POLITECNICO DI TORINO

Master's Degree in Engineering and Management

Politecnico di Torino

Master's Degree Thesis

The Impact of Integrated Supply Chain Platforms on Project Management Criteria: A Study of Time, Cost, and Risk Management in Construction Projects

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December 2023

Dedication

I dedicate this thesis to my wife, son, and family for their unwavering support and encouragement throughout my academic journey. thank you for always being there for me, for your love, and for your unwavering support. This thesis is dedicated to you with all my heart.

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Chapter 1
Introduction

1.1. Background

Information is now viewed as a key instrument in decision-making for the survival and growth of supply chain (SC) businesses. Gaining power from information would likely allow businesses dealing with SC challenges to exert more control over their suppliers and improve their supply chain management (SCM) capabilities.[1]

In the supply chain, information is frequently used to achieve two objectives (Mashreghi & Nahavandi, 2010): 1. Organizing everyday operations related to manufacturing, storage, positioning, and transportation 2- Using forecasting and planning to predict future demand and determine the necessary steps to requirements. Effective information dissemination and transmission can enhance all SCM components. A key factor in improving SCM implementation is the use of information technology for accurate and timely information sharing and transfer.[2]

Planning and operational decision-making can benefit greatly from accurate information. Earlier studies offer several definitional approaches for ERP. Adaileh and Abu-alganam (2010) define ERP as an integrated information system that unifies internal data processing operations, merges operational data, and integrates enterprise internal function working processes.[3]

data produced by various functions. ERP systems are widely used by enterprises to create integration with customers, suppliers, or both since they deliver accurate and timely information that will result in supply chain integrity. An ERP system, in the words of Kashyap (2011), is a collection of management tools that balances supply and demand. Additionally, it offers high levels of cross-functional integration across sales, marketing, and other departments, employs tried-and-true business processes for decision-making, and has the capacity to connect clients and suppliers into a full supply chain.[4]

An ERP system, according to Kashyap (2011) can be characterized as a collection of management tools that balance supply and demand. Additionally, it has the capacity to connect buyers and sellers into a seamless supply chain using tested commercial techniques.[5]

High levels of cross-functional integration across sales, marketing, production, operations, logistics, purchasing, financing, new product development, and human resources are provided by decision-making processes. As a result, it aids people in managing their businesses with high levels of productivity and customer service while also lowering expenses and inventory, laying the groundwork for successful e-commerce. The literature has divided its examination of the effectiveness of ERP systems into two components (Adaileh & Abu-alganam, 2010; Ifinedo & Nahar, 2009):[3], [6]

The technical effectiveness of such systems' installation, including project management indicators and time and cost estimation

2- ERP success elements in the organization after adoption, which refers to the application of such systems to improve operational efficiency.

According to the Delon and McLean (1992) model of information system success, which includes system quality, information quality, system use, user happiness, individual impact, and organizational effectiveness, Gable et al. (2003) developed an ERP system success measuring model. They provided their framework for ERP system success, which included system quality, information quality, individual impact, and organizational effectiveness. They removed system use and user satisfaction with multi-step data collection and analysis from the Delon and McLean model and provided their framework for ERP system success, which takes into account organizational effectiveness, individual influence, system quality, and information quality.[7], [8]

Several individuals view the construction industry, which is among the oldest in the world and is regarded as favorable, as troublesome and a complicated process that is challenging to manage. The construction sector still uses the majority of conventional techniques. According to recent studies, the construction sector is known for its poor performance and limited margins of profit (Cox and Ireland, 2002). According to Josephson and Saukkoriipi's research from 2005, waiting, handling materials, and other indirect labor accounted for more than 80% of the typical Swedish craftsmen's working day. It indicates that methods for increasing productivity must be found.[9]

Construction sector supply chains may be quite intricate. Particularly in a large-scale project, several suppliers and subcontractors may be involved. Any delay in the delivery of materials for a construction project might cause the work to be delayed, and if the work is vital, the project will probably get postponed as a result. As a result, to get the greatest outcomes upon completion of a construction project, managers must pay close attention when controlling the supply chain route. This must be done appropriately and successfully throughout the project. According to O'Brien and Fischer (1993), there is a strong probability of increasing construction project productivity by strengthening the supply chain throughout the project's life cycle.

Consequently, many firms have reconsidered the need for cooperative, mutually beneficial supply chain partnerships [10][11]and the improvement of inter-organizational processes in a joint manner has become a high priority.[12] The impact of the integration of the supply chain on different aspects such as performance, resilience, etc. … has been studied in different research and different industries.

Digital platforms have grown exponentially in recent years, and hence, the need for intra and extra-firm integration has gained popularity accordingly. This need is at the heart of businesses. Kache and Seuring [13] the key to the success of the e-supply chain and efficiency is integration. [14]

Additionally, observed is that the integration of e-Supply chains allows organizations to seamlessly exchange real-time information, enhancing productivity, efficiency, and the supply chain's capacity to deliver faster and superior products/services. It also helps in achieving a better balance between supply and demand while reducing costs through improved coordination and information sharing. The empirical evidence presented by Rai, Patnayakuni, and Seth [31] demonstrates that integrating supply chain processes enables firms to enhance their performance, particularly in terms of operational excellence and increased revenues. Furthermore, a survey conducted by European A.T. Kearney/WHU logistics [10] among

European supply chain managers found that approximately 80 percent of the participants acknowledged the significance of integration for the [15]digitalization of their supply chains. Thus, the requirement for integration significantly contributes to the concept of DSC.[16]

Digital technologies can improve supply chain processes to guarantee a prompt response to customer needs. This is achievable because smart products, such as smartphones, tablet computers, and handheld devices, have the capability to convert electronic messages needed by current systems and facilitate electronic data communication between the company and other members of the supply chain. Xue, Zhang, Ling, and Zhao define the digital supply chain (DSC) as a set of inter-organizational systems (IOSs) that companies adopt to digitize transactional and collaborative processes with their supply chain partners, including upstream suppliers and downstream customers. [14]

According to Farahani et al., the primary technological advancements with the most significant impact on the digital supply chain are big data and cloud computing.[17]

1. Big data: Big data plays a crucial role in enhancing visibility within the supply chain by offering an integrated platform for real-time data analysis, performance tracking, and informed decision-making scenarios. This, in turn, reduces the likelihood of disruptions and delays in the supply chain.

2. Cloud computing: Cloud technology enables the storage and real-time processing of large data volumes, making information accessible to all participants in the supply chain. Compared to traditional IT solutions, cloud technologies facilitate swift acquisition and deployment without necessitating extensive changes or expansions to a company's existing infrastructure, allowing for adaptable and agile operations.

According to Deloitte AG in 2015, incorporating advanced technology into businesses is crucial for enhancing productivity. This integration can result in various benefits, such as reducing operational costs, increasing customer satisfaction, and improving client retention. Moreover, it plays a significant role in establishing an efficient, adaptable, and responsive supply chain, which leads to shorter lead times and greater product availability. Lindgren (2015) further emphasized that having the courage to abandon outdated operating models is a crucial factor in achieving success. [18], [19]

According to a study conducted by Büyüközkan and Göçer in 2018, there is a significant research gap when it comes to real-life applications of digital supply chain (DSC), particularly within the manufacturing sector. They also noted that different companies in various industries have their unique policies, approaches, and practices for implementing DSC. Therefore, further research is necessary to develop specific sub-frameworks for DSC in each industry. These sub-frameworks would help enhance the important trends for future DSC. Several studies have suggested that digitalization plays a crucial role in improving supply chain operations. Hence, having a proper guideline and framework for implementing DSC is essential to facilitating this digital transformation.[20]

Bhargava et al. (2013) conducted a study that defined digital supply chain (DSC) as a combination of systems that facilitate communication and transactions between global distribution organizations and their partners in supply chains. This definition was further supported by Cecere (2016).[21] Kinnet (2015) emphasized that DSC is characterized by

speed, intelligence, and value creation throughout the entire chain. With the advent of new technologies and advanced analysis methods, DSC has the potential to generate new sources of revenue, returns, and profits. Schrauf and Bertram (2016) also argued that digitalization not only adds value to supply chains but also enables them to offer more accessible and affordable services. Israelite et al. (2018) conducted a similar study and found that companies that integrate digital technologies into their supply chains can enhance service levels rapidly. By implementing a digitalized and fully integrated supply chain network, businesses can respond swiftly to customer demands while improving effectiveness, efficiency, and overall productivity. McKinsey Digital (2015) stated that DSC allows manufacturers to gain a deep understanding of customer behavior and establish a unique position within a complex ecosystem of partners, suppliers, and customers.[22]

According to a 2015 study by Porter and Heppelmann, digitalization is anticipated to play an increasingly significant role in the management and design of global supply chains, particularly those that supply companies that are actively engaged in value-adding activities, such as those involved in production and logistics systems. Digitalization, in the opinion of Büyüközkan and Göçer (2018), is the DSC's first phase. Digitalization is defined as the use of digital technology and the transition of traditional businesses to digital businesses, which results in the creation of new sources of income. According to Isaksson, Wennberg, Se, and Se (2016), digitalization is a technological force that strengthens globalization in both economic and cultural aspects. Digital operations, digital organization and culture, and digitalization strategy can be divided into three essential stages (Corver & Elkhuizen, 2014). [20], [23], [24]

The process of digitization can be divided into three essential stages: digitalization strategy, digital organization and culture, and digital operations (Corver & Elkhuizen, 2014). The digitalization strategy focuses on establishing digital goals, formulating a digital strategy, and implementing it. Simultaneously, the digital organization and culture stage involves analyzing the current organizational and cultural aspects, managing the digital transformation of the organization and culture, and transitioning them into a digital state. On the other hand, digitalization operations emphasize enabling workers, managing digital operations, and implementing digital operations effectively.[25]

Basic Supply Chain Management (SCM) techniques have been used extensively in the production industry and these are finding their way into the construction industry as well. Basic Supply Chain Management (SCM) techniques have been used extensively in the production industry and these are finding their way into the construction industry as well. The earliest documented account of the construction supply chain has been reported in relation to Coordination, Costing, and Control in construction (O'Brien, 1995). It has been reported by researchers that the application of SCM can result in better coordination, costing and control in the construction industry. A better understanding of a firm's production costs and capabilities – in particular their ability to manage their resources across projects given changes in schedule and scope – affords several opportunities for improvement.

