of the latent variables' AVE scores, will be larger than the correlation between the other latent variables.

Second, the PLS-SEM structural model is assessed to determine factor loadings, and following corrections, the hypotheses are tested. The following criteria were used for this stage of analysis.

In a partial least square SEM analysis, the variance inflation factor (VIF) evaluates the collinearity of indicators [446]. Observed variables with VIF values greater than 5 show a serious collinearity issue. In the ideal situation, VIF values are 3 or less.

SmartPLS 3 also offers R^2 values for each dependent construct variable. The program determines R^2, the coefficient of determination, by using the conventional regression procedure [447]. R^2 values of 0.50 and 0.75 are regarded as moderate and considerable, respectively, whereas those of 0.25 are poor [426, 446, 448]. However, models with low R^2 values could still be reliable in certain situations [446, 449].

Additionally, each independent variable's impact size (f^2) on the dependent construct is assessed. The route coefficients and effect sizes are quite close, as claimed by Hair et al. [446]. Effect size values above 0.02, 0.15, and 0.35, respectively, indicate modest, medium, and large effect sizes (f^2) [450].

Higher path coefficients imply a better connection, and they represent the degree of effect the independent variable has on the dependent variable [449]. A significant impact is represented by a path coefficient value between 0.5 and 1.00, a moderate effect by one between 0.3 and 0.5, and a minor influence by one between 0.1 and 0.3.

The SmartPLS 3's bootstrapping feature is used to evaluate the structural model. At the 0.05 level, the pathways with a t-value larger than 1.96 are deemed statistically significant (p-value 0.05).

3.3. Research Setting

This research focuses on a broad concept and aims to provide insights for the organizational researchers and managers of small to large construction firms worldwide. However, due to data collection, time, and network limitations, this study targets small to large enterprises with their headquarters located in the following countries which conduct projects locally and internationally: Iran, Turkey, the United Arab Emirates, Germany, the United Kingdom, Canada, and the United States of America (Figure 3.6). The researcher used his Turkish and Iranian networks as well as international networks in the countries mentioned above to gather qualitative and quantitative data. The participants' profiles will be detailed in the fourth chapter of this dissertation.

Figure 3.6. The setting of the study.

Large construction companies in the regions mentioned above account for more than half of the annual revenue created by the construction industry worldwide [451]. So, even though I excluded Asia, Africa, Oceania, and South America, this study still stances a good chance to provide insight for construction organizations worldwide. Moreover, most construction companies pursuing digital transformation are based in Europe [452-454] and North America. So, the setting of this thesis is in line with its setting.

3.4. Data Collection

Because this is an exploratory study, I used a sequential data collection procedure [455], beginning with qualitative data collection to help me develop my hypotheses based on ground theory and define measuring factors for my hypothetical model. This process is followed by a quantitative data collection step to test the developed hypotheses.

The qualitative data collection period lasted ten weeks, from February to mid-April 2022, and included in-depth semi-structured interviews. Questionnaires were used to collect quantitative data over eight weeks in May and June 2022. The questionnaires were distributed to experts via email or their Linkedin profiles.

3.4.1. Sampling Criteria and Sample Size

I defined my criteria for the qualitative data collection based on the purposeful sampling method [455, 456]. I searched for experts who had experience with digital technologies in the construction industry and worked in organizations with long-term strategies focused on digital transformation and digital agility. Following a maximal variation sampling method [455], I contacted experts who worked at different levels of their companies to get access to different perspectives on the central concept of digital transformation and agility in construction organizations.

For the quantitative data collection, I used the simple random sampling method [455], where there is a fair chance of selection for every person in the population. This stage's population included B-level to C-level executives, presidents and vice presidents, executive managers, project managers, functional or supervisory managers, and individual contributors who work in small to large construction companies and are familiar with the concept of digital transformation as well as their companies' organizational culture, structure and long-term digital transformation strategies.

The sample size of the quantitative data highly depends on the approach used to conduct structural equation modeling (SEM) analysis. As discussed earlier, there are two

approaches to SEM: the covariance-based SEM (CB-SEM) and partial least squares SEM (PLS-SEM). For normal distributions, CB-SEM estimates were found to be inaccurate for small sample sizes, while PLS-SEM could produce accurate path estimates [457-459]. Comparing CB-SEM with PLS-SEM, CB-SEM estimates have lower variability for a larger sample size. Small sample sizes result in inaccurate CB-SEM path estimates under nonnormality [457].

Given the number of measuring factors in this study (30), using CB-SEM would necessitate a sample size of at least 300 [460, 461]. Due to the time limitations and novelty of this study which leads to even lower response rates from experts, I decided to use PLS-SEM (I also have other reasons for choosing this method which I will discuss in detail under 3.4.2). The cut-point for the sample size of this approach is suggested to be between 100 and 200 by some studies [462]. However, there are studies that suggest using PLS-SEM with even lower sample sizes [463]. In this regard, a couple of researchers took even a step further and saw PLS-SEM as a "silver bullet" or miracle cure for dealing with empirical studies challenges like small sample sizes [464, 465] which should be taken with a grain of salt.

There are examples of studies conducted PLS-SEM analysis with sample sizes smaller than 100 in the construction management literature. With the aid of survey information derived from 41 contractor questionnaires, Aibinu et al. [466] assessed the relationships between organizational justice factors and cooperative behavior. In addition, Alashwal and Abdul-Rahman [467] investigated the inter-project learning process in construction projects using 36 data gathered from large construction sites, and Darko et al. [468] assessed the effects of barriers, drivers, and promotion strategies on the adoption of green building technology using survey data from 43 professionals.

Due to Hair et al. [426], one way to estimate the minimum sample size for PLS-SEM is to use ten times the largest number of formative indicators used to measure one construct. This method is called the 10-times rule method by them. In this study's case (Figure 3.5), the minimum sample size for the model should be considered 40 using this method (In Section 3.4.2, I will explain why the model in Figure 3.4 is replaced with the one in Figure 3.5).

Another way is to use another variant of the 10-times rule method [426, 469] to estimate the minimum sample size for my model. This method is based on the premise that the sample size must exceed ten times the maximum number of inner or outer model links pointing at any latent variable including arrows coming from mediating variables. Based on the links in the model in Figure 3.5, the minimum sample size for this model can be assumed to be 50. Hair et al. [426] suggest using the maximum of the two numbers calculated above. Others suggest that the second one suffice [470]. Here, it seems reasonable to aim for a sample size of 50 as the minimum sample size for the model. Although being widely used by researchers, the 10-times rule method can lead to grossly inaccurate estimations of minimum required sample size [470]. So, the 10-times rule seems not to be a reliable indication of sample size requirements in PLS-SEM and should at best be seen as a rough estimate. On the other hand, "cautions about the 10 times rule for sample size typically do not suggest any concrete alternative." [471] This issue will be discussed further in the discussion section.

3.4.2. Semi-Structured Interviews

A semi-structured interview is a technique for gathering data that depends on formulating questions within a pre-established thematic framework. But neither the questions' order nor their wording is predetermined. Semi-structured interviews are frequently of the qualitative variety in research. In research fields like marketing, social science, survey methodology, and others, they are typically used as an exploratory tool. Furthermore, they are frequently used in field studies with a large number of interviewers because they provide everyone with the same theoretical framework while still allowing them to explore various angles of the research question [472].

A semi-structured interview uses both closed- and open-ended questions and is frequently followed by why- or how-specific questions. To prevent interviewer and respondent fatigue, it is recommended that semi-structured interviews not exceed one hour in length [472].

The semi-structured interviews encompassed a brief introduction, interviewees' understanding of digital transformation, and the challenges their company faced in

implementing it. According to the interviewees' knowledge and actual expertise, I modified the questions during the interviews to change the interviews' focus [473]. I also asked interviewees for their thoughts on the hypothetical model (Figure 3.3) and how they believed each component should be measured within an organization. The primary queries I used to begin the interviews are listed in Appendix B.

3.4.3. Questionnaire Design

I designed a questionnaire in three sections to gather quantitative data. The first section of the questionnaire serves the purpose of gathering information from the participants about their professional profiles. Their level of education, academic background, age, years of experience in the AEC industry, their role in their organization (C-level executive, president or vice president, individual contributor, etc.), and the kind of job they are involved in (engineering, management, IT, etc.) were questioned in this section.

In the second part of the questionnaire, I ask participants about their construction organization: the name of the company they have been working/worked at (optional), the region their company headquarters is located at, where the majority of the company's projects are located at, the number of employees their organization have, and the organizational structure their firm uses. This information helps to understand the general characteristics of the sample.

There are numerous standards for classifying organizations by the number of their employees, and they all follow a similar logic. As stated in the background, many scholars believe that this is a reasonable way to determine the size of an organization. In this study, I used the Federal Statistical Office of Switzerland's standard [474] to categorize the companies I gathered data from. Table 3.4 displays this standard's enterprise size measurements.

Table 3.4. The Size Categories of Enterprises [474].

Category	Number of Employees
Micro enterprises	1 to 9
Small enterprises	10 to 49
Medium-sized enterprises	50 to 249
Large enterprises	>=250

As discussed in the background, most of the organizations in the construction industry use either a functional structure (bureaucratic organizational structure) or a matrix structure. I ask participants to choose between four options, including flatarchy and holacratic structures and the two traditional structures mentioned above, to see if any companies were using flatter organizational structures.

In the last section of the questionnaire, I ask the participants to rate the 29 factors defined in 3.1.2 based on their experience using a 5-point Likert scale (1 = very low, 2 = low, 3 = medium, 4 = high, 5 = very high). All the latent variables are measured using these factors. Also, one of the variables used in the structural model itself is an observed variable: digital functional areas (transformed IT departments). I question the experts directly about how successful they believe a reformed IT department would be in improving the digital agility of a construction company's business model.

The questionnaires are created in Google Forms and distributed to experts by sharing the forms' link. Participants read the consent request text at the top of the form they are about to fill out and enter their email addresses for future communication.

4. RESULTS AND FINDINGS

In this chapter, I present the findings of both qualitative and quantitative analyses performed on the collected data.

4.1. Qualitative Analysis Results (A Directed Content Analysis)

Twelve experts from various construction companies were invited to interviews, and three of them agreed to participate in this study (resulting in a response rate of 25% for the qualitative part). So, three in-depth semi-structured interviews with AEC industry experts working in construction companies undergoing digital transformation were conducted online on the Zoom platform. These three people were from different levels of their organizations, including the mid-level management. Interviews lasted 30 minutes to an hour and were recorded with the interviewees' permission for transcribing and further analysis. Table 4.1 displays the interviewees' profiles as well as some information about the companies for which they work. The results of the content analysis can be found in Table 4.2.

Table 4.1. The interviewees' profiles and their companies.

No.	Nationality	Ed.	Yrs. of Ex.	Role in the Organization	Has Ex. in	Company Size	H.	Organizational Structure
1	Iranian	MSc	18	B-Level Executive and R&D Expert	Iran	Large	Iran	Matrix
2	Iranian	MSc	13	Contract Manager	Iran	Large	Iran	Matrix
3	Turkish	MSc	6.5	Business Developer and Project Set-up Engineer	Turkey, USA	Large	USA	Matrix

The scheme for the directed content analysis consisted of six main categories based on the existing literature: digital organizational culture, leadership vision, educational programs, distributed decision authority, employee resistance. Table 4.2. shows the results of the content analysis done on the interviews.

Table 4.2. Content analysis results.

No.	Category	Definition	Examples	Coding Rules
1	Digital Organizational Culture	The underlying beliefs, assumptions, values, and ways of interacting in a digital world that contribute to the unique social and psychological environment of an organization.	"Most employees do not choose to connect with supervisors utilizing the digital tools that are available to them. Some even do not use their corporate email regularly." "People do not trust that new digital technologies will make their jobs easier."	Concrete statements Deductive and inductive reasoning based on interview data
2	Leadership Vision	What leaders find important regarding the digitalization of the company.	"At the end of the day, no matter what we believe are required digital tools for project management, if top management does not think them valuable, we will not have them." "If top managers want to bring a new digital technology to the company, they will. They even force their staff to learn how to use these technologies."	Concrete statements
3	Educational Programs	Programs to improve employees' digital skills and update their digital knowledge.	"Educational programs are required if we are to develop a digital culture, and these programs should be dedicated not just for employees, but also for mid-level and senior managers."	Concrete statements Deductive and inductive reasoning based on interview data
4	Distributed Decision Authority	Letting teams self-organize and make strategic decisions on their own.	"Our division's president empowers his teams to make agile choices. This reduces paperwork and increases our agility. If we need to bring in new digital technologies to aid with project execution, he is supportive. According to my knowledge, this may not be the situation in other departments of our organization."	Concrete statements
5	Employee Resistance	When workers demonstrate resistance to using new digital technology and agree to the company's new digital culture.	"When senior executives introduce a new digital technology to one of their divisions, they often impose it on their workforce. I have not seen an innate desire among workers to abandon the status quo and embrace the new digital reality."	Concrete statements Deductive and inductive reasoning based on interview data
6	Communication Management	Planning, implementing, monitoring, and making changes to an organization's ways of communicating in a systematic way.	All of the interviewees implied that the concept of digital transformation had not been effectively disseminated among their construction organization's workforces.	Overal impression from interview data

4.2. Quantitative Analysis Results

The quantitative analysis findings are presented in the following three subsections.

4.2.1. Respondents' General Information

The questionnaires were disseminated among 250 experts. In total, 34 respondents participated in the study (response rate of 13.6%). Figure 4.1 illustrates the information about the age of the respondents. As it can be seen, 29.4% of respondents were 20-30 years old, 38.2% were 31-40 years old, 14.7% were 41-50 years old, and 17.6% were 51-60 years old.

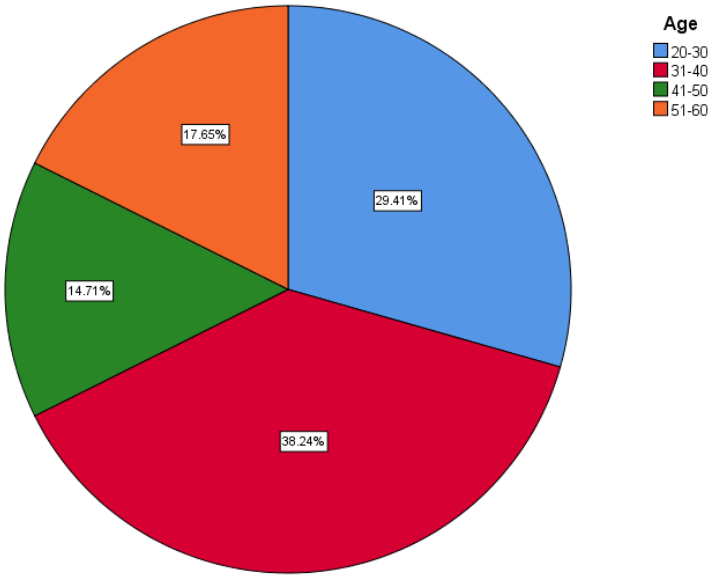

Figure 4.1. Age (years) of participants.

Figure 4.2 shows the distribution of respondents' educational backgrounds. As the figure shows, most of the respondents' educational background is engineering (91.18%), 5.88% are architecture, and 2.94% are engineering and management.