Cost and performance models must be complemented by econometric measures. These measurements help to generalize more specialized models and test their hypotheses. In general, these actions enable the creation of an empirical database that may illustrate the benefits that supply-chain strategies can provide. This should speed things up.

adoption of these methods by the whole construction sector. The study determined that supply chain management has the following effects on the construction sector.

•Cost and performance modeling of subcontractor and supplier production.

• Improved scheduling methods, particularly with regard to the design and placement of buffers against uncertainty and changes.

• Improved subcontractor coordination methods by linking site production to resource management.

• Improved accounting and production control systems.

The case study's findings indicate time and money savings. The favorable attitude among the partners in sharing their expertise and experiences on future initiatives must be maintained in order to keep the momentum of these gains. By using this strategy, the client and end users will receive additional benefits.

The planning of a construction project must include the process of risk management. Project managers use their own experience and knowledge to take the necessary actions when a risk event occurs while a project is being carried out. Although past project knowledge and expertise can be very helpful in detecting and managing risks in a new project, such knowledge typically sits in project managers' heads and is rarely recorded in a reusable form of information.

Managers can be helped by a decision support system that has a case-base of prior actions done and a record of prior risk management plans when managing the risk of construction supply chains in a new project. This study presents a framework for a decision support system that uses a case-based reasoning approach and can assist decision makers in both preventive and interceptive supply chain risk management in the construction industry.

1.2. Aim and Objectives

The primary objective of current research is to measure the effectiveness of integrated software platforms in management of the supply chain in the construction industry and examine their effectiveness in managing projects. Instead of investigating the effectiveness in the scale of the whole firm, we narrowed down our study to project level. This approach would take into account each individual project and by avoiding the aggregate performance measurement, can reveal valuable information on how each project may benefit from or even might be impaired by utilizing integrated software solutions for the supply chain management.

The research problem for this topic is to understand the influence and implications of integrated supply chain platforms on project management criteria in the context of

construction projects in a European country. Among the criteria of the project management, we focus on time, cost, and risk management as the parts that could be influenced by the implementation of the integrated software platforms. Mainly the construction industry was the focus of current researched to avoid any unconformities among different industries to bias the results. By using a survey, the validity of the proposed model would be examined and the degree of influence of the software utilization on different aspects of the project management within the construction industry.

1.4. Research scope and methodology

The research is limited to the construction industry in the Nordic countries, with main focus on the Danish and Norwegian markets. Also the research is limited to the use of the integrated software platforms in supply chain management. To get more detailed answers, we aimed our research on the projects and not the overall firm outcomes.

Our research is based on a survey that has been conducted aimed at the project managers or equivalent positions within the construction industry in Denmark and Norway, and the effects of the integrated software platforms on time, cost, and risk management within projects in this industry has been analyzed.

To analyze the survey results. Structural Equation Model (SEM) was used to check the data and perform statistical evaluations on it. (number of samples, limitations in the sampling and work…. This must be briefly stated here also with further exploring the SEM and statistical works done on the project we can add more items to this part)

- Contribution to Knowledge:
- The thesis structure:

In the next chapter, the existing literature will be reviewed to point to a common understanding of the previous research as well as the efforts taken to establish the current understanding of supply chain management and integration. Later, based on the current literature, we develop a theoretical model and discuss the SEM method to construct and examine the validity of our proposed model. In Chapter 4, we discuss our questionnaire and methods to collect data from the industry, and in the following chapters, the results of our study and implications will be discussed.

Research Scope

This section defines the boundaries and extent of the research, outlining the specific areas and aspects covered by the study. The current study is part of a series of similar studies to be conducted on different European countries and the aggregated results would form a great database for comparison among these countries. The research scope of this study encompasses:

Geographical Scope: The study focuses on the Nordic construction industry, namely Denmark and Norway as the primary geographical area of interest.

Construction Industry Focus: The research is limited to the construction industry, examining the implementation and impact of Enterprise Resource Planning (ERP) systems within this sector. It encompasses various construction project types, including commercial, residential, infrastructure, and industrial projects.

Participants: The study involves construction professionals, and project managers, in construction firms that have experience with integrated supply chain systems. Participants are drawn from diverse backgrounds and roles within the construction industry.

ERP System Aspects: The research delves into various aspects of ERP systems, including their adoption time, and benefits like their impact on project performance. It investigates how ERP systems are used for financial management, procurement, logistics, and project management in construction firms.

Limitations**:** While the primary focus is on the Nordic countries, the study acknowledges its limitations in terms of generalizability to other regions and industries. It does not extend to an in-depth exploration of ERP systems in other Nordic countries besides Norway and Denmark or continental or global contexts.

1.5 The Structure of the Thesis

The thesis is structured as follows: Chapter One serves as an introduction, providing context on the construction industry and the role of Integrated Supply Chain Management (ISCM) platforms, outlining the problem, research questions, objectives, and methodology. Chapter Two is dedicated to a comprehensive literature review, exploring construction industry issues, project delays, and ISCM platform adoption. Chapter Three contains the methodology and design, designing the questionnaire and sampling methods and how the model was built to test our hypothesis. Chapter four deals with collected data, its analysis and how description of the data whereas chapter five includes results and discussion of the final results than were taken in the current study.

Chapter 2
Literature Review

2.1. Definition and concepts

2.1.1 Supply Chain Management

Supply chain management, a term that emerged in the late 1980s and gained widespread adoption in the 1990s, refers to the strategic coordination of production, inventory, logistics, and transportation activities among supply chain participants. The goal is to achieve the optimal balance of market responsiveness and operational efficiency (Hugos, 2018)[26]. In essence, it represents a collaborative effort involving individuals and companies operating within a network of interconnected processes (Tommelein et al., 2003)[27].

Krajewski, Ritzman, and Malhotra (2007) describe supply chain management as "the planning, organization, control, and motivation of resources engaged in the movement of services and materials throughout the supply chain." Furthermore, This collaboration takes into consideration a range of factors, encompassing aspects like geography, customer base, products, and financial reporting, (bolster and Rosenbaum in their 2012 publication)[28]

SCM (supply chain management) is the integration of trade partners' core business processes from initial raw material extraction to final or end customer, encompassing all intermediate processing, transportation, and storage activities. er, Tan, and Leong (2012)[29]

This comprehensive approach to supply chain management emphasizes the importance of coordinating and optimizing various activities across the entire supply chain to enhance efficiency and meet market demands.

2.1.2. Integrated Supply Chain Platform (ISCP)

An Integrated Supply Chain Platform is a defined process in which suppliers, partners, and customers operating within a common market space work together to strategically coordinate, execute, and oversee the seamless flow of information, services, and products throughout the entire supply chain (Mathegu, 2017; Lambert & Cooper, 2000)[30].

The objective of this integration is to improve business operations in terms of speed, agility, real-time control, and customer response (Croxton et al., 2001; Christopher, 2016).[31] This platform integrates and streamlines the flow of data, materials, and resources across different stages of the supply chain, thereby facilitating real-time coordination, transparency, and efficiency (Chopra & Meindl, 2021; Monczka et al., 2020).[32]While this platform offers various tools to support supply chain collaboration, it also presents challenges in terms of obstructing integration with business partners. ISCP focuses on inventory management within supply chain coordination, leveraging quantitative modeling and organizational insights to optimize ordering and logistic policies, ultimately reducing supply chain costs and promoting cooperation among partners (Kellea & Akbulut, 2005)[33]

2.1.3 Supply Chain Software Solutions

Within the realm of supply chain management, various software solutions are available to manage and optimize the material supply chain. These solutions play a crucial role in streamlining operations, improving efficiency, reducing costs, and enhancing overall supply chain management. "In fact, the supply chain planning and execution processes need to be tightly integrated with each other as well as with the resident ERP systems. The supply chain

planning processes typically need transaction histories, budgets, and financial plan data from the ERP system to establish the decision parameters. Enterprise Supply Chain Management Integrating Best-in-Class Processes VIVEKSEHGAL2009 Published by John Wiley & Sons, Inc.Hoboken,NewJersey.[34]

Here are some commonly used software solutions in this domain:

- Enterprise Resource Planning (ERP) Systems:

Offer end-to-end visibility and control over the entire supply chain, integrating procurement, inventory, production, and logistics.

- Supply Chain Management (SCM) Systems:

Focus on optimizing supply chain processes, including demand forecasting, inventory management, supplier relations, and transportation.

- Warehouse Management Systems (WMS):

Manage warehouse operations, including inventory tracking, order fulfillment, and efficient material handling.

- Supplier Relationship Management (SRM) Systems:

Assist in supplier selection, evaluation, and collaboration, ensuring timely material deliveries.

- Demand Planning and Forecasting Tools:

Utilize historical data and predictive analytics to optimize material planning and reduce stockouts.

- Transportation Management Systems (TMS):

Optimize transportation and logistics with route planning, carrier selection, and shipment tracking.

- Material Requirement Planning (MRP) Systems:

Determine material requirements based on production schedules and demand to avoid shortages.

- Inventory Management Systems:

Provide real-time visibility and control over inventory levels, usage, and replenishment.

In the study, we explored companies utilizing these supply chain software solutions to enhance project management, improve decision-making, and achieve better outcomes in time management, cost control, and risk management.

2.1.3 Project Management Criteria

Project management criteria encompass the essential elements of knowledge, skills, tools, and techniques employed in the orchestration of project activities to fulfill project objectives. Project management involves the direction of project endeavors to produce desired results.

Project teams can employ diverse methodologies, such as predictive, hybrid, or adaptive, to attain these objectives (PMBOK® GUIDE, Seventh Edition).[35]

Project management criteria are standards, factors, or criteria that are used to evaluate the success of a construction project, according to the PMBOK definition. [36]They include parameters such as project scope, quality, schedule adherence, budget control, stakeholder satisfaction, and overall project performance. In this article, we will specifically examine the impact of an integrated supply chain platform on three important aspects: budget control, time management, and risk management.

The research by Xinyu Wei, Victor Prybutok, and Brian Sauser explores key antecedents for successful SCM integration in project-based environments (Wei et al.).[37] The study categorizes these factors into IT integration, organizational coordination, risk management, and supply chain resilience and complexity . It provides a systemic gram visually representing the SCM strategy adoption pathway**.** The study emphasizes the need for increased focus on SCM among project teams to enhance project (Wei et al.)[37]. This research highlights the significance of integrating supply chain management principles within project-based environments, shedding light on the factors contributing to successful SCM implementation in projects.

2.1.4 Time Management

Time management in construction projects involves the efficient allocation and utilization of time resources to ensure that project activities are completed within specified deadlines. It encompasses project scheduling, task sequencing, resource allocation, progress tracking, and schedule optimization. The success of the project highly depends on the appropriate implementation of time management procedures within the project team.

Time management, within the PMBOK framework, is mentioned as a crucial aspect of effective project management. It encompasses processes and activities aimed at ensuring a project's completion within the scheduled timeframe. This involves planning how the schedule will be created, defining tasks, sequencing activities, estimating durations, developing a detailed timeline, and controlling the schedule throughout the project. Effective time management in PMBOK [35]ensures projects are on track, avoiding delays and disruptions, and **is ess**ential for successful project execution.

According to Jason Westland (2006), time management is the process of recording and controlling the time spent by staff on the project. Max Wideman (1990)[38] offers a broader definition, stating that time management is the function required to maintain an appropriate allocation of time to the overall conduct of the project through its successive stages of the natural life cycle (i.e., concept, development, execution, and finishing). This is achieved through processes such as time planning, time estimation, time scheduling, and schedule control.

In essence, time management is all about planning and controlling time throughout all stages of the project, and it plays a vital role in construction project management.

2.1.5 Cost Management

Cost management revolves around strategic planning, meticulous control, and vigilant monitoring of project expenditures. This encompasses a spectrum of activities, vigilant including cost estimation, budget formulation, real-time expense tracking, variance analysis, and the execution of measures to exercise command over costs. This systematic approach ensures that projects remain faithful to the endorsed budget, curtails the risk of cost overruns, and optimizes the allocation of resources to achieve peak cost-effectiveness.

Aligned with the guidelines set forth in the Project Management Body of Knowledge (PMBOK) 7th edition[35], the project budget materializes from the consensus-based appraisals delineated for the project. The insights delineated pertaining to Estimating are seamlessly applied to the panorama of project costs, thus giving rise to a panoramic vista of cost estimates. The aggregation of these estimates takes the form of the cost baseline, a foundational cornerstone in project fiscal management. This bedrock of cost data is frequently apportioned across the tapestry of the project timeline, ingeniously mirroring the moments when these financial outlays will come to fruition. This strategic maneuver equips project managers with the ability to harmonize the fiscal resources allocated within a stipulated budgetary span with the choreographed cadence of project tasks.

If fiscal constraints encircle a specific budget phase, nuanced coordination of work rescheduling can be strategically orchestrated to harmonize in sync with these financial limitations.

Cost management revolves around strategic planning, meticulous control, and attentive monitoring of project expenditures. This systematic approach ensures that projects remain faithful to the endorsed budget, curtails the risk of cost overruns, and optimizes the allocation of resources to achieve peak cost effectiveness. (Project Cost Management – Global Issues and Challenges Dr. Peter Smitha 2014)

2.1.6 Risk Management

Risk management in construction projects involves identifying, assessing, and managing potential risks and uncertainties that may impact project objectives. The construction process of a construction project is actually a process full of uncertainty and risk. Effective risk control will be one of the key elements for the success of construction project management, especially considering the long duration, involvement of many participating units, and complex environmental impacts. Any one of the activities or changes in any party involved in the project construction can affect the activities of the relevant parties.

Risk management in PMBOK [35]is defined as a systematic process of identifying, analyzing, and responding to project risks to ensure project success. It involves assessing risks, developing strategies to mitigate or exploit them, and continuous monitoring and control throughout the project.

Risk management encompasses activities such as risk identification, risk analysis, risk mitigation planning, and risk monitoring. By effectively implementing risk management practices, construction projects can minimize the likelihood and impact of potential risks, ensuring project success and reducing the possibility of unexpected events or disruptions. ["Perspective on Supply Chain Management for Construction Engineering Management Risk Prevention" by Luoer Liao]

2.1.7. Construction Projects

In both developed and developing countries, the construction industry can be defined as the sector of the economy that, through planning, design, construction, maintenance and repair, and operation, transforms various resources into constructed facilities ranging from residential to nonresidential facilities that play critical roles in the development process (Moavenzadeh & Rossow, 1975). Civil engineering projects, such as transportation infrastructure, power projects, irrigation, drainage, and water supply, may account for up to half of overall building production in developing countries. Housing accounts for less than a third of the overall output, with the remainder going toward the development of schools, factories, offices, hotels, and hospitals, among other items (Wells, 1986). Owners, architects, engineers, quantity surveyors, project managers, construction project managers, and general contractors include special trade subcontractors, domestic subcontractors, selected subcontractors, and all other project participants such as laborers, plant operators, and the like.

The construction sector is recognized as a crucial participant due to the vast range of economic and social demands it meets, as well as the considerable contribution it contributes to the achievement of several main national goals. In essence, it is a service industry that obtains its inputs and outputs from sources outside its sector, with which it is frequently and complexly interrelated **(**Salleh, 2009; Moavenzadeh & Rossow, 1975). The development of the construction industry is an essential engine that supports growth because it contributes significantly to GDP, and its capacity and effectiveness to meet the demand of the national economy for physical infrastructure is an indicator of economic performance (Tanzanian Construction Policy, n.d.).

The importance of building is derived from its contribution to national employment and the development of built infrastructure, both of which are essential to a nation's development. UNIDO (1993).

2.2 The Theoretical Foundations

2.2.1 ISCP and Time Management (TM)

In the study by Cornelia Droge, ISCPA's impact on Time Management (TM) is evident. ISCPA, encompassing both external strategic design integration and internal design-process integration practices, significantly enhances time-based performance.

Integrated Supply Chain Platform Adoption (ISCPA) is intrinsically linked to Time Management (TM) in construction projects. Drawing from the insights of Mandičák et al. (2021)[39], it is evident that supply chain platforms in construction leverage big data and technology to streamline operations, ultimately influencing project timelines positively. As elucidated by Hatmoko (2006)[40], these platforms wield significant influence by mitigating delays. Without them, supply chain issues can cause median delays of up to 67 days, equivalent to a staggering 22% of the project's duration. The primary culprits include material

flow, labor allocation, and information dissemination. Particularly noteworthy, sourcing materials alone can result in a median delay of 14 days, equivalent to 5% of the project's duration. However, Hatmoko's findings emphasize that leveraging supply chain platforms to facilitate subcontracting can lead to a remarkable 45% reduction in median delays, underscoring their pivotal role in enhancing project efficiency[40]. Thus, the adoption of integrated supply chain platforms contributes significantly to effective time management in construction projects.

2.2.2 ISCP and Cost Management (CM)

According to Peter Kelle's article, "The role of ERP tools in supply chain information sharing, cooperation, and cost optimization," Integrated Supply Chain Platform Adoption (ISCPA) emerges as a pivotal element for cost management within supply chains. ISCPA, an integral aspect of ERP systems, facilitates efficient data exchange among supply chain partners, enabling them to minimize overall supply chain costs. The article highlights the potential for cost optimization through ISCPA and offers quantitative insights.

The nexus between Integrated Supply Chain Platform Adoption (ISCPA) and Cost Management (CM) within construction projects is of paramount importance. As established by Mandičák et al. (2021)[39], supply chain platforms in construction leverage big data and technology to streamline operations, ultimately contributing to cost minimization. Furthermore, Hatmoko's research (2006)[40] highlights that these platforms play a significant role in mitigating delays, which, in turn, impact costs. Without supply chain platforms, projects can experience substantial delays, equivalent to a significant portion of the project's duration. Material flow, labor allocation, and information dissemination emerge as critical cost drivers. Particularly striking, difficulties in sourcing materials alone can result in cost escalations of 5% of the project's budget. However, Hatmoko underscores that harnessing supply chain platforms to facilitate subcontracting can lead to substantial cost reductions. These findings emphasize the positive relationship between ISCPA and CM, affirming that integrated supply chain platforms are instrumental in optimizing cost management in construction projects.

2.2.3 ISCP and Risk Management (RM)

The relationship between Integrated Supply Chain Platform Adoption (ISCPA) and Risk Management (RM) in construction projects is a crucial aspect of project success. Mandičák et al[39]. (2021) highlight that supply chain platforms in construction, enriched by big data and technology, enhance project management integrity, ultimately mitigating risks. Concurrently, Hatmoko's research (2006)[40] underscores that these platforms significantly impact project efficiency by reducing delays, a factor intricately linked to risk management. Delays can trigger an array of risks, from cost overruns to contractual disputes. Thus, the adoption of integrated supply chain platforms enhances risk management by providing real-time visibility into the supply chain, enabling proactive risk mitigation measures, and ensuring smoother project execution. In essence, ISCPA contributes positively to risk management, enhancing the resilience and overall success of construction projects.

In the study titled "Enhancing Risk Management in a Changing World: The Impact of Integrated Supply Chain Platforms," Agustina Calatayud underscores the importance of a

connected supply chain and its significantly impact on smooth and continuous flow of materials, information, and finances. Calatayud identifies two primary drivers of this connectivity: information systems and physical infrastructure. The connectivity of information systems facilitates real-time risk detection, prevention, and swift responses, thanks to emerging digital technologies such as IoT, blockchain, and AI. Likewise, physical connectivity, dependent on infrastructure and logistics, is crucial for minimizing delays and disruptions.

2.3 Gaps in the existing literatures

Based on previous studies and literature, several notable gaps in the existing literature related to Integrated Supply Chain Platforms (ISCPs) and their impact on European construction project management are identified:

- **Comprehensive Studies**:

Existing literature lacks comprehensive studies specifically focused on the impact of ISCPs on project management criteria (time, cost, and risk management) in construction projects across European countries. Previous research often examines isolated aspects of supply chain or project management, neglecting the holistic impact of ISCPs.

- **Limited Empirical Studies:**

More empirical research is needed to analyze real-world implementations of ISCPs in construction projects. Empirical studies can provide valuable insights into the actual effectiveness of ISCPs and their influence on project outcomes in diverse European contexts.