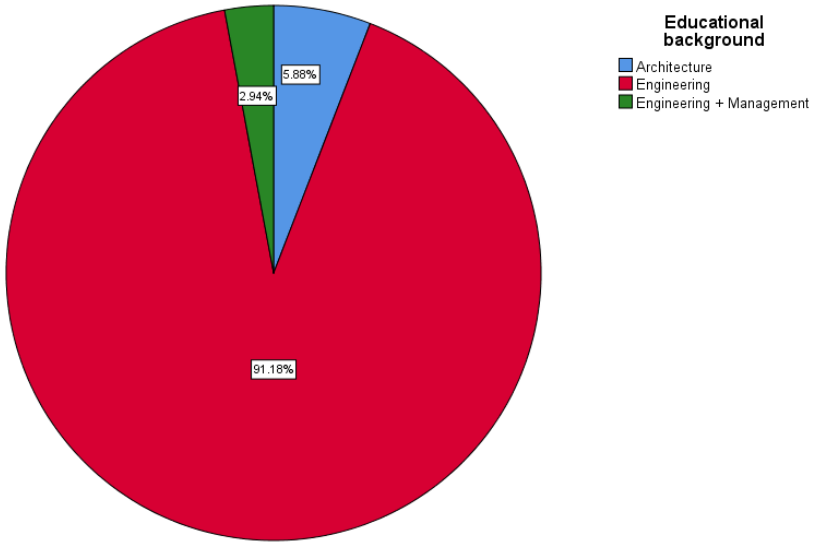

Figure 4.2. Educational background of participants.

Figure 4.3 shows the distribution of respondents' education. As the figure shows, most respondents have a master of science (61.76%), 26.5% have a bachelor of science, and 11.76% hold a Ph.D.

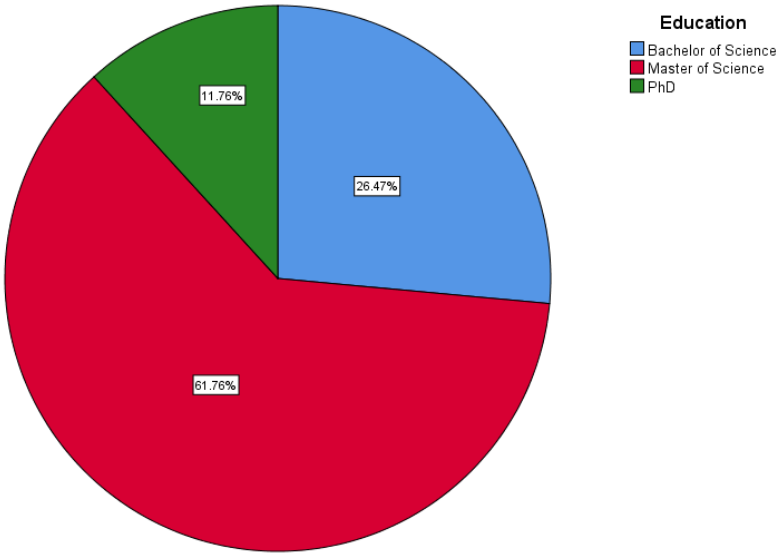

Figure 4.3. Education level of participants.

Figure 4.4 shows the distribution of respondents' years of experience in the AEC. As the figure shows, most of the respondents' experience is more than 10 years (52.94%),

14.71% of them have 3-6 years of experience, 11.76% of them have 6-10 years of experience, and 20.59% of them have less than 3 years of experience.

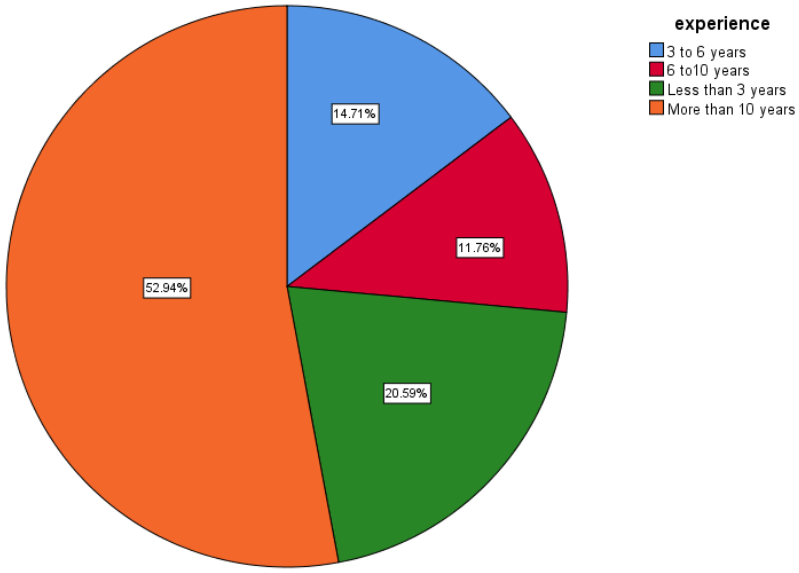

Figure 4.4. The experience of participants (years) in the AEC Industry.

Figure 4.5 shows the distribution of respondents' roles in the organization. As the figure shows, most of the respondents' roles are functional or Supervisory Manager (23.5%), and 11.8% are D-level executives (Director). D-level executive (Director), individual contributor, and project manager each were 11.76% of participants. Details of the distribution in other levels can be seen in the graph.

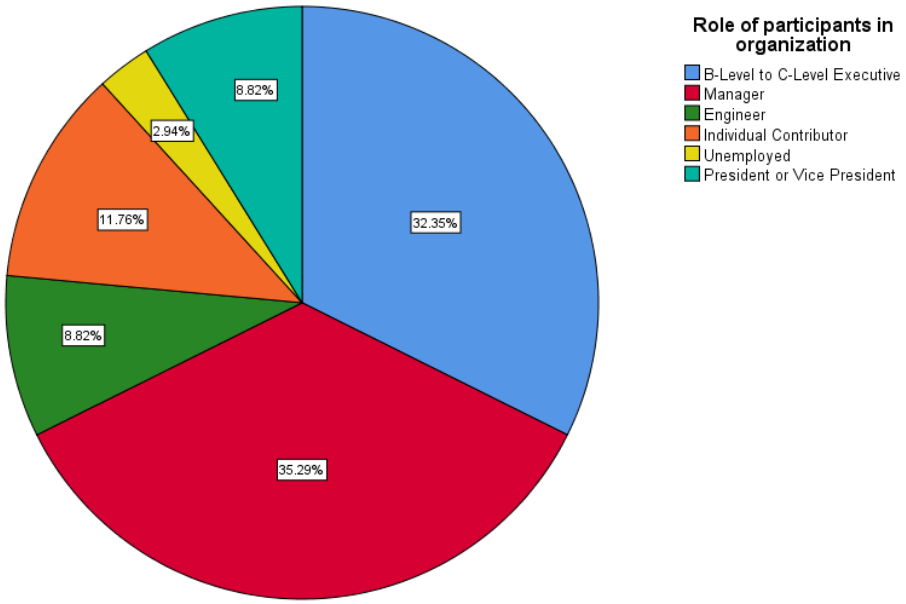

Figure 4.5. Participants' roles in their organizations.

Figure 4.6 shows the distribution of respondents' jobs in their organizations. As the figure shows, most respondents are in the operations category (50%), 35.29% are in the management category and 5.9% are in the IT category. Details of the distribution in other levels can be seen in the graph.

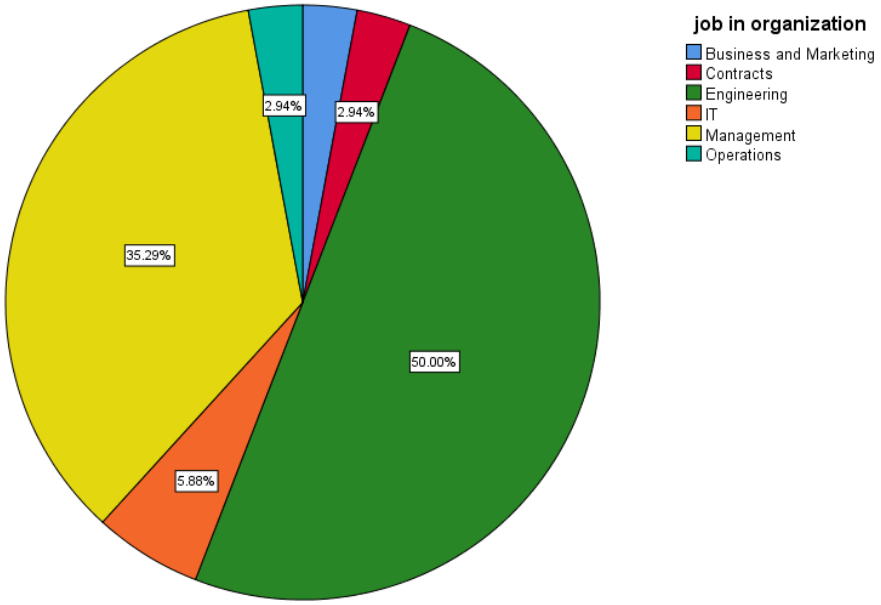

Figure 4. 6. Participants' jobs in their organizations.

Figure 4.7 shows the distribution of companies' headquarters. As the figure shows, most companies are located in the Middle East (52.94%), and 29.41% are located in North America. Details of the distribution in other levels can be seen in the graph.

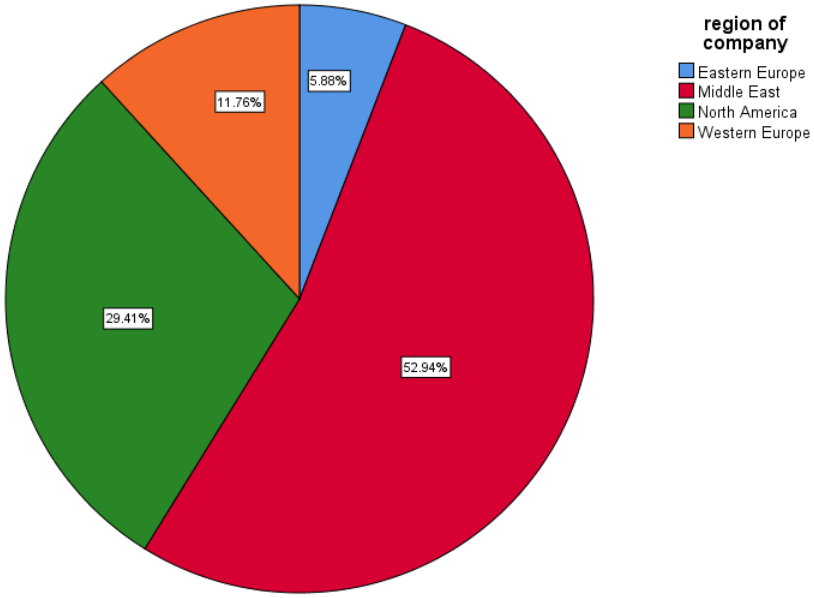

Figure 4.7. The location of the companies' headquarters.

Figure 4.8 shows the distribution of most companies' projects' locations. As the figure shows, most of the companies' projects are located in the Middle East (50%), and 23.53% are located in North America. Details of the distribution in other levels can be seen in the graph.

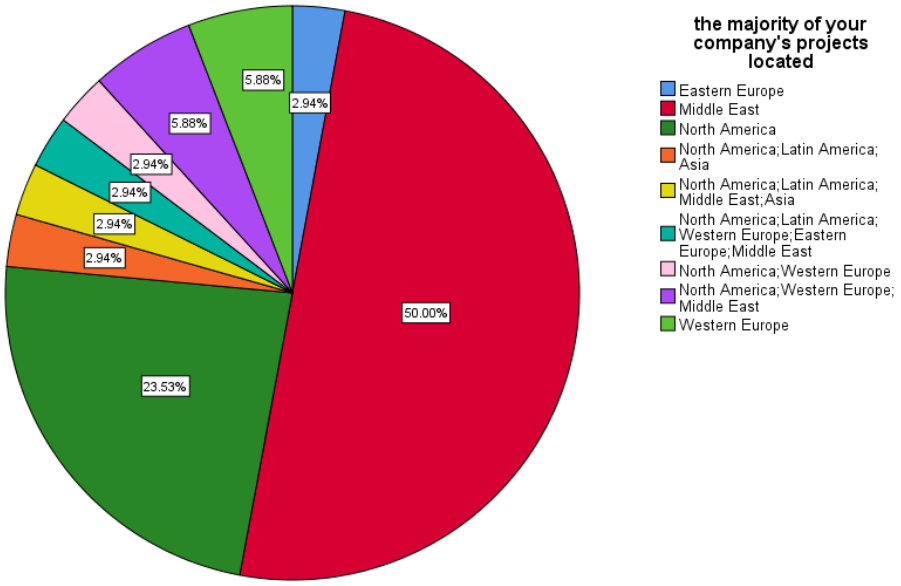

Figure 4.8. The location of the companies' projects.

Figure 4.9 shows the distribution of the number of employees. As the figure shows, most employees are more than 250 (64.71%), 26.47% of them have 10 to 49 employees and 8.62% have 50 to 249 employees.

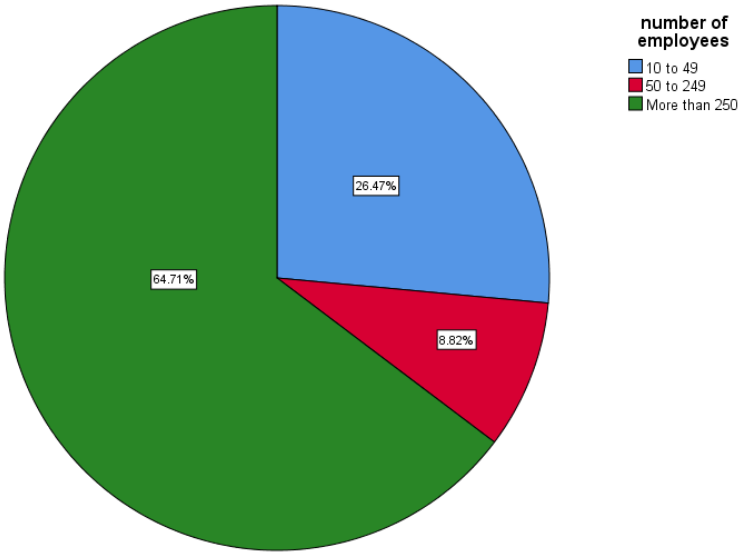

Figure 4.9. Companies' number of employees.

Figure 4.10 shows the distribution of organization structure. As the figure shows, most structures are functional (64.71%), 23.55% have matrix structure and 11.76% have holacratic structure.