- **Nordic-Specific Studies**:

Further research should focus on the unique characteristics, regulations, and practices within European countries that may influence the adoption and effectiveness of ISCPs in construction projects. Understanding country-specific factors is essential for successful ISCP integration.

Few studies compare different supply chain software solutions or ISCPs in terms of their impact on project management criteria. By directly comparing the effectiveness of various ISCPs, researchers and industry professionals can better understand which platforms are most suitable for specific project types or contexts.

- **Risk Management:**

More research is needed to explore how ISCPs specifically impact risk management in construction projects, including enhancing risk identification, analysis, and mitigation strategies. This study aims to address these gaps in the existing literature by focusing on the impact of ISCPs on project management criteria in Nordic construction projects. Through empirical insights and consideration of the Nordic context, including risk management implications, this research seeks to enrich the understanding of ISCPs' influence on construction project management practices in Europe.

Chapter 3
Research Methodology and Design

In this chapter, we review existing research methods and adopt the one that best suits our current research. Later, we discuss the steps that we have taken to use the selected method in our research.

3.1 Research methods overview

Collis and Hussy argue that research can be divided into four categories: rationale, process, purpose, and outcome. If the research is shifting from specific to general or vice versa, it will be expressed in the rationale. The research can be categorized as either inductive or deductive under this heading. The second category is the procedure, which describes the procedure for gathering and analyzing data. The research can be categorized as either qualitative or quantitative under this heading. The purpose, or the rationale for undertaking the research, is the third category. Those classifications include analytical, descriptive, predictive, and exploratory. The fourth category, research outcome, indicates whether a study is aiming to further knowledge or address a particular issue.[8]

Explanatory or analytical research extends descriptive research by seeking to explain phenomena through measurement and comprehension of their interconnections. This method of analysis expounds upon and delineates the reasons and mechanisms underlying various occurrences. In this category, the most fitting questions are "why" and "how."

Descriptive research endeavors to discern and categorize distinctive details pertaining to a specific matter or concern. This type of study aims to identify events in their natural state. The following questions are appropriate: "where," "how much," "how many," "what," or "who."

The goal of predictive research is to make the use of information from analysis simpler by anticipating a particular phenomenon based on a hypothesis. In other words, the goal of this kind is to calculate the likelihood of an event. Questions like "where," "what," "who," "how many," and "how much" are appropriate.

Exploratory research looks for theories, concepts, or patterns. When there are only a few researches to refer to, this research is used. What are the right questions to ask for this type of research? Why? How? How much? How often? Where?

3.1.1 Quantitative and qualitative research

Research can be divided into qualitative and quantitative categories depending on the methodology. According to Creswell (2009), quantitative data is an approach to research where the researcher uses positivist claims to: develop knowledge based on prior investigation, which can be seen in particular in (i.e. use of observation and measurement, cause and effect thinking, test of theories, reduction to specific variables, and hypothesis with questions), employ investigation strategies and inquiry (i.e. surveys and experiment), and also collect data on preexisting conditions. With the use of numerical data collection, analysis, and testing, this kind of research aims to comprehend a certain phenomenon (Creswell, 2009). This strategy is deductive, which may be better suitable for mature or specialized study fields.

According to Creswell (2009), qualitative research is defined as "a research where the inquirer regularly makes knowledge claims, mainly founded on constructivist perspectives"

(i.e. meanings socially and historically constructed, the multiple meanings of individual experiences, with the intention of developing a pattern or theory). In terms of analyzing and considering perception in order to gain a deeper knowledge of human and social activities, this research may be more subjective. This strategy might be more appropriate for less well-developed topics and fields of study that are ambiguous or still confusing and need explanations for why and what (Yin, 1994).

Along with the ideas already discussed, Creswell (2009) also contributed a mixed approach. This technique of inquiry is "where the researcher is inclined to base claims of knowledge claims on practical grounds (e.g. pluralistic, problem-centered, consequences-oriented,)" according to the definition given by the author. The mixed approach allows for techniques for study that call for collecting data sequentially or concurrently and, using numbers paired with text-based information, in order to have a better knowledge of the research problem. A more thorough explanation of these three strategies may be found in table 13.

3.1.2 Inductive or deductive research

Deductive or inductive research might be used to describe the study. According to Collis and Hussy (2013), deductive research is a study in which a theoretical and conceptual framework is created, verified by experimental observations, and then specific examples are drawn from generalizations, moving from the general to the specific. Inductive research, in contrast, moves from the specific to the general based on observations of experimental reality.

Table 1: Research main classifications (Collis and Hussey, 2013)

Research type	Classification base
Inductive or deductive research	Logic of the research
Qualitative or quantitative research	Process of the research
Analytical, descriptive, predictive or exploratory research	Purpose of the research
Basic or applied research	Research outcome

3.2 Research Approach and Strategy

The systematic empirical exploration of quantitative qualities, phenomena, and their interactions is referred to as quantitative research. According to Mouton (1983, referenced by Brynard et al. (2014) and Anonymous (n. d.), it is related to analytical study and aims to reach a universal conclusion.

Quantitative research is based on generating the research hypotheses and empirically testing them on a particular set of data because it is deductive and particularistic in character (Frankfort-Nachmias & Nachmias, 1992). Its goal is to create and apply mathematical theories, models, and hypotheses related to the phenomenon.

Additionally, it tests variables on a sample of people and expresses the link between variables using effect statistics like correlations, relative frequencies, or variations between means: its emphasis is mostly on testing theory. The quantitative research method, which applies techniques from the physical sciences to ensure objectivity, generalizability, and reliability, is thought to be appropriate in situations where it is possible to measure the variables of interest, form and test hypotheses, and draw conclusions from samples of the population (Liebscher, 1998; Weinreich, 2006). Data is created by counting and measuring things or objects.

In quantitative research methodology, the researcher is regarded as being external to the actual research, and regardless of who does the research study, the results are assumed to be replicable. The ability of this paradigm's approaches to generate accurate and quantitative data and their generalizability to a larger population are some of its strengths. In order to assure impartiality, generalizability, and reliability, quantitative research employs techniques adapted from the physical sciences, according to Weinreinch (2006).

In order to ascertain the perception of ISCPs in the construction industry, the advantages of implementing an ERP system in a construction firm, the key impacts on project management criteria, time, cost, and risk, as well as the overall performance of the project, the study adopted a quantitative research approach. It also sought to ascertain whether the outcome of the ISCPs could differ if they were used by different companies in different European countries.

Experiments and surveys are required in quantitative research to characterize and explain the phenomenon being studied. According to Hittleman and Simon (1997), quantitative research uses methods like quantitative analysis and questionnaires, initial investigation, observations, and experiments to collect data that is revised and tabulated in numbers, allowing the data to be characterized by the use of statistical analysis. Based on this, the researchers disseminated a questionnaire survey to participants in the current study in order to collect primary data, which served as the major data used for the analysis. The following criteria for choosing this approach to gathering primary data were endorsed by Kealey and Protheroe (1992) and De Vos et al. (2004):

- Gives an account of characteristics with precision;
- Covers large portions of the sample population in relatively short periods of time;
- Minimizes or eliminates subjectivity of judgement; and
- Uses a standardized research design according to a fixed procedure which can be replicated.

3.2.1 Targeted Population

Kothari (2004) states that all items in any field of inquiry constitute a “universe” or “population”. For purposes of sampling, a population does not refer to the population of a country but to objects, subjects, phenomena, cases, and events that the researcher wishes to research in order to establish new knowledge (Brynard et al., 2014). A population refers to a group in the universe that possesses specific characteristics—the universe being all subjects who possess the attribute in which the researcher is interested, e.g. The total number of

inhabitants in the country who possess a post-graduate qualification. The targeted respondents that made up the population that was sampled for this study were

Mainly Project managers or other managers such as construction managers, construction project managers, logistics managers, civil engineers, and other professionals who are involved in construction projects in European countries, namely Italy, Germany, and Ireland. The list of the companies was taken from the internet directories that contained firms who are active in different sectors of the construction industry, from suppliers to consultants and developers. In order to have the maximum inclusion, no preliminary screening based on the size of the firm or the value of the projects that they perform were made.

3.3 Model Development

In the process of developing the model for this study, several key parameters were considered; each represents a critical aspect of the research and contributes to the overall understanding of integrated supply chain platform adoption (ISCPA) in the context of time management (TM), cost management (CM), and risk management (RM) within construction projects. Based on these parameters and their interactions and relations, we define our variables and build our model, and then we check if the data supports our model or not.

3.3.1 Integrated Supply Chain Platform Adoption

This subsection delves into the concept of Integrated Supply Chain Platform Adoption (ISCPA). It explores the extent to which construction firms adopt and integrate digital supply chain platforms into their project management processes. ISCPA is reflected through indicators that consider factors like technology adoption, information sharing, collaboration, visibility, and transparency.

3.3.2 Time Management

Time Management (TM) is a primary focus within this study. It assesses the efficiency and effectiveness of project scheduling, project delays, and overall project time performance within construction projects. TM is evaluated based on various time-related metrics and indicators, including project duration, critical path analysis, schedule adherence, and time-related deviations.

3.3.3 Cost Management

Cost Management (CM) represents another critical dimension. It assesses financial control and expenditure monitoring within construction projects. CM evaluates how well construction firms manage total project costs, avoid cost overruns, control expenses, and adhere to budgetary constraints. This construct encompasses factors such as cost estimation accuracy, cost tracking, cost overruns, and financial control mechanisms.

3.3.4 Risk Management

Risk Management (RM) is the third major focus, centering on the identification, assessment, mitigation, and response to risks within construction projects. RM can be measured through Risk Exposure (a measure of potential project risks) and Risk Mitigation

Effectiveness (the effectiveness of risk management strategies implemented during the project).

3.3.5 Hypothesis Relationships

In this section, we delve into the intricacies of the hypothesized relationships among our core constructs: Integrated Supply Chain Platform Adoption (ISCPA), Time Management (TM), Cost Management (CM), and Risk Management (RM).

Hypothesized Relationships

H1) **ISCPA and TM**: according to Cornelia Droge, Mandičák et al., and Hatmoko, a higher level of Integrated Supply Chain Platform Adoption (ISCPA) will positively influence Time Management (TM) within construction projects. This hypothesis implies a positive linear relationship between these two variables, where an increase in ISCPA corresponds to an increase in effective Time Management.

H2) **ISCPA and CM**: the studies of Kelle, Mandičák et al, and Hatmoko shows that a greater degree of ISCPA will positively affect Cost Management (CM). In line with this, a positive covariance is anticipated, indicating that as ISCPA increases, Cost Management also tends to increase.

H3) **ISCPA and RM**: Our hypothesis asserts that based on Mandičák et al and Hatomo studies, there exists a positive relationship between ISCPA and Risk Management (RM). This positive covariance signifies that heightened levels of ISCPA align with improved Risk Management practices within construction projects.

Given the overall abovementioned effects of ISPCs on different aspects of the construction projects, a.e. time, cost, and risk, it is acceptable to state that the ISPC adaptation will positively impact the overall project performance in the construction industry.

H4) **TM and CM**: Effective Time Management (TM) is expected to have a positive influence on Cost Management (CM). This implies a positive covariance, indicating that proficient Time Management corresponds to better Cost Management practices.

H5) **RM and TM**: We propose that adept Risk Management (RM) can enhance Time Management (TM). A positive covariance between RM and TM indicates that improved Risk Management tends to coincide with more effective Time Management within construction projects.

H6) **RM and CM**: Risk Management (RM) and Cost Management (CM) are intertwined. Proficient Risk Management is anticipated to have a positive impact on Cost Management by preventing incurred costs due to risks that become reality. This implies a positive covariance, signifying that as RM improves, so does CM.

H7) **ISCPA and Overall Performance:** we hypothesize that the adaptation of the ISCP will result in a better performance overall, through affecting time, cost, and risk managements. This influence would be indirect.

Table 2: The proposed impact of the variables

Hypothesis	Relationship	Interpretation
H1	ISCPA ➞ TM	ISCPA positively influences Time management
H2	ISCPA ➞ CM	ISCPA positively influences Cost management
H3	ISCPA ➞ RM	ISCPA positively influences Risk management
H4	TM ➞ CM	Effective time management positively impacts cost management
H5	RM➞ TM	Effective risk management positively impacts time management
H6	RM ➞ CM	Effective risk management positively impacts cost management
H7	ISCPA➞Overall Project Success	ISCP adoption positively influences the overall project performance in the construction industry through time and cost management

3.3.6 Variables and Relationships

Independent variable:

Integrated Supply Chain Platform Adoption (ISCPA)

The construct of Integrated Supply Chain Platform Adoption (ISCPA) encapsulates the extent to which construction firms adopt and integrate digital supply chain platforms into their project management processes. ISCPA is **reflected** through a set of indicators that consider factors like technology adoption, information sharing, collaboration, visibility, and transparency.

Dependent variables

Time Management (TM)

Time Management (TM) is the primary dependent variable in this study, focusing on the efficiency and effectiveness of project scheduling, project delays, and overall project time performance within construction projects. TM is evaluated based on various time-related metrics and indicators, including project duration, critical path analysis, schedule adherence, and time-related deviations.

Cost Management (CM)

Another important dependent variable in the current study is the Cost Management (CM), which represents financial control and expenditure monitoring within construction projects. This construct assesses how well construction firms manage total project costs, avoid cost overruns, control expenses, and adhere to budgetary constraints. CM encompasses factors such as cost estimation accuracy, cost tracking, cost overruns, and financial control mechanisms.

Risk Management (RM)

Risk Management (RM) is a third dependent variable, focusing on the identification, assessment, mitigation, and response to risks within construction projects. RM can be measured by Risk Exposure: A measure of the potential risks associated with the project, and Risk Mitigation Effectiveness: The effectiveness of risk management strategies implemented during the project.

Control Variables:

To isolate the effect of ISCP adaptation, it is desired to include control variables that could also influence cost, time, and risk management in construction projects. Control variables are typically included in SEM to control for potential confounding factors or to explore moderation effects. In the current study, these could include:

- Project Size: The scale and complexity of the construction project since the implementation of ISCP might result differently in the complexity and size of the projects
- Experience of Project Team: The level of experience and expertise of the project management and construction team.
- Adaptation time of ISCP: the more the ISCP has been used by the company, the more the personnel are familiar with its aspects and it becomes part of the routines of the company so, the firms and the projects face fewer problems using it

Research questions

Based on the research problem, the following objectives can be formulated:

Research question 1:

How does the adoption of integrated supply chain platforms (ISCP) in construction projects affect overall project performance and success rate?

Research question 2:

What are the specific time management benefits that construction projects gain when using ISCP compared to conventional supply chain techniques?

Research question 3:

In what ways do construction projects that use ISCP demonstrate more efficient cost management compared to projects that rely on traditional supply chain management techniques?

Research question 4:

How do construction projects that use ISCP demonstrate better risk management than those that rely on traditional supply chain management methods?

Research question 5:

How do construction project managers perceive the effect of time, cost, and risk management on each other based on their experiences of implementing and using such platforms

RQ1 ➞ ISCPA ➞ TM, CM, RM➞ Project Performance.

RQ2 ➞ ISCPA ➞ TM

RQ3 ➞ ISCPA ➞ CM

RQ4 ➞ ISCPA ➞ RM

RQ5 ➞ ISCPA ➞ (TM➞ CM, RM➞ CM, RM➞ TM)

Chapter 4
Data Collection and Analysis

4.1 Data collection approaches

The most frequently used techniques of data collection within the two basic research methods are the following:

- Review of relevant literature
- Interviews
- Questionnaires
- Observation

To successfully carry out this research study, a questionnaire was chosen as the preferred data collection instrument. The questionnaire was designed based on information gathered from the reviewed literature. After it had been approved for data collection, it was then distributed by email and through online data-gathering platforms to various respondents around the targeted area. After the respondents had completed filling in the questionnaire, the researchers gathered and filed the answers.

- INSTRUMENTS OF DATA COLLECTION

The recommended data-gathering instrument for this study was a questionnaire. Questionnaires are regarded as an effective way of gathering a wide range of information from a large number of responders. Questionnaires are defined as a sequence of questions asked of persons in order to acquire statistically meaningful information about a specific topic (Wikipedia, n.d.). According to Burns and Grove (1993), a questionnaire is a printed self-report form meant to elicit information from the subject's written responses. When correctly designed and presented, surveys can be used to make statements about certain groups, individuals, or the entire community (Mofokeng, 2012).

Questionnaires are considered advantageous based on the reason that they give the respondents time to think about the responses to the questions posed to them in the questionnaire. They are easily analyzed and are, in most cases, familiar to the participants; a number of people have had some sort of experience with completing questionnaires, therefore this reduces the participants' uneasiness in participating. Furthermore, questionnaires make it possible for a larger geographical area to be reached. Closed-ended or open-ended questionnaires are available. Respondents in open-ended questionnaires are required to write their responses in their own words. If responders choose, they may submit further information. According to Burns and Grove (1993), in closed-ended surveys, respondents are provided options linked to the research topic that are defined by the researcher. For the portions that require more uniform responses, a closed-ended questionnaire was used; nevertheless, in the initial section of the questionnaire, there is the opportunity to write the answers if the correct answer is not included in the selections.

The questionnaire was created by dividing it into three sections: The questionnaire was also developed in such a way that the participants' anonymity was not jeopardized, since they were guaranteed that their identities would be kept private and would not be published with the research findings. The questionnaire included an expected time to complete the questionnaire, which was calculated through a pilot survey, as well as the researcher's contact information in case the respondents wanted clarification on anything in the questionnaire.

Section one was aimed at extracting demographic data. This is concerned with data such as gender, age, level of education, profession, and so forth, which would assist the researcher with the interpretation of the results. Section 2 of the questionnaire focused on gaining the industry perception of ISCPs. Section 3 was meant to evaluating the possible benefits of implementing ISCPs and their impact on the time, cost, and risk of the projects in a construction firm.

Validity and reliability of data-measuring instruments are crucial to scientific research (Brynard et al., 2014). Thus content, criterion-related, construction, and external validity were carefully observed. Furthermore, attached to the questionnaire were instructions and guidelines for the purpose of guiding the respondents on how to answer the questionnaires.

• SAMPLING

Sampling is a fundamental aspect of research methodology, and it plays a pivotal role in the process of gathering and analyzing data (Brynard et al., 2014; Ashraf & Brewer, 2004). Whether in the fields of social sciences, natural sciences, or even market research, sampling allows researchers to make inferences about a larger population based on a subset of that population. It often happens in research that the population being studied for a particular research study is of such magnitude that it could take the researcher years to complete the research (Brynard et al., 2014). Therefore, the researcher has to select from the population being studied a small group that is still representative of the general population being studied. This small group that represents the larger population is referred to as a sample. Sampling is a technique of selecting willing members of the population and involving them in a study so that the results are representative of the entire population. It is a technique employed to select a small group (the sample) with a view to determine the characteristics of a large group (the population) (Ashraf & Brewer, 2004; Brynard et al., 2014). If selected critically, the sample will present the same characteristics as the large group. This thesis explores the intricacies of sampling techniques, their application in various disciplines, and the critical role they play in the generation of reliable research outcomes.

Sampling is a convenient and cost-effective method for conducting research because it makes studying a representative sample of a population easier than studying the entire population. Also, sampling saves time because studying the entire population can be time-consuming, especially if it is very large or spread out over a large geographical area. Finally, sampling is thought to be a cost-effective method because collecting data from every single element of the population can be very costly, especially when one also takes into account the size of the population and how distributed it is.

In research terms, particularly for the purpose of sampling, ‘population’ does not refer to the total number of citizens in a country. It refers to all objects, activities, phenomena, events, or cases the researcher wishes to study in order to establish new knowledge (Brynard et al., 2014). Therefore, it is important to determine which objects, activities, phenomena, events, or cases are to be considered as a population from which the sample will be selected for the

purpose of the study. It is also important to bear in mind that a larger sample is more representative of the population, making the conclusions to be drawn more accurate. The more heterogeneous a population is, the larger the sample should be (Bless & Higson-Smith, 1995). There are two categories of statistical sampling in social sciences, according to Teddlie and Yu (2007) and Latham (2007), which are indicated as follows:

In the case of probability sampling, we can determine the probability that any element or member of the population will be included in the sample. The advantages of probability sampling is that it enables us to indicate the probability with which sample results deviate in differing degrees from the corresponding population values.