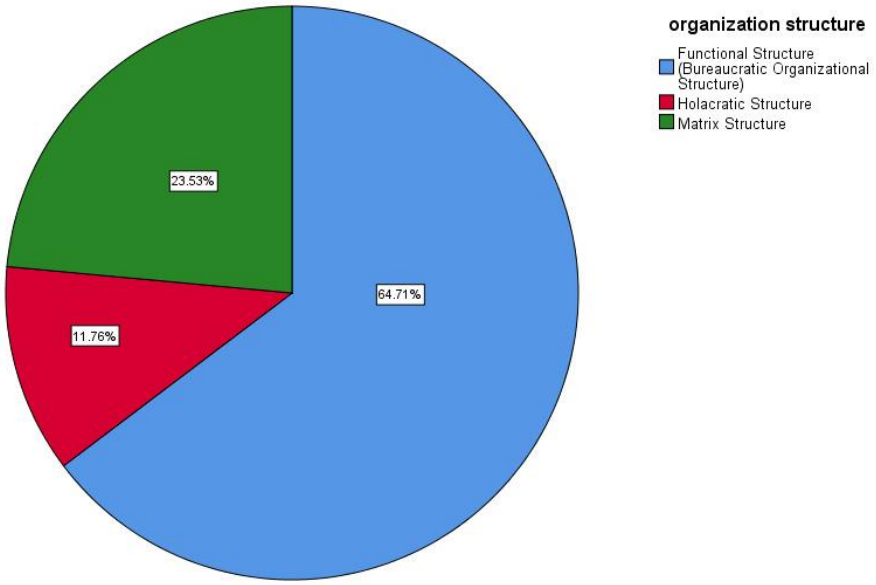

Figure 4.10. Companies' organizational structure.

Table 4.3. shows a detailed view of the participants' profiles and the companies they work at.

Table 4.3. Detailed participant and company profiles.

No.	Nationality	Ed.	Years of Ex.	Role in the Organization	Has Ex. in	Company Size	Company H.
1	Iranian	BSc	>10	C-Level Executive	Iran	Small	Iran
2	Iranian	MSc	>10	Functional or Supervisory Manager	Iran	Large	Iran
3	Iranian	BSc	>10	Project Manager	Iran	Large	Iran
4	Iranian	MSc	>10	Unemployed	Iran	Small	-
5	Turkish	PhD	>10	President or Vice President	Turkey, USA	Small	Turkey
6	Turkish	PhD	>10	President or Vice President	Turkey	Small	Turkey
7	Iranian	MSc	>10	B-Level Executive	Iran	Large	Iran
8	Turkish	MSc	6-10	Functional or Supervisory Manager	USA, Turkey	Large	USA
9	Iranian	MSc	>10	C-Level Executive	Iran	Large	Iran
10	Iranian	MSc	3>	Functional or Supervisory Manager	Iran	Small	Iran
11	Iranian	MSc	3>	Individual Contributor	Iran	Small	Iran
12	Iranian	MSc	3-6	Individual Contributor	Iran	Medium	Iran
13	Iranian	MSc	>10	Functional or Supervisory Manager	USA	Large	USA
14	Iranian	MSc	3-6	Executive Manager	Iran	Medium	Iran
15	Iranian	MSc	6-10	Project Manager	USA	Large	USA
16	American	MSc	>10	Individual Contributor	USA	Large	USA
17	Turkish	BSc	3>	Operational Risk Engineer	Turkey	Large	Turkey
18	Turkish	BSc	>10	D-Level Executive	USA	Large	USA
19	Iranian	MSc	3>	Individual Contributor	Iran	Small	Iran
20	Iranian	PhD	6-10	Executive Manager	Iran	Medium	Iran
21	Iranian	BSc	>10	Executive Manager	Iran	Large	Iran
22	Iranian	MSc	3>	Functional or Supervisory Manager	Iran	Large	Iran
23	Iranian	MSc	3-6	Project Manager	Germany	Large	Germany
24	Turkish	MSc	>10	D-Level Executive	UAE	Large	USA
25	American	MSc	>10	D-Level Executive	UAE	Large	USA
26	Iranian	MSc	3>	Construction Engineer	Canada	Large	Canada
27	American	BSc	>10	D-Level Executive	USA	Large	USA
28	Iranian	PhD	>10	C-Level Executive	Iran	Small	Iran
29	Indian	MSc	3-6	Project Manager	USA	Large	USA
30	Turkish	MSc	6-10	Functional or Supervisory Manager	UK	Large	UK
31	Arab	BSc	3>	Functional or Supervisory Manager	USA	Large	USA
32	Turkish	MSc	>10	President or Vice President	Turkey	Small	Turkey
33	Turkish	MSc	>10	Functional or Supervisory Manager	UK	Large	UK
34	Iranian	MSc	3-6	Risk Engineer	UK	Large	UK

4.2.2. Descriptive Statistics

Descriptive statics of each measurement variable is presented in Table 4.4. The table shows maximum and minimum values, mean, variance, standard deviation, skewness, and kurtosis (normality indicators) values.

Table 4.4. Descriptive statistics.

Factor	Items	Min	Max	Mean	SD	Skewness	Kurtosis
Organizational structure	Formalization	8	14	10.73	1.62	0.18	-0.47
	Complexity	11	20	15.52	1.92	0.15	0.49
	Centralization	9	17	12.79	2.01	0.06	-0.53
	Integration	9	15	13.32	1.70	-0.93	0.07
Digital agility	Hyper Awareness	5	10	8.44	1.23	-0.52	0.49
	Informed Decision-Making	8	20	14.88	2.74	-0.483	-0.52
	Fast Execution	13	20	17.42	2.04	-0.338	-0.88
Agile leadership	AGL 1	2	5	3.97	0.67	-0.59	1.34
	AGL 2	1	5	3.38	1.12	-0.29	-0.48
	AGL 3	2	5	3.88	0.76	-0.21	-0.29
	AGL 4	2	5	4.35	0.73	-1.1	1.77

The following figures present the mean values of each observed item of latent variables. Figure 4.11 shows that the mean values of organizational structure factors range from 0-16. Mean value of formalization, complexity, centralization and integration are 10.73, 15.52, 12.79, and 13.32 respectively.

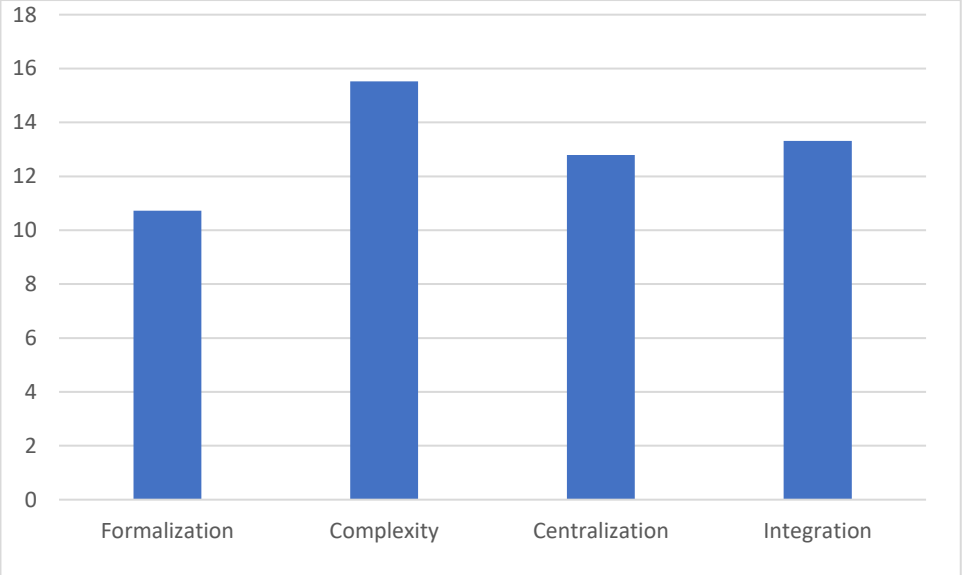

Figure 4.11. Mean value of organizational structure.

Figure 4.12 shows the number of vertical layers suggested by experts for a digitally agile organizational structure to separate management from employees. Due to this figure, 64.7% of the experts believe 3 to 5 managerial levels should exist between employees and top management, while 29.4% believe 1 to 2 levels are enough.

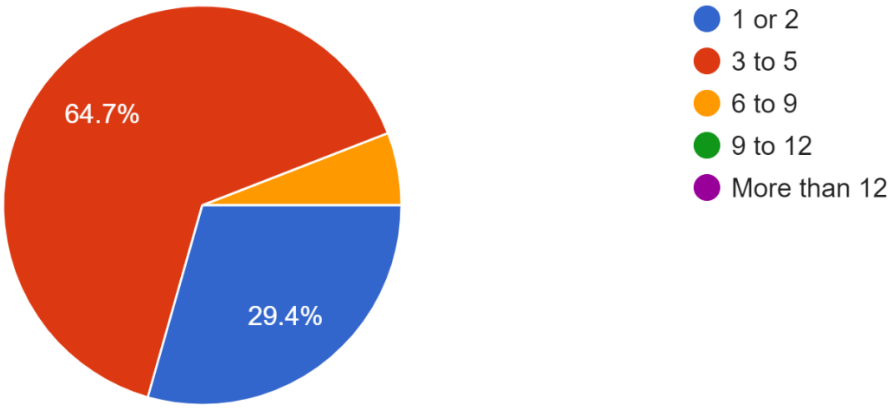

Figure 4.12. The number of managerial levels Suggested for a DACO.

Figure 4.13 shows that Digital agility factors' mean values range from 0-18. The mean value of hyperawareness, Informed decision-making, and fast execution are 8.44, 14.88, and 17.42, respectively.

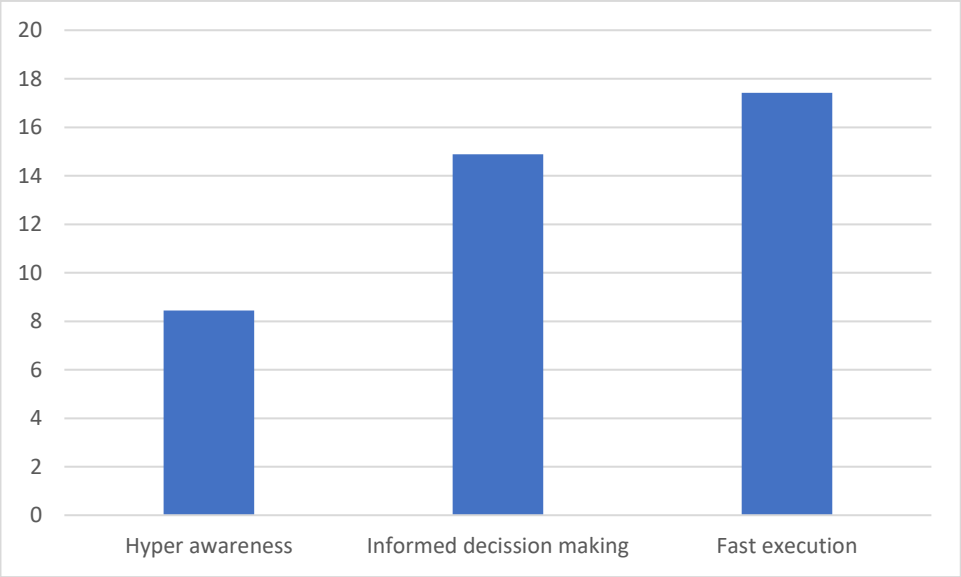

Figure 4.13. Mean value of digital agility.

Figure 4.14 shows that Agile leadership factors' mean values range from 0-4.5. The mean value of AGL1, AGL2, AGL3, and AGL4 are 3.97, 3.38, 3.88, and 4.35, respectively.

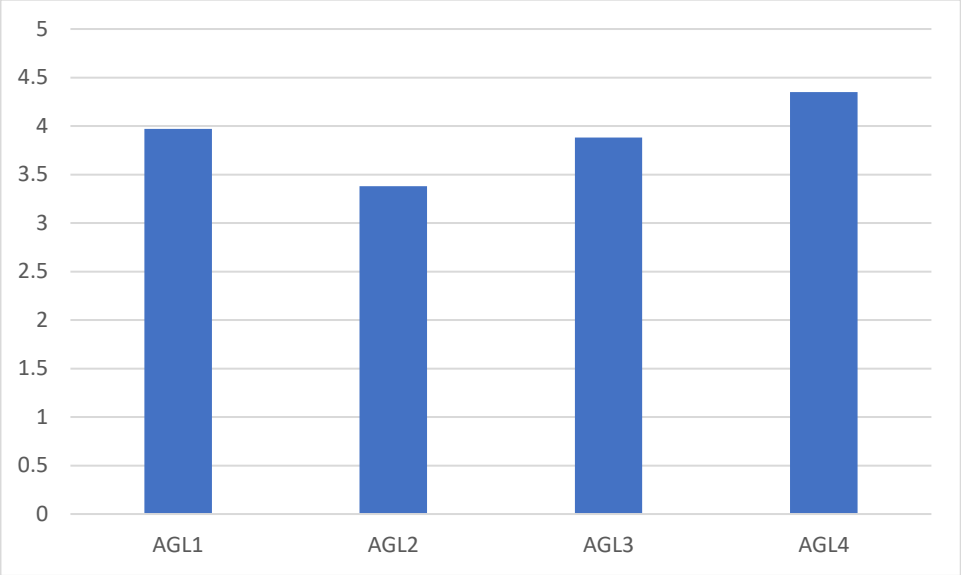

Figure 4.14. Mean value of agile leadership.

4.2.3. PLS-SEM Model Results

Table 4.5 shows that I excluded items with a factor loading lower than 0.5 (Centralization and AGL2). I repeated the analysis and listed edited factor loadings, which are statistically significant and higher than 0.5, in Table 4.5.

Table 4.5. Factor loadings of measurement items.

Latent Variable	Code	Factor Loading	Final Loading
Organizational structure	Formalization	0.484	0.509
	Complexity	0.511	0.594
	Centralization	-0.325	Excluded
	Integration	0.877	0.879
Agile leadership	AGL1	0.822	0.849
	AGL2	-0.360	Excluded
	AGL3	0.616	0.593
	AGL4	0.653	0.699
Digital agility	Hyper awareness	0.886	0.880
	Informed decision making	0.377	0.503
	Fast execution	0.877	0.876

As Table 4.6 shows, all AVE values are higher than 0.5 for each latent variable of the model.

Table 4.6. Cronbach's Alpha, Composite Reliability, and AVE values.

Latent variable	Cronbach's Alpha	Cr	AVE
Organizational structure	0.72	0.773	0.526
Agile leadership	0.745	0.761	0.520
Digital agility	0.614	0.783	0.568

In order to test the discriminant validity of construct variables, Fornell-Larcker Criterion and Cross Loadings were assessed. Table 4 shows the Fornell- Larcker Criterion table that compares the correlations of latent variables and the square root of the AVE of each latent factor. The diagonal values indicate the square root of the AVE score of latent variables, and they are expected to be higher than the correlation between other latent variables. Table 4.8 shows the cross-loadings of the model.

Table 4.7. Fornell-Larcker criterion.

Latent Variable	Organizational Structure	Agile Leadership	Digital Agility
Organizational structure	0.725	-	-
Agile leadership	0.415	0.721	-
Digital agility	0.706	0.431	0.754

Table 4.8. Cross Loadings of measurement variables.