Examples of probability samples:

- Simple random samples
- Stratified random samples
- Systematic samples
- Cluster samples

Non-probability sampling is frequently connected to qualitative research and case study research design. Regarding the latter, case studies frequently concentrate on small samples and are meant to explore a real-world occurrence rather than draw conclusions about the whole population statistically (Yin, 2003). It is not necessary for a sample of participants or cases to be random or representative, but there must be a good reason to include some situations or people over others.

Examples of non-probability samples:

- Accidental or incidental samples
- Purposive samples
- Quota samples
- Snowball samples
- Convenience samples

● Purposive or judgmental sampling is a strategy in which particular settings, persons or events are selected deliberately in order to provide important information that cannot be obtained from other choices (Maxwell, 1996). It is where the researcher includes cases or participants in the sample because they believe that they warrant inclusion

● Quota sampling is a nonrandom sampling technique in which participants are chosen on the basis of predetermined characteristics so that the total sample will have the same distribution of characteristics as the wider population (Davis, 2005).

● Snowball sampling is a nonrandom sampling method that uses a few cases to help encourage other cases to take part in the study, thereby increasing sample size. This approach

is most applicable in small populations that are difficult to access due to their closed nature, e.g. secret societies and inaccessible professions (Breweton and Millward, 2001).

- Convenience sampling is selecting participants because they are often readily and easily available. Typically, convenience sampling tends to be a favored sampling technique among students as it is inexpensive and an easy option compared to other sampling techniques (Ackoff, 1953). Convenience sampling often helps to overcome many of the limitations associated with research. For example, using friends or family as part of the sample is easier than targeting unknown individuals.

In this study, for the purpose of pre-test validity, we have used a convenience sampling method through which we reached out to experts and checked the validity of our questions prior to sending out the questionnaire. On the other hand, for the final submission of the questions, we used a purposive or judgemental sampling method. By definition, in this method the respondents are selected deliberately based on the information that can be taken from them and not the other groups. Here, we aimed our questions at the project manager in the construction industry who is working in Europe and therefore, restricting our responses to those given by the above-mentioned groups.

4.2 Ensuring Validity and Reliability

Statistical Conclusion Validity (SCV)

Statistical Conclusion Validity (SCV) holds a central position within our research endeavors, serving as a critical determinant of accuracy and the derivation of meaningful conclusions from our meticulous data collection and analysis. To fortify the reliability of our findings, we employ a diverse array of statistical methods, including regression analysis and hypothesis testing, which form the foundation of our study.

In the realm of educational research, the overarching significance of validity is incontestable. As articulated by Muijh (2004: 67), validity is the linchpin governing the design and application of measurement instruments, ensuring that the tests we utilize faithfully gauge the constructs they are intended to represent. Furthermore, echoing Latif's insights (2011: 223), valid outcomes obtained through assessments faithfully mirror the true skills and attributes under scrutiny. These observations underscore the profound impact of validity within the sphere of educational research, where the integrity of our findings is pivotal to our comprehension and evaluation of learning and performance.

Appropriate Statistical Methods

The selection of appropriate statistical methods is paramount to align with our research questions. Nayak BK, Hazra A. How to choose the right statistical test.? Indian J Ophthalmol. 2011;59:85–6 indicates that To select the appropriate statistical method, one need to know the assumption and conditions of the statistical methods, so that proper statistical method can be selected for data analysis.

Careful consideration has been given to the statistical techniques that best suit the nature of our data and the specific inquiries we aim to address. These methods encompass regression analysis, hypothesis testing, and other relevant statistical tools chosen to ensure that our analyses closely align with our research objectives.

Ensuring the Robustness of Statistical Conclusion Validity in Research:

"In this study, a series of essential principles are upheld to secure the statistical conclusion validity (SCV) of our findings. Central to this endeavor is our commitment to data quality, where rigorous cleaning and validation procedures are employed to eliminate outliers, missing values, and inaccuracies, reinforcing the reliability and validity of our dataset. Furthermore, we emphasize the determination of an appropriate sample size, conducting power analyses to fortify the robustness of our statistical analyses and enhance the generalizability of our results. We meticulously balance statistical power with resource constraints, making informed decisions about sample size that contribute significantly to the strength and credibility of our conclusions.

Hypothesis testing is a foundational element in our research methodology, driven by well-defined, pre-planned hypotheses that guide our statistical analyses. We meticulously select and outline the appropriate statistical tests in alignment with our research objectives, facilitating objective evaluation. We interpret our results diligently, considering effect sizes alongside p-values to gauge the real-world significance of our findings. The possibility of replication and peer review is also actively considered to bolster the robustness of our conclusions, and our commitment to transparency is unwavering, with clear documentation of statistical procedures and results. By rigorously adhering to these principles and practices, we ensure that our research's SCV remains unassailable, producing findings that are robust, credible, and reliable.

Internal Validity

Instrument Validity

Instrument validity stands as a pivotal determinant in affirming the trustworthiness of our questionnaire as a measure of the constructs under investigation. Our rigorous validation process encompasses various tests, including content validity, construct validity, and criterion-related validity, all aimed at ensuring the questionnaire's reliability and validity.

Content Validity

Content validity is a foundational element of our research methodology, serving to guarantee that the questions within our questionnaire not only exhibit clarity and comprehensibility but also directly pertain to our research objectives. To rigorously assess the content validity of our questionnaire, we meticulously followed these steps:

1. Convening an Expert Panel: An expert panel, comprising professionals with substantial expertise in the fields of construction project management and supply chain platforms, was

convened. Their specialized knowledge was harnessed for a thorough evaluation of our questionnaire.

2. Evaluation on Multiple Dimensions: The expert panel conducted a comprehensive assessment of the questionnaire from various dimensions to gauge its content validity in alignment with our research objectives. Specifically, they deliberated on the following aspects:

Clarity: The language used in the questions was carefully scrutinized to ensure clarity and comprehensibility, with the aim of eliminating ambiguities or confusing language that might hinder respondents' understanding.

Relevance: The expert panel meticulously assessed whether each question had a direct bearing on our research objectives, thus ensuring that the questions centered on topics of genuine significance to our study.

Comprehensiveness: The panel also considered the questionnaire's comprehensiveness, seeking to identify any significant topics or variables that may have been inadvertently omitted.

3. Rating System: To systematize the assessment process, a rating system was implemented for each questionnaire item. Expert panel members were tasked with rating each item's necessity as "necessary," "useful but not necessary," or "unnecessary." Additionally, they provided ratings for each item's relevance, ranging from "completely relevant" to "not relevant."

This rigorous evaluation process enabled us to refine the questionnaire, ensuring its seamless alignment with the focus and objectives of our research. By incorporating expert feedback, we elevated the content validity of our research instrument, thus fortifying the quality and reliability of our data collection process

4.3 Data Collection

In order to test our hypothesis on the effects of the ISCP on the project management in the construction study, we used a questionnaire to run our survey. Based on different literatures, we selected an initial list of the questions that we thought could be asked from our respondents. The initial list was revised to eliminate the subjects that were less relevant to our purpose which left us with 29 questions. In the next step, these questions were revised again and some of them were merged together since they covered almost the same area. One thing that we had in mind was to limit the number of the questions so that we could get more responses since large number of questions are usually left without proper answers and experts do not will to engage in responding such questionnaires. As a result, a questionnaire with 14 main questions on the Likert scale was generated. This questionnaire again was revised based on the opinion of our professors and also some experts who commented on it from different points, including it being right to the point, being concise and also covering the areas of our interest. The questionnaire is composed of 4 sections, the first asking for some

personal information and some of our control variables. Section 2 contains some specific questions about the software that they have used, the third section covers our main questions and in the fourth section, we asked for some additional comments or anything that they wish to add to our current questions. The questionnaire is presented in the Annex A.

Online business directories were used to extract the name, web address and contact details of countries in Norway and Denmark in the construction sector. For some cases direct contact of the project mangers or construction managers were available and in some cases the general firm contact details were shown, in which case if contacting directly the PMs was not possible, in the email we asked them to send it to as many PMs within their firm as possible, to increase the number of the responses and also making sure that these data were answered by the targeted population. Out of the 594 questionnaires sent out, 197 answers were recollected, representing a response rate of 33% per cent. In fact, after closing the data collection phase we received some other responses that we did not include in this study.

The initial cleaning process, eliminated 25 of the responses, mainly because the job position was not related, or they did not used the ISCP in their company or the countries were outside the desired ones.

Table 3: Questionnaire survey summary

Survey responses	Denmark	Norway	Total
Questionnaires sent out	350	244	594
Questionnaires collected	104	88	192
Usable questionnaires	94	78	172
Usable response rate (%)	26.8%	31.9%	28.9%

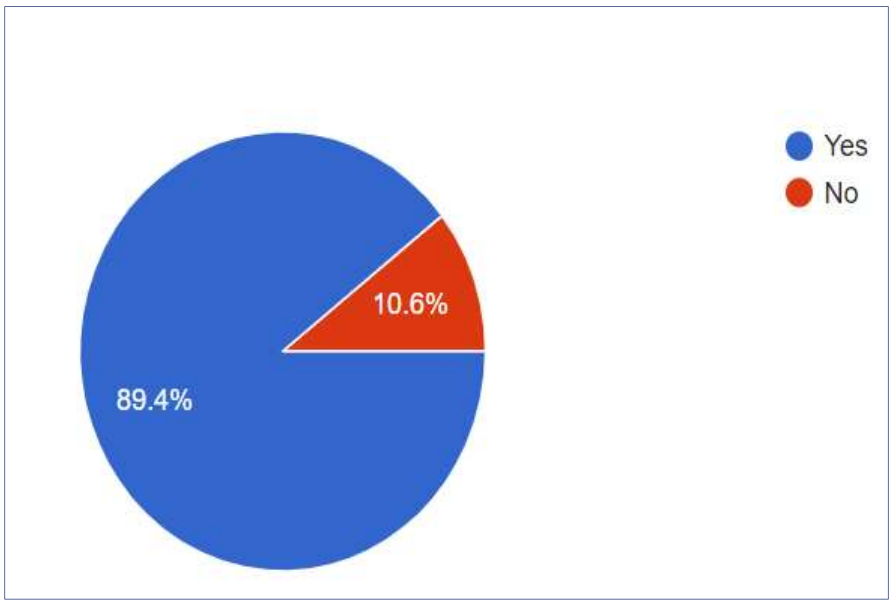

Figure 1: Respondents who are using ISCPA vs. those who are not

Before analysis could be initiated, the collected data from the respondents had to be cleaned and screened. Frequency analysis of the raw data was then done using the AMOS software. One of the reasons that the number of usable responses are relatively high is that all the questions were marked as “Required”, so those we did not have incomplete responses. In the next sections, we analyse the responses and check our hypothesis against the data that we have collected.