Measurement Items	Organizational structure	Agile leadership	Digital agility
Formalization	**0.509**	-0.012	0.42
Complexity	**0.494**	0.15	0.222
Integration	**0.879**	0.483	0.63
AGL1	0.365	**0.849**	0.52
AGL3	0.238	**0.593**	0.227
AGL4	0.278	**0.699**	0.386
Hyperawareness	0.574	0.556	**0.88**
Informed decision making	0.254	0.138	**0.403**
Fast execution	0.675	0.44	**0.876**

4.2.4. Structural Model Results

The structural model was tested using the bootstrapping function of the Smart-PLS 3. Figure 4.15 and Table 4.6 show the structural model obtained results. The paths having a t-value greater than 1.96 are considered statistically significant at the 0.05 level. The path coefficients indicate the independent variable's level of influence on the dependent variable, and higher path coefficients mean superior association. The path coefficient values ranging between 0.5 and 1.00 stand for a strong effect, values between 0.3 and 0.5 indicate a moderate effect, and values ranging from 0.1 to 0.3 indicate a weak influence.

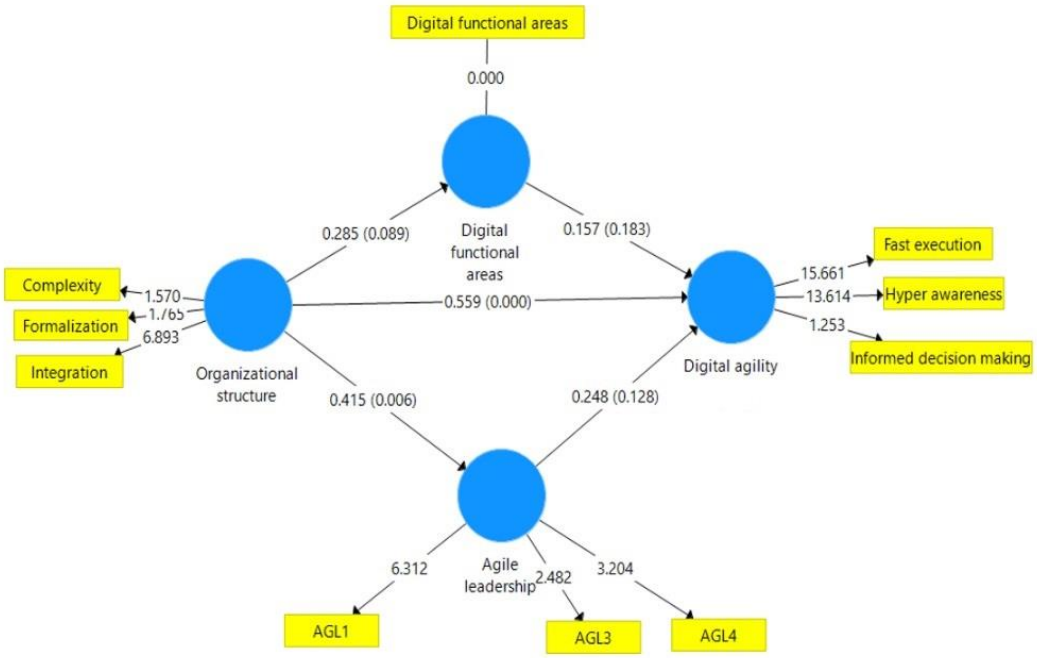

Figure 4.15. Structural model of factors affecting digital agility - pass coefficients (p-values).

Based on the results, a digitally agile organizational structure has a moderately significant effect on agile leadership (P=0.006) and also a strong significant effect on Digital agility (P<0.001). Table 4.9 shows the structural model results.

Table 4.9. Structural model results.

Hypothetical Path	**Path Coef. (β)**	**t-Value**	**p-Value**	**Result**
Agile leadership -> Digital agility	0.248	1.52	0.128	Not Supported
Digital functional areas -> Digital agility	0.157	1.33	0.183	Not Supported
Organizational structure -> Agile leadership	0.415	2.507	<0.001	Supported
Organizational structure -> Digital agility	0.559	3.849	0.006	Supported
Organizational structure -> Digital functional areas	0.285	1.168	0.089	Not Supported

Tables 4.10 and 4.11 show the effect sizes of model R^2 and F^2 respectively.

Table 4.10. R^2 of factors.

Dependent Const.	**R^2**
Organizational structure	0.59
Agile leadership	0.37
Digital agility	0.40

Table 4.11. F^2 of factors.

Effect of Independent Factor on Dependent Factor	**F^2**	**Inference**
Agile leadership -> Digital agility	0.107	Small Effect
Digital functional areas -> Digital agility	0.048	Small Effect
Organizational structure -> Agile leadership	0.208	Medium Effect
Organizational structure -> Digital agility	0.636	Large Effect
Organizational structure -> Digital functional areas	0.089	Small Effect

Table 4.12 shows VIF values of observed variables, and it confirms that there is no collinearity issue in the model.

Table 4.12. VIF Values.

Observed Items	**VIF**
AGL1	1.236
AGL3	1.141
AGL4	1.128
Complexity	1.123
Fast execution	1.513
Formalization	1.087
Hyperawareness	1.553
Informed decision making	1.076
Integration	1.046

5. DISCUSSION

The AEC industry has lagged behind other industries in adopting new digital technologies [15-17]. However, it is inevitable for this industry to go through digital transformation if it wants to survive in a digital VUCA environment [11, 12]. Digital technologies have the potential to transform established business models and evoke organizational change [8-10]. They make companies become agile, or as it is called in the literature, digitally agile [246]. AEC firms are confronted with significant difficulties in terms of knowledge sharing and management, which is at the core of agile digital businesses [25]. So, the digital world forces business to transform, and organizations must develop adaptable open systems. Systematic thinking manifests itself in the conception of organizational structure.

An organization's philosophy of existence is embodied in its structure, which is a complex combination of the relationships between its various elements. The relationship between a company's digital agility and its digitally agile organizational structure (H1) has not been studied yet. The purpose of this academic work is to shed light on the subject. And answer the question of whether changing construction firms' organizational structure to one that is more flexible, flatter, and agile will improve the digital agility of their business model.

According to studies, communication management may play an important role in developing the organizational culture required for businesses to adopt new digital technologies [33]. Furthermore, in a digital world, organizational agility can be achieved through agile leadership [28]. The characteristics of agile leadership and their effects on the digital transformation process by valuing digital agility have yet to be researched in the context of construction organizations. I want to see if construction companies can benefit from changing the role of IT departments to more integrated ones, which could aid in knowledge and communication management (H2), and if agile leadership can bridge the gap between organizational structure and the digital agility of construction organizations' business models (H3). The qualitative portion of this study seeks to determine how applicable organizational concepts deemed important in the context of digital transformation in other industries are in the AEC industry.

According to the content analysis of qualitative data, six themes emphasized in the literature about digital transformation in organizations also emerge in the construction industry context. These themes are digital organizational culture, leadership vision, educational programs, distributed decision authority, employee resistance, and communication management.

The quantitative portion of this study supports the dissertation's main hypothesis by demonstrating that there is a meaningful and positive relationship between the digitally agile structure of a construction organization and the digital agility of its business model. However, two of the study's hypotheses are not supported, implying that the quantitative model does not support the positive mediating roles of digital functional areas (transformed IT departments) and agile leadership between organizational structure and digital agility.

5.1. Interpretation of the Results

This section represents a detailed interpretation of the findings based on the qualitative and quantitative results, as well as the literature. The structure of this section is similar to that of the previous chapter (chapter 4). I divided this section into two subsections. The first represents the discussions about qualitative results, while the second is about quantitative results. In the following and final chapter of this thesis, I synthesize the outcomes of these two discussions and conclude my dissertation. All of the findings of this study are compared to the existing literature throughout the text.

5.1.1. Qualitative Results Interpretation

The participants in this study's qualitative section were chosen using a purposeful sampling method. I decided to interview people from various levels of companies to create a holistic perspective because construction organizations are mostly traditional hierarchies. A mid-manager (B-level executive) and R&D expert, a contract manager, and a business developer and project set-up engineer are among three of the interviewees, as shown in Table 4.1. They have extensive experience and have all worked in the construction industry for

more than six years. All of the interviewees work for large construction companies and claim that digital transformation is high on their priority lists.

While one of the subjects had worked in her company's North American division, the rest had gained experience in the Middle East. This may have an impact on the scope of the qualitative portion of this academic work which will be discussed in the limitation and future research section. Notwithstanding the aforementioned fact, the participants had adequate knowledge of digital transformation in the construction industry and were aware of their companies' long-term digital transformation strategies.

As shown in Table 4.1, all of the companies the interviewees worked at had a matrix organizational structure. As I discussed in the background section, a matrix structure is used by businesses that feel the need for more flexibility and thus answer this need by forming cross-functional teams, or in the case of large enterprises, cross-functional divisions. This supports the interviewees' claim that their companies have realized that flatter and more flexible organizational structures may be beneficial in adapting to the new VUCA digital world.

The content analysis performed on the interview data resulted in the emergence of six themes that have already been discussed in the context of digital transformation in other industries, as summarized in Table 4.2. This reveals that the construction industry deals with the same concepts, and practitioners should keep this in mind as they plan to undergo digital transformation.

According to experts, creating a digital organizational culture is critical when a construction company decides to adopt new digital technologies and attempts to change the organization's traditional status quo. As it is emphasized in the literature, only when an organization decides how it wants its members to behave, what attitudes it wants to encourage, and what it wants its members to accomplish can it design its structure and encourage the development of cultural values and norms to obtain these desired attitudes, behaviors, and goals [32]. As a result, organizational culture may act as a catalyst for digital transformation.

“Most employees do not choose to connect with supervisors using the digital tools that are available to them,” one interviewee says. “Some even do not check their corporate email on a regular basis.” As will be mentioned later, this is an example of a failed digital culture creation and communication of change, which has resulted in employee resistance. As supported by existing literature, one of the major challenges in digitalization in the construction sector is a lack of digital culture [334].

According to the literature, in order to achieve the desired results for digital transformation, leaders must strike the appropriate balance between businesspeople and digital talent [28]. Because this transition is not a one-off routine technical project, agile leadership is at the heart of every digital transformation attempt. In fact, digital transformation involves social and cultural elements that must be led by agile leaders.

The interviewees are well aware of the significance of leadership vision in the digital transformation process. “At the end of the day, no matter what we believe are required digital tools for project management, if top management does not think they are valuable, we will not have them,” one of them says. Another interviewee stated, “If top management wants to bring new digital technology to the company, they will. They even force their employees to learn how to use these technologies.”

Because it involves power, leadership is not a simple concept. Leaders decide what long-term plans their company should follow, what organizational structure it should have, and what digital technologies it should employ. As a result, construction companies should value the role of leadership in their organizations and be cautious about whom they appoint as their strategic leaders. This brings us to the significance of educational programs in businesses.

According to one interviewee, “if we are to develop a digital culture, educational programs are required, and these programs should be dedicated not only to employees but also to mid-level and senior managers.” According to studies, educational programs have a number of advantages for companies undergoing organizational change [33, 475]. To successfully implement digital business strategies, employees must acquire an appropriate adaptive skill set and digital know-how [180, 476]. Moreover, it helps reduce employee

resistance [33], helps with communication management, and increases organizational integrity by providing an environment for internal and unofficial communication [477, 478].

As mentioned in the background section, organizational structure distributes authority and responsibility among organizational members. It is also known that the centralization of decision-making authority occurs when decision-making authority is concentrated somewhere in the organization. Furthermore, I stated that digital transformation is primarily concerned with the use of digital technologies to manage knowledge. A bottom-up approach to knowledge management is preferable to a top-down approach in which individuals drive the management process. Digital organizations, as complex social processes, depend significantly on creative people [126, 127], and this approach advocates open and adaptable organizations in which the learning process is actively fostered [126]. In this regard, most technology companies these days try to use flatter organizational structures to cope with the challenges of the digital world. This organizational structure can be described as the systematic process of delegating power and authority among employees.

According to the interview data, even when traditional construction organizations want to deal with the challenges of the digital business world, they tend to decentralize decision authority and delegate more authority to their management teams to make strategic decisions. “Our division’s president empowers his teams to make agile choices,” one of the subjects says. “This reduces paperwork while increasing agility. He is supportive if we need to bring in new digital technologies to help with project execution.” According to experts who participated in this study, decentralized organizational structures may benefit future companies.

Many studies have found that staff resistance to change and transformation is a recurring theme [33, 475, 479, 480]. It is also regarded as one of the most significant managerial challenges in the context of digital transformation [35]. Employee resistance was mentioned previously, but it was also frequently emphasized by the interviewees, as in this statement by one of them: “when senior executives introduce new digital technology to one of their divisions, they often impose it on their workforce. I have not noticed a natural desire among workers to abandon the status quo and embrace the new digital reality.” This resistance, as Boswell [481] argues, is because employees do not see the organization’s

strategy and do not think that they are part of it. So, it is important to align employees with the company's strategies for digital transformation.

As previously stated, organizational culture, leadership vision, and educational programs all contribute to reduced employee resistance. Furthermore, communicating change to employees and developing organizational culture are critical components of change because they alleviate employee resistance [33]. The interviewees all agreed that their companies struggle with effective communication management when it comes to digital transformation. The causes of this problem should be investigated further in future studies.

5.1.2. Quantitative Results Interpretation

According to the data in Figures 4.1 to 4.6, 53% of the participants have more than ten years of experience in the AEC industry, and 70% have a graduate degree in the field of engineering. Nearly 75% of them work in management in their companies, which means they are well aware of their companies' strategic decisions. Furthermore, nearly 85% of the participants' jobs involve engineering and management. This demonstrates that they are conscious of their companies' managerial and engineering challenges and could reflect them in their answers.

According to the data in Figures 4.7 to 4.11, up to 53% of the participants work for companies with headquarters in the Middle East, while 47% have headquarters in North America and Europe. This is mentioned because the headquarters primarily represents the organizational culture of companies [482]. Furthermore, 65% of these businesses are large enterprises. So, the data gathered using the simple random sampling method [455] covers the setting of this study: North American, European, and Middle Eastern small to large construction companies that have digital transformation on their long-term agenda.

Almost 90% of the companies use a traditional bureaucratic (functional) structure or a matrix structure. According to the data, only experts working in some small to medium-sized organizations reported using a holacratic organization, and no participants reported using flatarchies. This demonstrates that most construction organizations currently employ either

functional organizational structures or matrix structures. As mentioned in the background section, these organizational structures have not been able to fully accommodate PBOs, of which construction organizations are a subset, in the digital vortex [182].

Table 4.3 provides a more detailed look at the participants and the organizations where they work. As can be seen, even though my network is primarily made up of Iranians and Turks, they work in international companies throughout the study's setting (Figure 3.5). The majority of these companies have digital transformation as a strategic priority. As a result, this could be inferred that the information provided by the experts working at these companies could provide valuable insights and support for construction organizations in the setting of this study: North American, European, and Middle Eastern small to large construction companies that have digital transformation on their long-term agenda.

Before interpreting the results of hypothesis testing, I need to discuss the descriptive statistics. This discussion is based on the distributions' moments represented in Table 4.4, Figures 4.12 to 4.14, and Hair et al.'s book on PLS-SEM [483]. Centralization has a near-normal distribution among the measurement factors of digitally agile organizational structure. Later in my analysis, I discovered factor loadings of less than 0.5 between digitally agile organizational structure and centralization, implying that centralization is not significantly related to digitally agile organizational structure. The normality of centralization's distribution might be the reason for this since experts' opinions do not lean towards centralization or decentralization significantly and hence the data derived from them cannot provide a significant correlation between centralization and digitally agile organizational structure.

Regarding the remaining organizational elements, expert responses back up the assumptions about construction firms' digitally agile organizational structure. The distributions of formalization (skewness = 0.18) and complexity (skewness = 0.15) are positively skewed. Even if their skewness value is insignificant, it may be noteworthy. The mean value for formalization is 10.73 (with a total score of 15), and when the standard deviation (1.62) is taken into account, this means that 68% rated this item as "moderately important" to "important." According to the literature, this result is not far from the mind as some types of formalization, such as employee performance appraisal formalization, may be

deemed important for DACOs [484]. This last line is a speculative conclusion that should be investigated further in future research. Furthermore, formalization's distribution is slightly flat due to its negative kurtosis (-0.47). This means that the tails of this distribution contain extreme values. As a result, future studies examining formalization in digitally agile organizational structures will benefit from using a more detailed questionnaire with more measuring factors.

The mean value for complexity is 15.52 (with a total score of 20), and when the standard deviation (1.92) is taken into account, this means that 68% of the participants rated complexity as "important." The kurtosis of complexity is positive (0.49), which means it moderately peaks around the mean value. These results are in line with the characteristics that the literature suggests for a digitally agile organizational structure. Complexity is important for organizations to survive in a VUCA digital environment because companies need many specializations and job titles to handle project tasks in cross-functional groups. Moreover, due to Figure 4.13, 64.7% of the experts believe 3 to 5 managerial levels should exist between employees and top management of a DACO, while 29.4% believe 1 to 2 levels are enough. So, even though the experts consider complexity important, their responses imply that a digitally agile organizational structure should not put so many layers between employees and top managers. This is in line with some studies that see successful organizational digital transformation in a de-layered or flatter hierarchy and less formalization [148, 302, 304, 305].

The distribution of integration has a negative skewness value (-0.93 ~ -1) which is significant. Its mean value is 13.32, which is also high (with a total score of 15). So, one can conclude that experts believe that DACOs are highly integrated organizations that have a reach collaboration and communication environment [412], strategically involve customers in their decision-making [413], and hold educational programs for their managers and employees [411]. Moreover, according to the literature, integrity and formalization are two characteristics of the organizational structure that help a construction project succeed [185]. The results of this study also provide support for this claim since DACOs are categorize as PBOs.

All digital agility measurement factors' distributions are negatively skewed, and when their mean value is taken into account, 68% of respondents rated hyperawareness, informed decision-making, and fast execution as "important" or "very important." According to Table 4.4, hyperawareness has a positive kurtosis of 0.49, indicating that this factor peaks around its mean value. These findings back up my assumptions based on the existing literature on agility and digital agility, and they demonstrate that digital agility can be measured using its elements and accelerators [246].

As can be seen in Table 4.4, the kurtosis for valuing distributed decision authority (AGL1, kurtosis = 1.34 > 1) and collaborative systems thinking (AGL4, kurtosis = 1.77 > 1) are high. So, these distributions are too peaked, meaning that, considering their low standard deviation and high mean, 68% of respondents scored these items between "important" and "very important." So, one can conclude that experts believe that valuing distributed decision authority and collaborative systems thinking are the most important features of agile leadership. Also, this claim is supported by the fact that collaborative systems thinking (AGL4, skewness = -1.1 < -1) is also highly negatively skewed.

Overall, descriptive statistics show that the data collected moderately supports my assumptions and can be safely used for hypothesis testing. It also allows me to describe DACOs as less formalized, complex and highly integrated. However, the decentralization of these organizations requires further investigation.

This study's central hypothesis (H1) is that digitally agile organizational structure relates positively to digital agility. One should use the information in Figure 4.15 and Table 4.5 to respond to this hypothesis. According to this data, the correlation between organizational structure and digital agility is approximately 0.56. So, based on t-value output, demonstrate a meaningful relationship between organizational structure and digital agility ($t = 3.849 > 1.96$) can be demonstrated. So, this hypothesis is supported: there is a direct and positive relationship between digitally agile organizational structure and digital agility.

However, due to the low factor loading of centralization (Table 4.5), this measurement factor is removed from the model. Based on the literature, I previously provided lengthy

discussions about the importance of decentralization in digitally agile organizations. Furthermore, interviewees emphasized the importance of decentralized decision-making and how it improves organizational agility. Future studies should design questionnaires that can measure centralization in a viable and reliable way. One reason for removing centralization from the model could be that I did not conduct a pilot study to test my questionnaire's viability and reliability, leading to a normal centralization distribution.

So, this study accomplished its goal of taking the first step toward closing the gap between organizational structure and digital agility as put forth by Verhoef et al. [29] and Vial [35]. Also, as I previously stated, existing research from other industries has shown that organizational structure significantly impacts how well digital transformation works and how digitally agile their business models can be [148, 302, 304, 305]. According to the findings of this study, this claim could be extended to construction organizations. This is significant because construction firms are PBOs, and this topic has not been researched in the context of PBOs before.

The second hypothesis of this thesis (H2) is: The relationship between organizational structure and digital agility can be moderated using digital functional areas (transformed IT departments), such that the relationship is stronger when these areas are used in the organization and weaker when they are not. Based on the information presented in Figure 4.15 and Table 4.5, the analysis does not provide support for this hypothesis, and it is thus rejected. The mediating role of digital functional areas is defined by two hypothetical paths: one between organizational structure and digital functional areas ($\beta = 0.285$, $t = 1.68, \alpha = 0.089$), and the other between digital functional areas and digital agility ($\beta = 0.157$, $t = 1.33, \alpha = 0.183$).

So, this study fails to show the critical contribution of digital functional areas or transformed IT departments to organizations' efficiency and agility as emphasized in the literature [29]. Since construction is the least digitalized industry in the era of digital economies [15, 16], I believe that the reason for the rejection of this hypothesis can be found in how I designed the hypothetical model. Perhaps defining digital functional areas as a latent variable rather than an observed variable will aid in reaching different conclusions. The experts may be unfamiliar with the concept of a transformed IT department and

providing a brief definition in the questionnaire may not have helped. As a result, and as the literature on digital functional areas grows, it is recommended that measurement factors for this variable be used in future studies.

The third and final hypothesis of this thesis (H3) is: The relationship between organizational structure and digital agility can be moderated by agile management so that the relationship is stronger with agile management and weaker with traditional management styles. Based on the data in Figure 4.15 and Table 4.5, the analysis does not support this hypothesis, and it is thus rejected. This result seems counterintuitive since agile leadership plays an important role in bridging between organizational structure and digital agility [383]. However, one of the hypothetical paths that define a relationship between organizational structure and agile leadership is supported by the model with a moderate significance effect ($\beta = 0.559,\ t = 3.849,\ \alpha = 0.006$). This shows that an organizational structure that supports digital agility creates a suitable environment for agile leadership.

The literature supports this finding. Studies emphasize the necessity of multidisciplinary, cross-functional, networked self-organizing teams with decision-making authority to enable flexibility, which is impossible in the absence of agile leadership [383]. According to the literature, there may be an inherent relationship between agile leadership vision and organizational flexibility because leadership talent supports team decision authority [384]. Moreover, due to Schlaepfer et al. [318] a company's culture that is committed to digital transformation must foster an environment where employees are free to try new things and where innovation is encouraged on a regular basis. This is one of the characteristics of agile leadership and given the correlation between digitally agile organizational structure and agile leadership, it is possible that a DACO can foster agile leadership.

The other hypothetical path from agile leadership to digital agility, however, is not supported by the structural model ($\beta = 0.248,\ t = 1.52,\ \alpha = 0.128$). As a result, I were unable to provide evidence for agile leadership's positive mediating role between digitally agile organizational and digital agility of construction companies' business models. Aside from the small sample size of this study, this issue could have been caused by the agile leadership measurement factors I used. As mentioned in the previous chapter, the failing-

fast mindset (AGL2) was removed from the model because of its low factor loading (-0.36). Using different measurement factors and larger sample sizes may be helpful in future studies to resolve this issue.

5.2. Limitations and Future Research

Like any academic attempt at a novel topic, this scientific work has limitations. First is the number of people who participated in this study in the qualitative and quantitative stages. Despite my efforts to contact as many people as possible during the course of this master's project, I encountered low response rates (25% for the qualitative and 13.6% for the quantitative part of the study). Compared to published papers in the construction management literature that use SEM for data analysis, the response rate of this study is quite low in the quantitative part. For example, Özorhon and Oral [428] had a response rate of 33%, while Sambasivan et al. [485] had a response rate of 77.5%. This may cause a few issues that jeopardize the thoroughness of this work.

In section 3.4.1, I discussed how, according to the 10-times rule, the minimum sample size for my analysis is 50. I ended up collecting information from 34 people. Due to Gefen et. al [486], "the core of the PLS estimation method - ordinary least squares - is remarkably stable even at low sample sizes." Despite this fact, the sample size of 34 is quite small. Other methods exist for calculating the minimum sample size for PLS-SEM after the analysis has been completed to ensure that the sample size is reliable. The Monte Carlo simulation [487-489] and the minimum R-squared method [483] are among these methods. The Monte Carlo simulation method is complex and time-consuming but precise [470]. However, I would like to continue my discussion here by using the minimum R-squared method.

This method is based on Cohen's [450] power tables for least squares regression. It is founded on a table that lists the minimum required sample sizes based on three factors: the maximum number of arrows pointing at a latent variable in a model, the significance level used, and the model's minimum R^2.

One can estimate the minimum sample size using the table in Appendix C from Hair's book [483] at the significance level of 0.05 (power set at 0.8). The model has a maximum of five arrows pointing at a latent variable (considering the arrows coming from the mediating variables) and a minimum R^2 of 0.37. The minimum R-squared method has no cell in the table where these two values intersect, but the closest cell has a minimum sample size of 70. As a result, one can see that using small sample size, such as 34 in this study's case, can cause such problems that more accurate methods do not support the initial minimum sample size calculated after the analysis.

This study's small sample size caused several issues for the quantitative model. I used the sum score method to adjust the quantitative model to achieve reasonable goodness of fit. Despite the fact that it aided me in achieving this study's goal, I did not investigate the relationship between each organizational element and the digital agility of the company's business model. Future studies using similar methodologies would benefit from larger sample size and more complex models with more latent variables and links to provide a more comprehensive understanding of the topic.

Second, because the interviewees worked for multinational corporations with Middle Eastern subsidiaries, their knowledge and expertise may have been influenced by the local organizational culture and local development strategies of these corporations. Only one of the three subjects had prior employment outside of the Middle East. As previously stated, this may have an effect on the scope of the qualitative portion of this academic work. As claimed earlier, the purpose of the qualitative portion of this study was primarily to provide support for the measuring factors derived from literature and to provide insights into the themes that emerged in the context of digital transformation of construction organizations. As a result, the findings of the qualitative portion of this study should not be generalized to companies outside of the Middle East. Future studies would benefit from involving experts from around the world to broaden the scope of their qualitative studies. Furthermore, future studies should consider interviewing people at higher managerial levels, such as CEOs and presidents or vice presidents of construction companies, who hold higher responsibility and power for long-term strategic decisions of their companies. This will contribute to the qualitative study's thoroughness and dependability.

Third, despite the fact that the questionnaire designed for this study is based on literature and interview data, it has not been subjected to viability and reliability tests due to sample size constraints. This occurred due to the small number of construction industry participants for whom data collection is appropriate. Using the findings of this study, I recommend that future researchers conduct pilot studies with sample sizes of 20 to 30 to test the viability and reliability of their questionnaire. This could also keep some of the measurement factors from being eliminated.

Fourth, I used directed content analysis, which allowed me to create categories ahead of time. It aided me in making the most of the interview data. However, if one has the opportunity to interview a large number of people, traditional content analysis could provide researchers and practitioners with more in-depth insights into the industry and its organizational challenges in the face of digital transformation. Furthermore, I did not use triangulation to represent the qualitative findings against the backdrop of existing literature. Triangulation could thus benefit future studies conducting a content analysis on the subject of this dissertation.

Fifth, this study did not investigate the relationship between each organizational element and the business model's digital agility. In addition, two measurement factors were removed from the quantitative model: centralization and failing-fast mindset. This occurred as a result of the aforementioned constraints. Future research should investigate the effects of formalization, centralization, complexity, and integration as independent variables on hyperawareness, informed decision-making, and fast execution of digital agility using the SEM or any other suitable approach. Furthermore, more research may be conducted to investigate the causal relationship between organizational components (strategy, industry, size, environment, power-control, and technology) and digital agility in order to develop an excellent model for evaluating digital agility implementation.

Sixth, as mentioned in Section 5.1.1, interviews indicated that their companies have difficulty communicating change to their employees. This could be investigated in future research. Furthermore, future research should look into the relationship and correlation between organizational culture, leadership vision, and communication management, as well as their impact on employee resistance to digital transformation in construction companies.

Seventh, despite the experts' claims that their companies are in the digital transformation stage, I recommend that follow-up studies conduct case studies on construction organizations and investigate their level of development and potential for transformation using the measures presented in the literature.

Eighth, even though I speculated that shifting to flatter organizational structures and learning from holacratic company models would be beneficial for construction organizations, this needs to be studied in depth in future research. Despite the fact that the results provided some hints, I was unable to achieve the study's goal of discovering a meaningful relationship between SMOs and digitally agile organizational structures. Besides, change management strategies and processes must be investigated further through action research and case studies.

As a hypothetical discussion that may provide insights for future research, I would like to highlight the role of standardization in construction companies' digital transformation practices. As previously stated, digital transformation is primarily concerned with learning from the knowledge generated during construction projects. The ability to integrate numerous digitized technologies that are generally mature and simple to implement is essential for digital transformation. However, in reality, things are rarely that straightforward, and businesses frequently have strategic interests that are at odds with one another. If various construction companies pool their intellectual and material resources, they can start to create standards that could spread throughout the construction industry. These standards may then spread to other contexts, gaining strength and legitimacy along the way. This creates an inter-organizational collaboration that could foster learning and facilitate the change management process towards, in the context of this study, DACOs.

As the final contribution of this study for future practice and research, I would like to share the vision this study could provide regarding the current status of construction companies and the future path they may take. As one could conclude from what has been discussed so far, this study spreads over three main topics: digital transformation, digital agility, and organizational structures in the construction industry. Moreover, as mentioned in the background, digital maturity depicts how an organization steadily evolves over time, hence it is a more tangible concept than digital transformation [222]. Figure 5.1 depicts the

current and future hypothetical status of construction companies against the backdrop of these four concepts.

In this digital age, most construction companies have almost completed the analogue and digitization stages, which means they have converted their processes from handwritten or typewritten text to digital form [198]. At this stage, the concept of digital agility and its components have not been developed in construction organizations. Traditional hierarchical organizational structures or functional organizational structures are mostly used by digitized construction companies. These companies are classified as pre-digital in terms of digital maturity. Today's construction companies can be classified as digitalized, which means they are transitioning from analog to digital technologies and incorporating digital technologies into the organization's day-to-day operations [199]. At this point, construction companies are aware of the complexities of the digital vortex and recognize that in order to survive and thrive, they must become digitally agile [246]. They attempt to become hyperaware by increasing their behavioral and situational awareness and thus becoming digitally reactive. Furthermore, businesses recognize the importance of automation and developing documented IT plans. In doing so, they strive for informed decision-making and, as a result, strive to become digitally purposeful. Companies at this stage struggle to communicate change to their workforce and instead choose to force the change on them. As a result, they fail to develop dynamic resources and processes and are unable to achieve the final element of digital agility: fast execution. Most construction organizations in the digitalization stage continue to use functional structures or are converting to matrix structures to increase flexibility. However, if they do not implement deep organizational changes, their digital transformation journey will come to an end [8-10, 255, 348]. This is where the sidewalk ends. Existing literature does not provide much information about the future path that construction companies should take in order to complete their journey towards digital transformation.