4.4 Analysis of Data

4.4.1 Description of Qualitative Variables

Examination of the Characteristics of Qualitative Variables in ISCP Supply Chain Users

In the first stage, we investigate the qualitative characteristics of ISCP users concerning their job position, country, level of work experience, project size, software platforms utilized, and time since such a system has been used in the construction project organization. For each variable, statistical values are calculated, accompanied by graphical analyses for a comprehensive understanding.

- **Job Position**

Analysis of this variable indicates that the job position of users falls into 18 different categories, with the highest frequency belonging to the Project Manager, "PM", job category. The relative frequency of this job category is 61.6%, which is in line with the main objectives of the research. Following that, "project director" has the next highest frequency at 17.4%, and "PM assistant" constitutes the majority of users' job frequencies with 8.1%. This issue is also visually represented

in the chart below. As it can be seen, only the management-related job positions are left in the final data analysis.

Table 4: Job position of the respondents in alphabetical order

	Frequency	Percent	Valid Percent	Cumulative Percent
After Market Director	1	.6	0.6	0.6
Assistant Manager	2	1.2	1.2	1.7
Business Analyst	1	.6	0.6	2.3
CFO	1	0.6	0.6	2.9
Consultant	1	0.6	0.6	3.5
Data Specialidt	1	0.6	0.6	4.1
Engineer	3	1.7	1.7	5.8
Head Of Investor Relations	1	0.6	0.6	6.4
Manager	1	0.6	0.6	7.0
PM	106	61.6	61.6	68.6
PM Assistant	14	8.1	8.1	76.7
Procurement Manager	1	0.6	0.6	77.3
Program Manager	2	1.2	1.2	78.5
Project Coordinator	2	1.2	1.2	79.7
Project Director	30	17.4	17.4	97.1
Project Lead	3	1.7	1.7	98.8
Project Lead Engineer	1	0.6	0.6	99.4
Coordinator	1	0.6	0.6	100.0
Total	172	100.0	100.0	

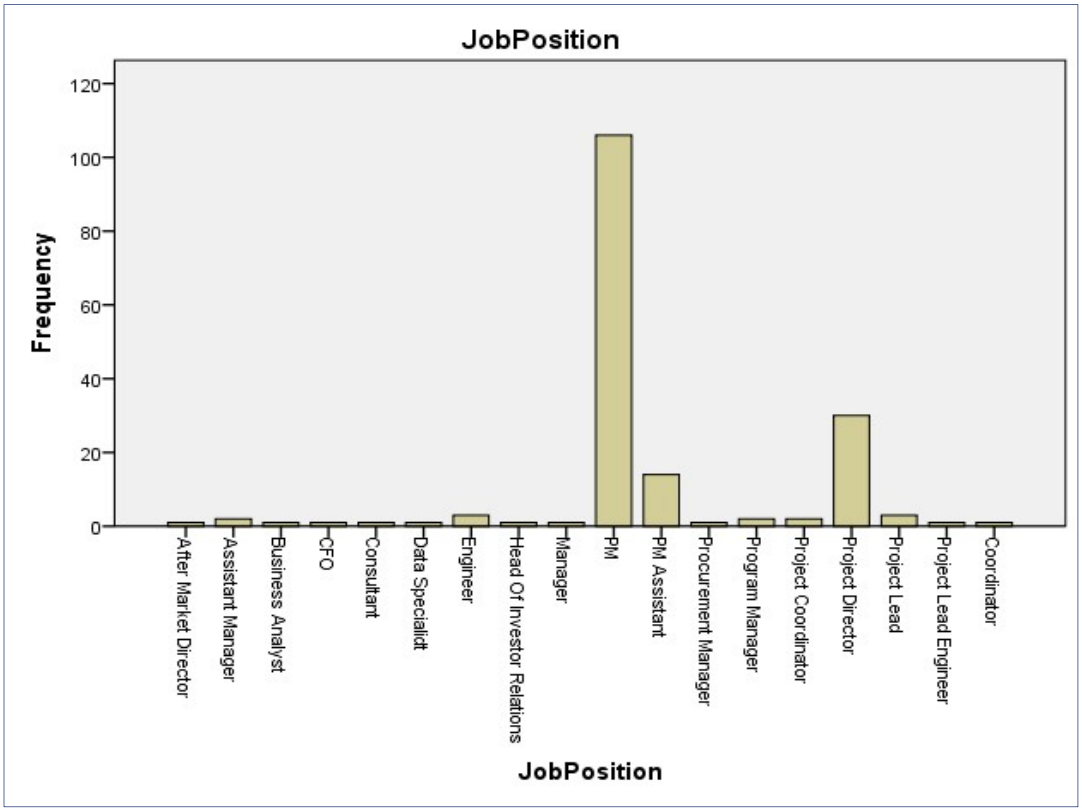

Figure 2:Job position frequencies

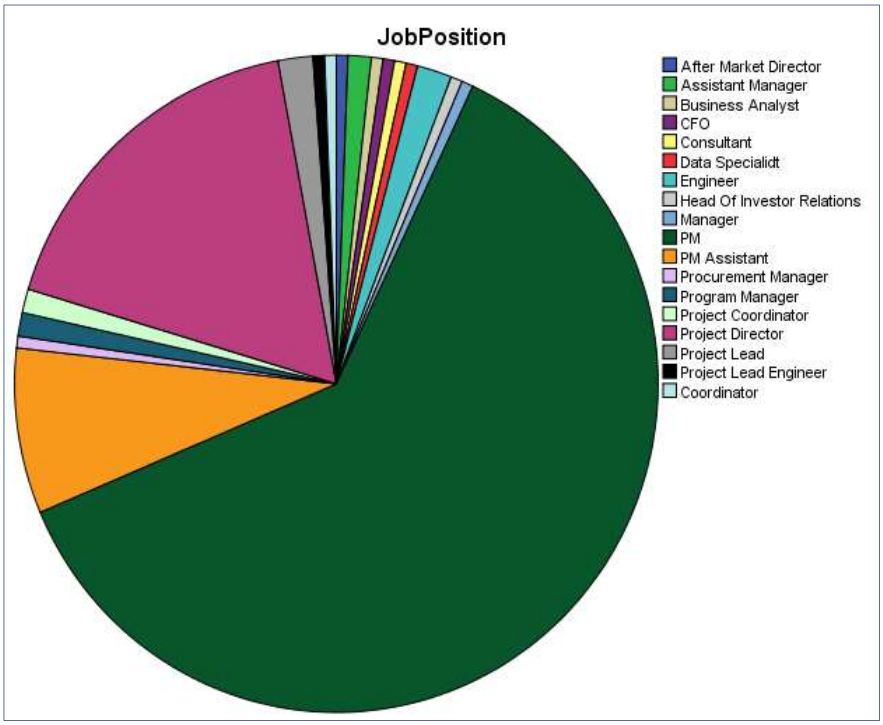

Figure 3: Job position pie chart

➢ Country

Users in this sample study belong to two countries: Norway and Denmark. In fact, since this study is a part of a bigger comprehensive research which deals with conducting the same study in different countries and comparing the results. The current research was aiming at two Nordic countries which could represent those countries and hopefully the result can be compared with the results of other colleagues. According to the frequency table of this variable, more than half of the users are from Denmark, while less than half reside in Norway. It can be roughly stated that the frequency of these two countries in the sample is similar, and this is clearly illustrated in the chart.

Table 5: number of the responses based on each country

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Norway	78	45.3	45.3	45.3
	Denmark	94	54.7	54.7	100.0
	Total	172	100.0	100.0	