According to the findings of this study, one of the organizational changes that could benefit construction organizations is to change their organizational structures to be less formalized, complex, and integrated. To give this hypothetical organization a name, it has been decided to call it a DACO (digitally agile construction organization). Other industries are moving toward flatter organizational structures and self-organizing teams to distribute

decision authority in their firms, according to the literature. Holacratic structures are proposed in this regard, and real-world examples of their implementation exist. It is possible that future construction organizations will adopt a holacratic and agile structure to suit their digitally agile business model. They will be able to complete their digital agility cycle (Figure 2.11) and become digitally optimized and strategic in this manner, which means they will adopt digital technology and integrate it into their organizations' external interface as well as continuous internal activities [208].

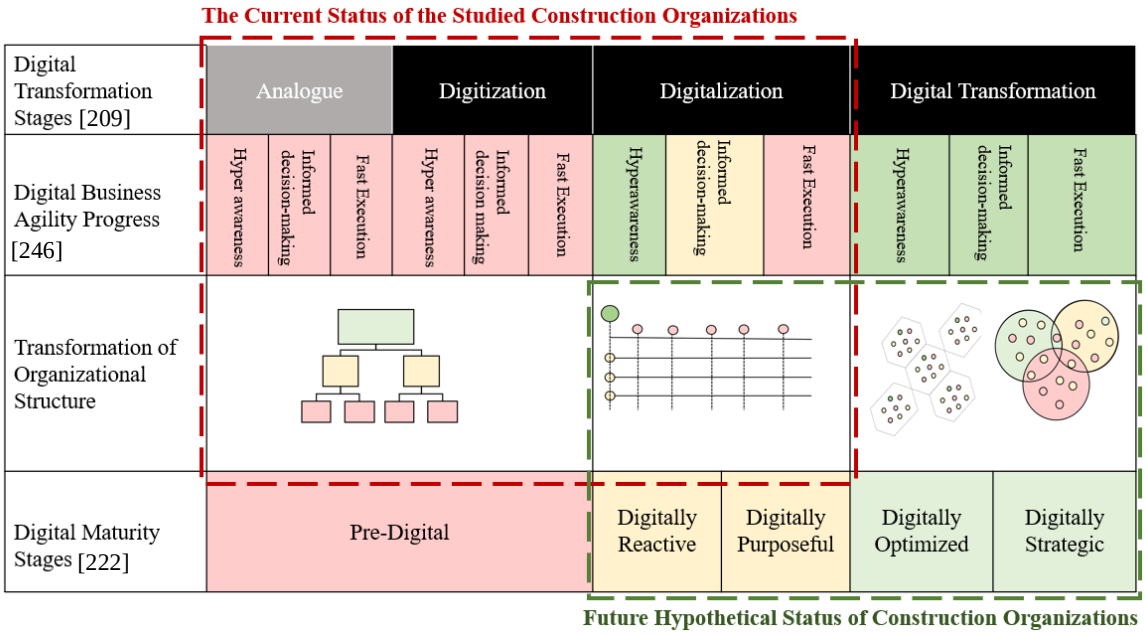

Figure 5.1. Digital transformation journey of construction organizations.

Figure 5.2 depicts a conceptual guide for construction organizations to contribute to the construction industry's digital transformation. The idea for the organizational structural changes of this guide is in line with Dimovski et. al's [490] findings about the evolution of organizational structures in the future. Ventures can follow this guide for getting insights about how they want to implement change towards becoming a DACO. Detailed roadmaps need to be developed as our understanding of the digital transformation of construction companies increase. Also, this conceptual guide is followed by a research plan proposed for future researchers who may wish to investigate DACOs further (Figure 5.3).

In Appendix D, an example of a standard questionnaire that could help experts assess their company's digital transformation status is provided for the first step of this guide. This questionnaire can be customized by experts based on their companies' needs and project specifications.

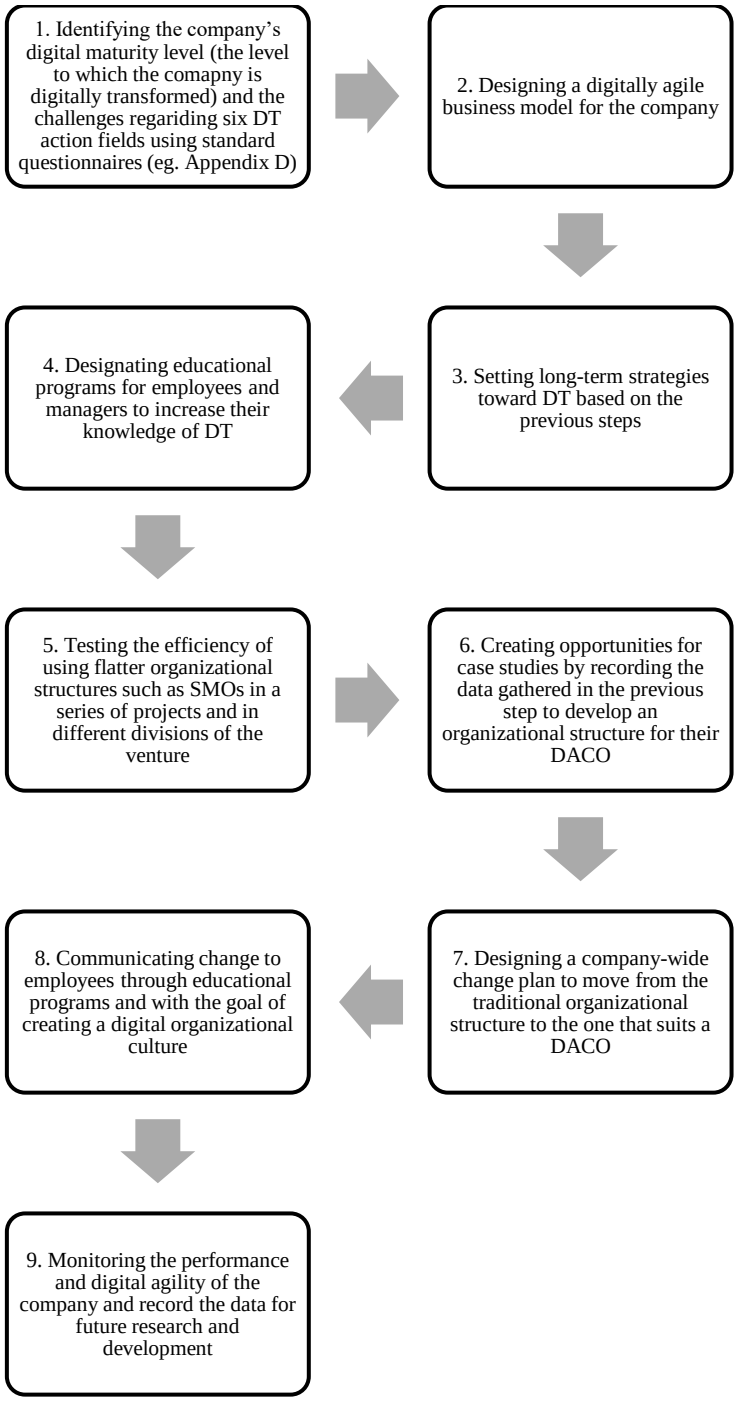

Figure 5.2. A conceptual guide for construction firms to become DACOs.

Based on the findings of this study, the path depicted in Figure 5.3 is proposed as a future research agenda for scholars interested in DACOs.

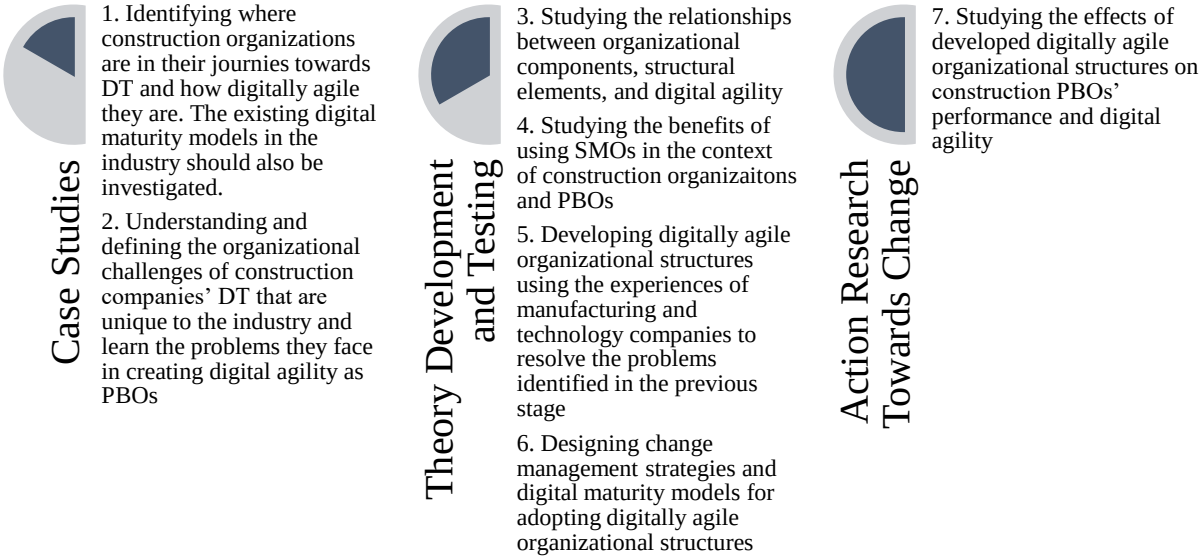

Figure 5.3. Future research agenda for DACOs.

6. CONCLUSIONS

Even though it is defined as the ability of an organization to leverage digital technology to improve the efficiency and efficacy of its internal operations and external market offerings, I explain digital transformation as a social process rather than a technical one in this dissertation. A digital tool's transformational power is not found in the technology itself but rather in the insight required to see the advantages of using it in the course of solving a business issue. There is a lot of untapped business potential in the digitalization of the AEC industry, but construction firms are still wary of it. Customer (stakeholder) involvement, new business practices, and new market offerings are all conditions for digital transformation that must be translated into the vernacular of the construction sector.

The digital agility of a firm's business model is one of the main characteristics of organizations that have been successful in their digital transformation process. Despite the fact that the potential of digital transformation for the construction industry has been investigated in the literature, there is no study that focuses on the digital agility of construction firms and its relationship to their organizational structure. Knowing this, I attempted to introduce these concepts into the construction industry in this dissertation.

Using management, organizational, and digital transformation literature, as well as studies that combine these in the context of various industries, I arrived at a hypothetical definition of digitally agile organizational structure for construction firms. I believe that such an organization should be project-based, with less formalization of business processes, moderately high complexity, and high integration, allowing decentralized decision-making and fostering hyperawareness, informed decision-making, and rapid execution. This definition was supported by construction experts who took part in this study to a reasonable extent.

A content analysis of interview data revealed that a DACO undergoing digital transformation must invest in the socio-technical side of this transformation. It is possible to create a digital organizational culture by holding educational programs for both employees and managers to provide them with the necessary skills and knowledge. Furthermore, such

programs may aid in communicating the change to employees, reducing employee resistance to the digital transformation process. Furthermore, interviews stress the importance of leadership in digital transformation, implying that if company leaders do not value digital transformation and agility, the business will suffer, and change will be difficult.

This study demonstrates that utilizing a digitally agile organizational structure with the aforementioned characteristics will foster digital agility and assist construction companies in being hyperaware of their environment as open systems, making informed, inclusive, and augmented decisions, and quickly executing these decisions through dynamic resources and processes.

A digitally agile organizational structure has been shown to foster agile leadership and help leaders manipulate collaborative systems thinking for solving complex problems by delegating decision-making authority to teams and encouraging risk-taking when it comes to adopting new technologies and technology investments.

I fail to define the role of digital functional areas and provide evidence for the positive effects of a transformed IT department that provides technological support and aids in knowledge and communication management via IT ambidexterity on construction companies' digital agility. It is also unclear whether a DACO can facilitate the transformation of the IT department into a more integrated one.

The primary contribution of this study to the construction management literature is to provide the industry with an introductory definition of a digitally agile organizational structure for PBOs and to demonstrate that there is a positive, meaningful relationship between such an organizational structure and digital agility of the firm's business model. Furthermore, it attempts to define the characteristics of a DACO and provide insights to construction practitioners and researchers. This study also paves the way for future research on the topic of organizational studies on construction firms undergoing digital transformation and proposes a research agenda in this regard.

This study's main limitations are the small sample size in both the qualitative and quantitative stages and the scarcity of literature on the topic in the context of construction

organizations. Furthermore, because the interviewees' knowledge was primarily gained through work in the Middle East, generalizing the findings of the qualitative portion of this thesis should be done with caution. However, I believe this study overcame these limitations by a very narrow margin and achieved its primary goal of emphasizing the importance of organizational changes in construction companies seeking to undergo digital transformation. It is hoped that as more construction companies embrace digital transformation, more opportunities for further research on DACOs will emerge.

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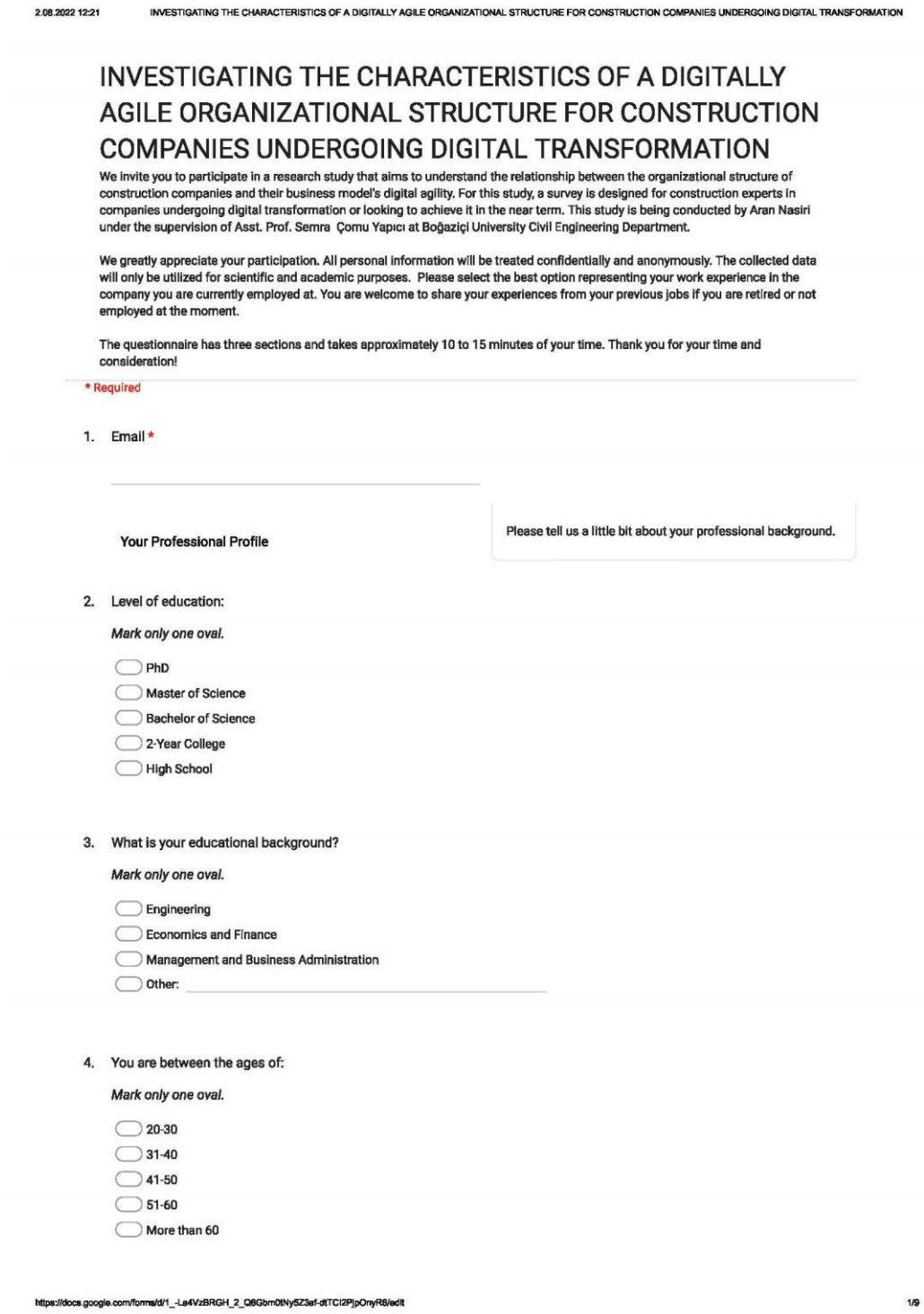
APPENDIX A: QUESTIONNAIRE



2.08.2022 12:21 INVESTIGATING THE CHARACTERISTICS OF A DIGITALLY AGILE ORGANIZATIONAL STRUCTURE FOR CONSTRUCTION COMPANIES UNDERGOING DIGITAL TRANSFORMATION

INVESTIGATING THE CHARACTERISTICS OF A DIGITALLY AGILE ORGANIZATIONAL STRUCTURE FOR CONSTRUCTION COMPANIES UNDERGOING DIGITAL TRANSFORMATION

We invite you to participate in a research study that aims to understand the relationship between the organizational structure of construction companies and their business model's digital agility. For this study, a survey is designed for construction experts in companies undergoing digital transformation or looking to achieve it in the near term. This study is being conducted by Aran Nasiri under the supervision of Asst. Prof. Semra Çomu Yapıcı at Boğaziçi University Civil Engineering Department.

We greatly appreciate your participation. All personal information will be treated confidentially and anonymously. The collected data will only be utilized for scientific and academic purposes. Please select the best option representing your work experience in the company you are currently employed at. You are welcome to share your experiences from your previous jobs if you are retired or not employed at the moment.

The questionnaire has three sections and takes approximately 10 to 15 minutes of your time. Thank you for your time and consideration!

* Required

1. Email *

Your Professional Profile

Please tell us a little bit about your professional background.

2. Level of education:

Mark only one oval.

- PhD
- Master of Science
- Bachelor of Science
- 2-Year College
- High School

3. What is your educational background?

Mark only one oval.

- Engineering
- Economics and Finance
- Management and Business Administration
- Other:

4. You are between the ages of:

Mark only one oval.

- 20-30
- 31-40
- 41-50
- 51-60
- More than 60

https://docs.google.com/forms/d/1_-Le4VzBRGH_2_Q8Gbm0tNy5Z3ef-dTCI2PjpOnyR8/edit 1/9

Figure A.1. Questionnaire: section 1/3, participants' profiles.

5. The years of experience you have in the AEC (Architecture, Engineering, and Construction) industry are:

Mark only one oval.

- ◯ Less than 3 years
- ◯ 3 to 6 years
- ◯ 6 to10 years
- ◯ More than 10 years

6. Your role in the organization you are currently at is:

Mark only one oval.

- ◯ C-Level Executive (CEO, COO, CDO, CTO, CFO, CHRO, CMO)
- ◯ President or Vice President
- ◯ D-Level Executive (Director)
- ◯ B-Level Executive (Mid-Level Manager)
- ◯ Executive Manager
- ◯ Project Manager
- ◯ Functional or Supervisory Manager
- ◯ Individual Contributor
- ◯ Other: _____

7. Your job in your organization involves: (Please select the most appropriate.)

Mark only one oval.

- ◯ Management
- ◯ Business and Marketing
- ◯ Contracts
- ◯ Engineering
- ◯ Operations
- ◯ Facilities
- ◯ IT
- ◯ Supply Chain

Your Company

In the following section, we would like you to share a little bit about the company at which you have experience.

8. Company Name

_____

Figure A.2. Questionnaire: section 1/3, participants' profiles (cont.).

9. In what region is your company headquarters? *

Mark only one oval.

- ◯ North America
- ◯ Latin America
- ◯ Western Europe
- ◯ Eastern Europe
- ◯ Middle East
- ◯ Africa
- ◯ Asia

10. Where are the majority of your company's projects located? (Please select all that apply.) *

Check all that apply.

- ☐ North America
- ☐ Latin America
- ☐ Western Europe
- ☐ Eastern Europe
- ☐ Middle East
- ☐ Africa
- ☐ Asia

11. How many employees does your company have? *

Mark only one oval.

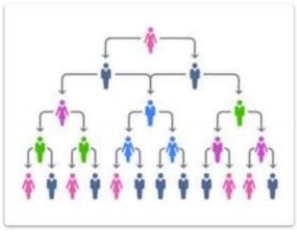
- ◯ 1 to 9
- ◯ 10 to 49
- ◯ 50 to 249
- ◯ More than 250

Figure A.3. Questionnaire: section 2/3, company information.

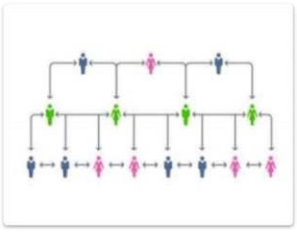
12. As you may be aware, which of the following organizational structures does your company utilize? *

Note: These structures could also be used by divisional or multidivisional organizations. | A matrix organization is a company structure where teams report to multiple leaders. | In a flatarchy, there are little to no levels of management. A company using this structure could have only one manager in between its executive and all other employees. | Holacracy is a method of decentralized management and organizational governance, which claims to distribute authority and decision-making through a holarchy of self-organizing teams rather than being vested in a management hierarchy.

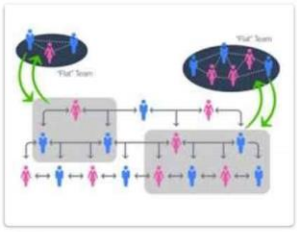
Mark only one oval.



Functional Structure (Bureaucratic Organizational Structure)



Matrix Structure



Flatarchy Structure

Holocratic Structure

Your Valuable Opinion

Lastly, we would like to know your opinion about the following characteristics of a Digitally Agile Construction Organization (DACO), which will be used to test our hypotheses.
Note: Digital agility is the ability of an organization to quickly and easily change its processes by applying and leveraging digital technology tools, processes, and software to perform basic business functions. A digitally agile organization has a structure that facilitates digital agility.

13. Considering a digitally agile construction organization's formalization, how important is each one of the following characteristics? *

Mark only one oval per row.

	Unimportant	Slightly Important	Moderately Important	Important	Very Important
Having written and defined job description					
Employees' allowance to deviate from the standards					
Defined standards and procedures for the organization's activities					

Figure A.4. Questionnaire: section 2/3, company information (cont.).

14. In your Opinion, to what extent should be the following allowed in a digitally agile construction organization? *

Mark only one oval per row.

	Very Little	Little	Neutral	Large	Very Large
Having different job titles	◯	◯	◯	◯	◯
Having different specialities	◯	◯	◯	◯	◯
Having management layers and levels	◯	◯	◯	◯	◯

15. How many vertical levels should exist to separate the management from the employees of a digitally agile construction organization? *

Mark only one oval.

- ◯ 1 or 2
- ◯ 3 to 5
- ◯ 6 to 9
- ◯ 9 to 12
- ◯ More than 12

16. Considering the organizational decentralization of an ideal digitally agile construction organization, do you agree/disagree with the following statements?

Mark only one oval per row.

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
Managers should use employee feedback in their decisions.	◯	◯	◯	◯	◯
Managers should give the employees authority in proportion to their duties and tasks.	◯	◯	◯	◯	◯
Managers should obey the organization's central authority and control.	◯	◯	◯	◯	◯
Employees' decisions and actions should be controlled by managers.	◯	◯	◯	◯	◯
Using self-organizing teams with decision-making authority is necessary.	◯	◯	◯	◯	◯

Figure A.5. Questionnaire: section 3/3, SEM.

17. Considering the organizational integration, how important are the following for a digitally agile construction organization?

Mark only one oval per row.

	Unimportant	Slightly Important	Moderately Important	Important	Very Important
Having a rich collaboration and communication environment among people and departments (or among cross-functional teams)	⬭	⬭	⬭	⬭	⬭
The collaborative involvement of customers (stakeholders) to strategically share information and knowledge about their needs	⬭	⬭	⬭	⬭	⬭
Existance of educational programs and training sessions for employees and managers	⬭	⬭	⬭	⬭	⬭

18. In your opinion, how effective are the following tools and strategies to reach hyperawareness in construction companies?

Note: Hyperawareness is a company's ability to detect and monitor changes in its business environment. Companies that are hyperaware are attuned to what is going on around them, particularly to changes that highlight opportunities or threats.

Mark only one oval per row.

	Not Very Effective	Somewhat Effective	Moderately Effective	Effective	Very Effective
Collecting data from employees and contractors and constantly monitoring their value creating to your projects	⬭	⬭	⬭	⬭	⬭
Collecting data from the work environment and physical assets	⬭	⬭	⬭	⬭	⬭

Figure A.6. Questionnaire: section 3/3, SEM (cont.).

19. In your opinion, how effective are the following tools and strategies considering a construction company's informed decision-making processes?

Mark only one oval per row.

	Not Very Effective	Somewhat Effective	Moderately Effective	Effective	Very Effective
Using "ubiquitous analytics" which embeds analytics and informed decisions directly into the work process, providing both executives and employees with the tools to make the best decisions in a given context	⬭	⬭	⬭	⬭	⬭
Using "automated or fast decisions," whereby technology helps accelerate the speed of decision cycles through automation and analytics	⬭	⬭	⬭	⬭	⬭
Using "inclusive decision making" tools such as multi-criteria voting systems that connects the shared intelligence of the workforce while giving voice to diverse viewpoints and expertise	⬭	⬭	⬭	⬭	⬭
Using augmented reality applications that support employees at the point of operation	⬭	⬭	⬭	⬭	⬭

Figure A.7 Questionnaire: section 3/3, SEM (cont.).

20. Considering a digitally agile construction organization's resources and processes, how important do you believe the following capabilities are?

Mark only one oval per row.

	Unimportant	Slightly Important	Moderately Important	Important	Very Important
The ability to find workers with the necessary skills and knowledge and to assemble teams with speed and precision	◯	◯	◯	◯	◯
The ability to obtain technology resources quickly and to use technology infrastructure to meet emerging business needs	◯	◯	◯	◯	◯
The ability to adjust day-to-day operations and capture value that is time-bound	◯	◯	◯	◯	◯
The ability to create new organizational capabilities quickly across a broad spectrum of activities including marketing, customer support, commerce and application development	◯	◯	◯	◯	◯

21. If we were to create a transformed IT department that not only supports the digital technologies the company is implementing, but also actively manages knowledge and communication, what would be the impact of such a department on organization's digital agility?

Mark only one oval.

- ◯ Not Very Effective
- ◯ Somewhat Effective
- ◯ Moderately Effective
- ◯ Effective
- ◯ Very Effective

Figure A.8. Questionnaire: section 3/3, SEM (cont.).

22. In terms of agile leadership mindset, how important do you believe each of these characteristics is for construction company's leaders who are pursuing digital agility?

Note: Collaborative systems thinking considers the social component of engineering and the exchanges of knowledge and information within a team during the course of system design that result in team-level cognition.

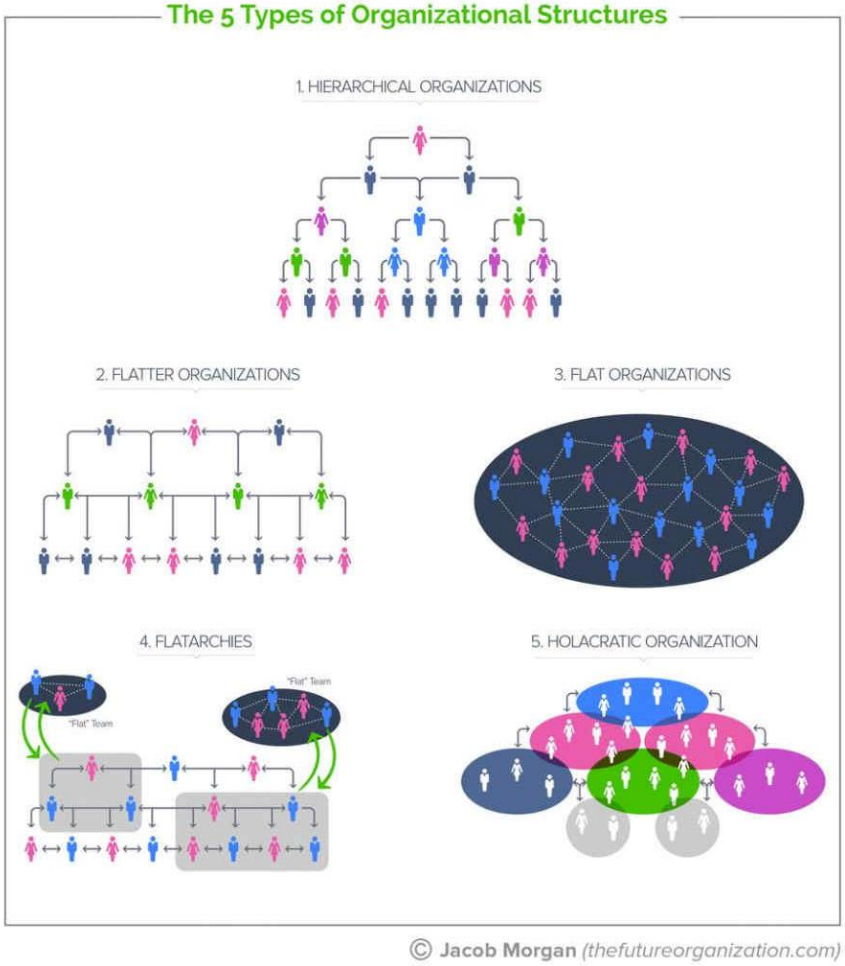
Mark only one oval per row.

	Unimportant	Slightly Important	Moderately Important	Important	Very Important
Valuing and implementing distributed decision authority	◯	◯	◯	◯	◯
Having a failing-fast mindset	◯	◯	◯	◯	◯
Risk-seeking behavior	◯	◯	◯	◯	◯
Valuing and implementing collaborative systems thinking	◯	◯	◯	◯	◯

Figure A.9. Questionnaire: section 3/3, SEM (cont.).

APPENDIX B: THE GUIDING QUESTIONS FOR THE SEMI-STRUCTURED INTERVIEWS

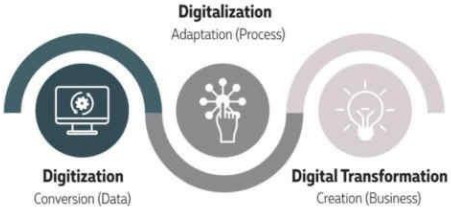
1. Tell me a little about your job at … (background and experience, type of projects, job title, years of experience).
2. What is the organizational structure of your company?



3. What digital capabilities does your organization have? What digital tools do your staff in your company utilize on a regular basis to manage their projects?

Figure B.1. The form of guiding questions for the semi-structured interview.

4. Is your organization making long-term strategies to digitalize its operations? If so, what steps have you taken to digitalize your firm thus far? To what extent do you believe your organization views new digital technology as a competitive advantage over other construction firms? What values do you believe digitalization will bring to your organization?
5. Have you encountered any employee resistance while introducing new digital technology to your company? If so, what do you believe the main issue was? What steps should your company take to address this problem? What are the primary hurdles you see an organization facing while embracing digital technologies?
6. What, in your opinion, are the key characteristics of an ideal organizational structure for construction companies undergoing digital transformation (the use of digital technology to radically change an enterprise's performance and reach) in order to be digitally agile (the ability of an organization to rapidly change or adapt their business processes)?



7. Have you ever engaged a change agent/a transition team to assist you in implementing organizational changes to digitalize your business? What is your take on/experience with self-organized teams for digital transformation?
8. Can you please assess the role of leadership in moving a company towards digital transformation?
9. Do you have any education/training programs for your managers and employees to improve their digital skills?
10. Finally, I would want to hear your thoughts on this hypothetical model of the fundamental elements of a digitally agile organizational structure for construction firms. Do you see any concept that you haven't thought of before or had in mind and didn't mention but we have here in this model?

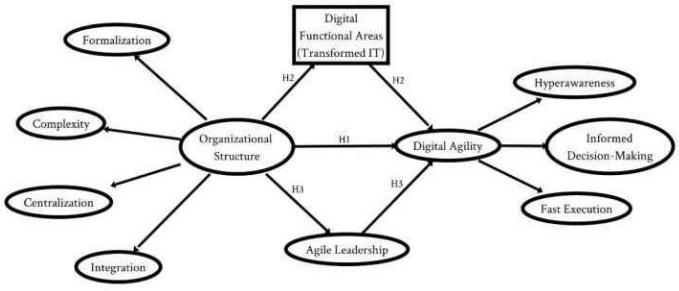


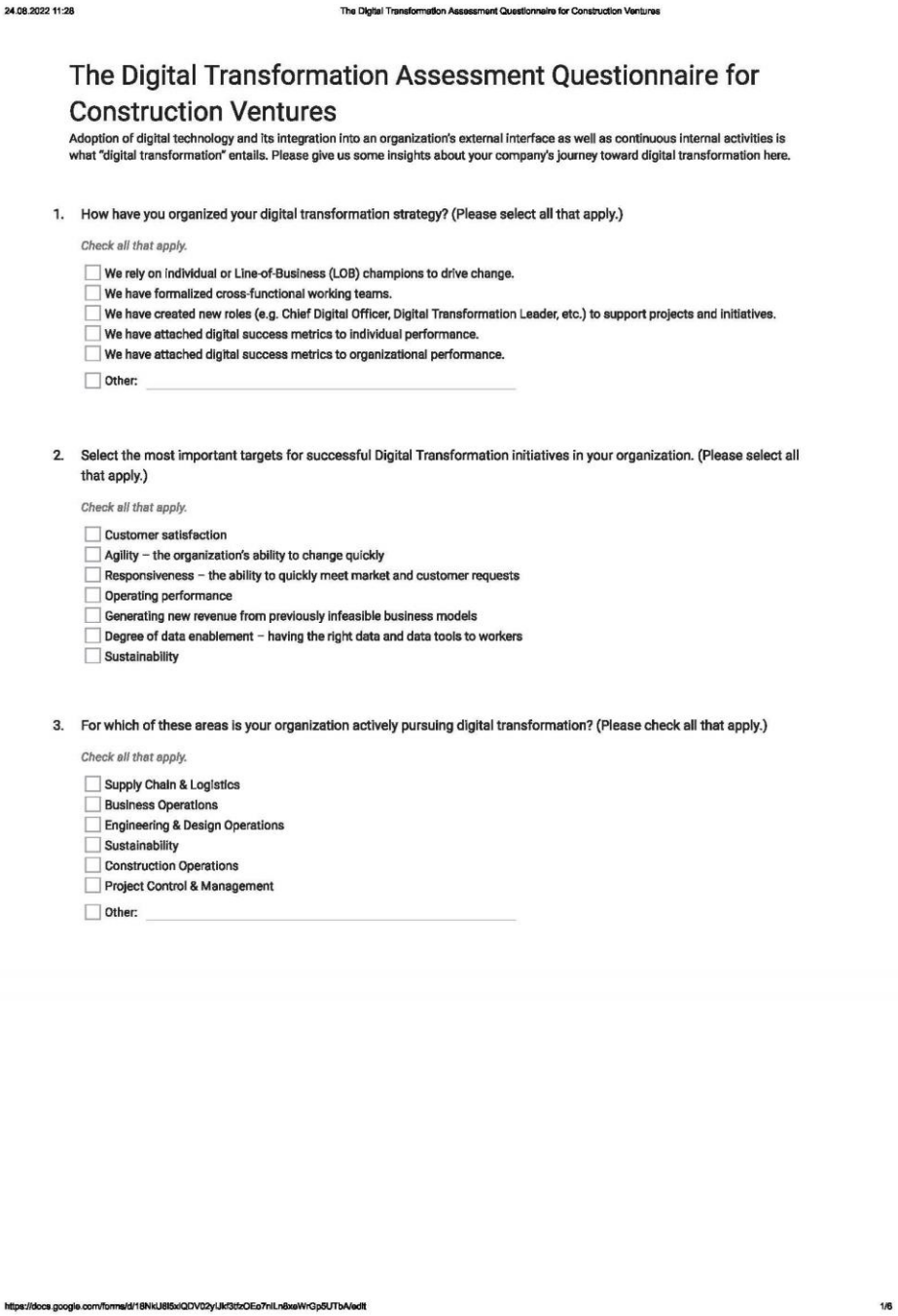
Figure B.2. The form of guiding questions for the semi-structured interview (cont.).

APPENDIX C: SAMPLE SIZE RECOMMENDATION IN PLS-SEM FOR A STATISTICAL POWER OF 80%

Table C.1. Sample size recommendation in PLS-SEM for a statistical power of 80% [483].

Maximum Number of Arrows Pointing at a Construct	Significance Level											
	1%				5%				10%			
	Minimum R^2				Minimum R^2				Minimum R^2			
	0.10	0.25	0.50	0.75	0.10	0.25	0.50	0.75	0.10	0.25	0.50	0.75
2	158	75	47	38	110	52	33	26	88	41	26	21
3	176	84	53	42	124	59	38	30	100	48	30	25
4	191	91	58	46	137	65	42	33	111	53	34	27
5	205	98	62	50	147	70	45	36	120	58	37	30
6	217	103	66	53	157	75	48	39	128	62	40	32
7	228	109	69	56	166	80	51	41	136	66	42	35
8	238	114	73	59	174	84	54	44	143	69	45	37
9	247	119	76	62	181	88	57	46	150	73	47	39
10	256	123	79	64	189	91	59	48	156	76	49	41

APPENDIX D: SAMPLE QUESTIONNAIRE FOR ASSESSING THE DIGITAL TRANSFORMATION LEVEL OF CONSTRUCTION COMPANIES



24.08.2022 11:28 The Digital Transformation Assessment Questionnaire for Construction Ventures

The Digital Transformation Assessment Questionnaire for Construction Ventures

Adoption of digital technology and its integration into an organization's external interface as well as continuous internal activities is what "digital transformation" entails. Please give us some insights about your company's journey toward digital transformation here.

1. How have you organized your digital transformation strategy? (Please select all that apply.)

Check all that apply.

- [ ] We rely on individual or Line-of-Business (LOB) champions to drive change.
- [ ] We have formalized cross-functional working teams.
- [ ] We have created new roles (e.g. Chief Digital Officer, Digital Transformation Leader, etc.) to support projects and initiatives.
- [ ] We have attached digital success metrics to individual performance.
- [ ] We have attached digital success metrics to organizational performance.
- [ ] Other: _____

2. Select the most important targets for successful Digital Transformation initiatives in your organization. (Please select all that apply.)

Check all that apply.

- [ ] Customer satisfaction
- [ ] Agility – the organization's ability to change quickly
- [ ] Responsiveness – the ability to quickly meet market and customer requests
- [ ] Operating performance
- [ ] Generating new revenue from previously infeasible business models
- [ ] Degree of data enablement – having the right data and data tools to workers
- [ ] Sustainability

3. For which of these areas is your organization actively pursuing digital transformation? (Please check all that apply.)

Check all that apply.

- [ ] Supply Chain & Logistics
- [ ] Business Operations
- [ ] Engineering & Design Operations
- [ ] Sustainability
- [ ] Construction Operations
- [ ] Project Control & Management
- [ ] Other: _____

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Figure D.1. The DT assessment questionnaire.

4. How are you using the following technologies in your construction operations?

Mark only one oval per row.

	No plans to use	Plan to use within 2-3 years	Piloting	Scaling	Fully Deployed
5G	◯	◯	◯	◯	◯
Additive Manufacturing (3D Printing)	◯	◯	◯	◯	◯
Advanced Analytics (AI, ML, etc.)	◯	◯	◯	◯	◯
Augmented Reality	◯	◯	◯	◯	◯
Blockchain	◯	◯	◯	◯	◯
Cloud Application/IoT Platforms	◯	◯	◯	◯	◯
Digital Twin	◯	◯	◯	◯	◯
IIoT Endpoint Devices	◯	◯	◯	◯	◯
IIoT Gateways & Routers	◯	◯	◯	◯	◯
Mobile Enablement for Frontline Workers	◯	◯	◯	◯	◯
Robotic Process Automation	◯	◯	◯	◯	◯
Smart Video or LIDAR	◯	◯	◯	◯	◯
Voice/Audio	◯	◯	◯	◯	◯
Wearable Sensors & Devices	◯	◯	◯	◯	◯

Figure D.2. The DT assessment questionnaire (cont.).

5. How do the following roles influence Digital Transformation initiatives/spending decisions?

Mark only one oval per row.

	No Influence	Some Influence	Great Influence	Key Decider	N/A
C-Level Executives	◯	◯	◯	◯	◯
Presidents or Vice Presidents	◯	◯	◯	◯	◯
D-Level Executives (Directors)	◯	◯	◯	◯	◯
B-Level Executives (Mid-Level Managers)	◯	◯	◯	◯	◯
Executive Managers	◯	◯	◯	◯	◯
Project Managers	◯	◯	◯	◯	◯
Supply Chain Managers	◯	◯	◯	◯	◯
Human Resources Officers or equivalent	◯	◯	◯	◯	◯
IT/OT Systems Managers	◯	◯	◯	◯	◯

6. For data and analytics tools, how effective is your organization in:

Mark only one oval per row.

	Not Very Effective	Moderately Effective	Highly Effective	Don't Know
Widespread adoption of techniques and tools used to produce insight from data.	◯	◯	◯	◯
Using AI throughout your operations.	◯	◯	◯	◯
Creating and deploying your own analytics models and applications.	◯	◯	◯	◯
Encouraging broad use of data as a strategic asset.	◯	◯	◯	◯
Establishing joint IT/OT rules that determine access to and use of data by people and systems.	◯	◯	◯	◯

Figure D.3. The DT assessment questionnaire (cont.).

7. Please identify those areas where your digital transformation programs have yielded measureable improvements. (Please check all that apply.)

Check all that apply.

- [ ] Increased Revenue
- [ ] Faster Innovation
- [ ] Reduced Cost
- [ ] Increased Productivity
- [ ] Improved Safety
- [ ] Improved Quality
- [ ] Improved Customer Outcomes
- [ ] Other: _____

8. How do the following describe your organization?

Mark only one oval per row.

	Doesn't Fit My Organization	Somewhat Fits My Organization	This Describes Us Pretty Well	Don't Know
Assets, devices, and machines are connected, supplying machine health data in addition to process and automation data.	◯	◯	◯	◯
Advanced analytics are applied to data collected from assets, devices, and machines.	◯	◯	◯	◯
Systems and data are distributed among edge devices, network devices, and cloud devices as appropriate.	◯	◯	◯	◯
Asset performance optimization and asset maintenance is aligned to production, business, and customer priorities.	◯	◯	◯	◯
Physical/cyber systems, networks, and devices are secure by design throughout the entire system	◯	◯	◯	◯

Figure D.4. The DT assessment questionnaire (cont.).

9. Similarly, how do the following describe your organization?

Mark only one oval per row.

	Doesn't Fit My Organization	Somewhat Fits My Organization	This Describes Us Pretty Well	Don't Know
My organization routinely assesses new technologies and skills to enable people to support customer success.	◯	◯	◯	◯
Customer needs directly influence operations. Customer-connected business models are common, and digital use cases begin with customer problem statements.	◯	◯	◯	◯
My organization blends operations skills with specialized data skills throughout the organization to empower a broader audience for analytics tools and systems.	◯	◯	◯	◯
Senior executives actively drive and invest in Digital Transformation programs and initiatives and focus the efforts on serving the customer.	◯	◯	◯	◯

10. What challenges or hurdles does (did) your organization face on the road to Digital Transformation? (Please check all that apply.)

Check all that apply.

- ☐ Obtaining executive support
- ☐ Cost
- ☐ Creating an initial business case/ROI justification
- ☐ Creating an organizational roadmap for digital transformation
- ☐ Composing the right team (champions)
- ☐ Addressing cultural resistance
- ☐ Finding data scientists
- ☐ Migrating/deploying software
- ☐ Implementing hardware
- ☐ Accessing and managing data
- ☐ IT/OT cooperation
- ☐ Identifying the right partners/suppliers
- ☐ Identifying the necessary skills
- ☐ Lack of internal expertise
- ☐ Deciding what technologies to pursue
- ☐ Measuring success
- ☐ Moving beyond pilot phases
- ☐ Other: _____

Figure D.5. The DT assessment questionnaire (cont.).

11. What sources of information do you rely on for learning about digital transformation and assessing technologies? (Please select up to 5.)

Check all that apply.

- [ ] Internal Experts
- [ ] Pilot Projects
- [ ] Academia
- [ ] External peers
- [ ] Competitors
- [ ] Consultants
- [ ] Suppliers
- [ ] System Integrators
- [ ] Engineering Service Providers
- [ ] Standards and Professional Organizations
- [ ] Google/Internet Search
- [ ] Industry Analysts

12. What, in your opinion, is the biggest pitfall in a successful digital transformation?

Figure D.6. The DT assessment questionnaire (cont.).