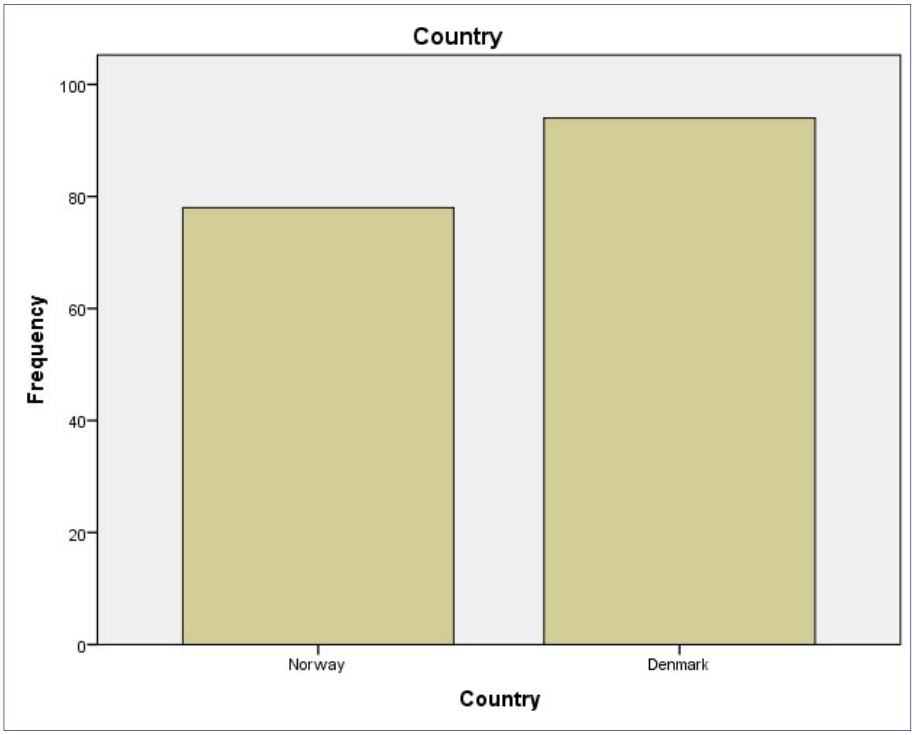

Figure 4: comparison of the number of responses in each country

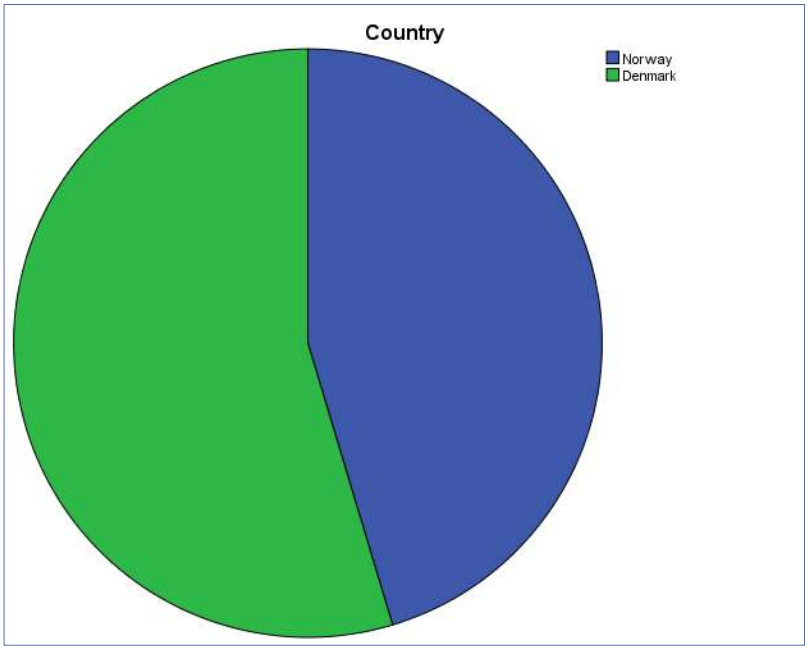

Figure 5: graphical representation of the responses based on the country

- **Experience Level**

Another important qualitative variable in this study is the skill level of ISCP users. The original chart of the experience of the respondents is shown in the figure…. To deal with this variable more conveniently, the users' experience level was categorized into 3 main categories. In this research, users are classified into three skill levels: Junior (between 1 to 4 years of experience), Senior (between 5 to 9 years of experience), and Experienced (10 years and beyond), accounting for 51.2%, 35.5%, and 13.4% of user frequencies, respectively. This implies that the majority of users are at the Senior skill level. A bar (or circular) chart related to this variable schematically illustrates this issue.

Table 6 Experience level of the respondents:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Junior	23	13.4	13.4	13.4
	Senior	88	51.2	51.2	64.5
	Experienced	61	35.5	35.5	100.0
	Total	172	100.0	100.0	

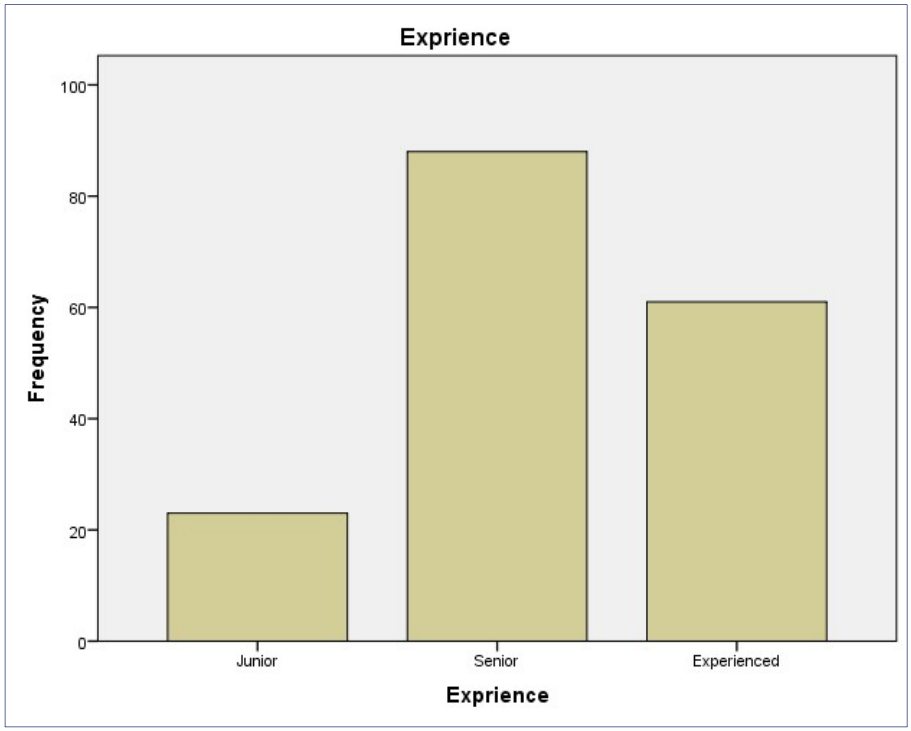

Figure 6: distribution of the experience level based on the categories assigned

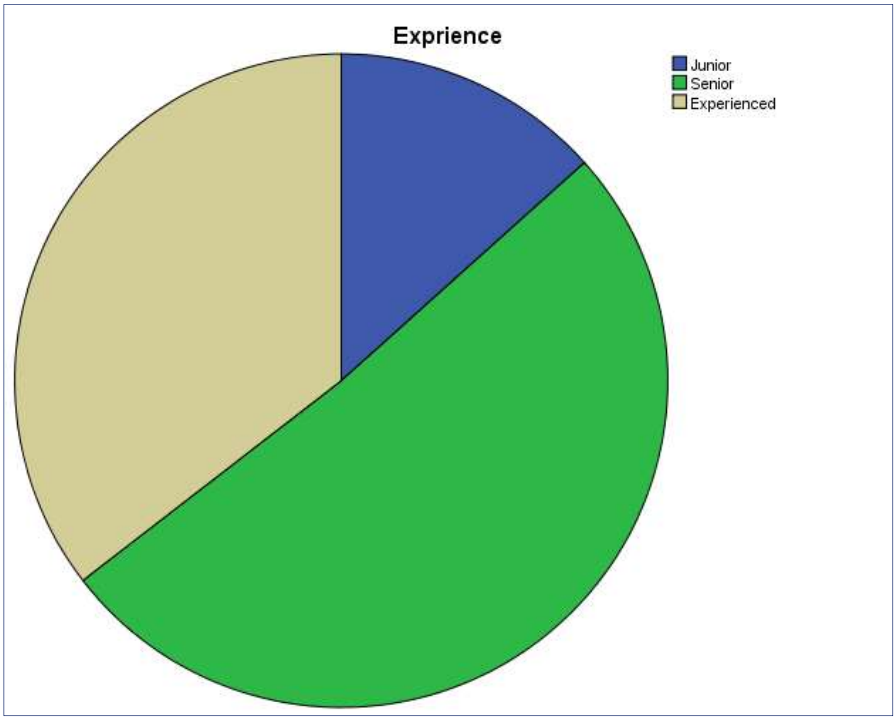

Figure 7: Graphical representation of the experience level of the respondents

➢ Project Size

The size of the projects undertaken by ISCP users is another qualitative variable that seems interesting to examine, and it has been considered in the present study. As seen in the frequency table for this variable, users' projects fall into three categories: Less than 1 M Euros, Between 1 to 10 M Euros, and More than 10 M Euros. According to users, the highest frequency of economic project scale is, in order, in the category Between 1 to 10 M Euros at 44.8%, followed by Less than 1 M Euros at 34.9%, and More than 10 M Euros at 20.3%. here it can be stated that 79.9% of the respondents are managing projects with values less than 10 M Euroes as shown in the following table and figures.

Table 7: Size of the projects in the target population

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 1 M Euros	60	34.9	34.9	34.9
	Between 1 to 10 M Euros	77	44.8	44.8	79.7
	More than 10 M Euros	35	20.3	20.3	100.0
	Total	172	100.0	100.0	

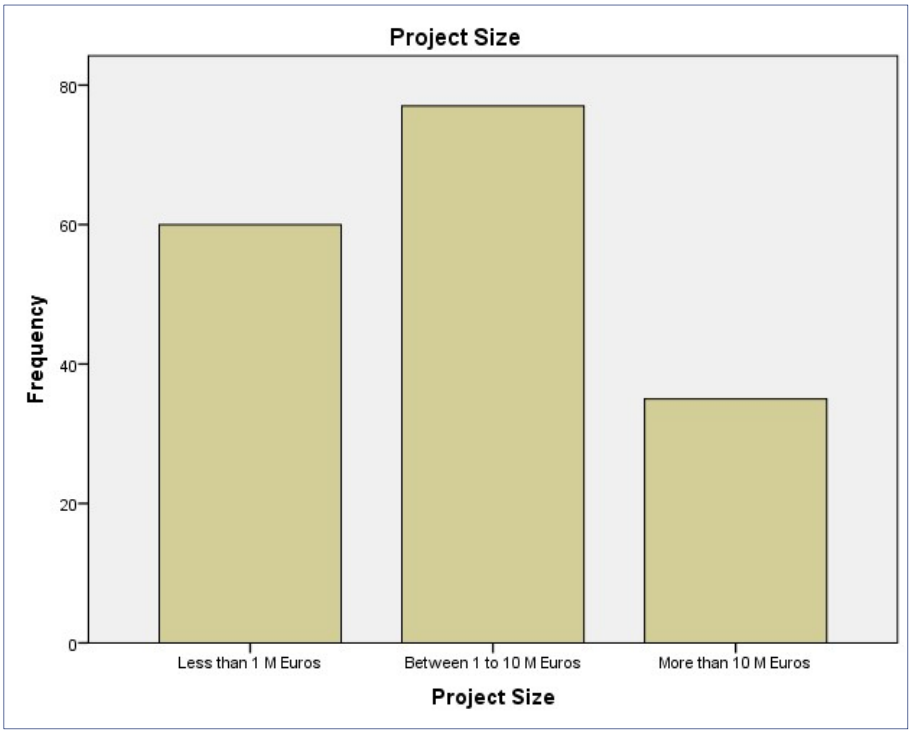

Figure 8: Distribution of the project size in the target population

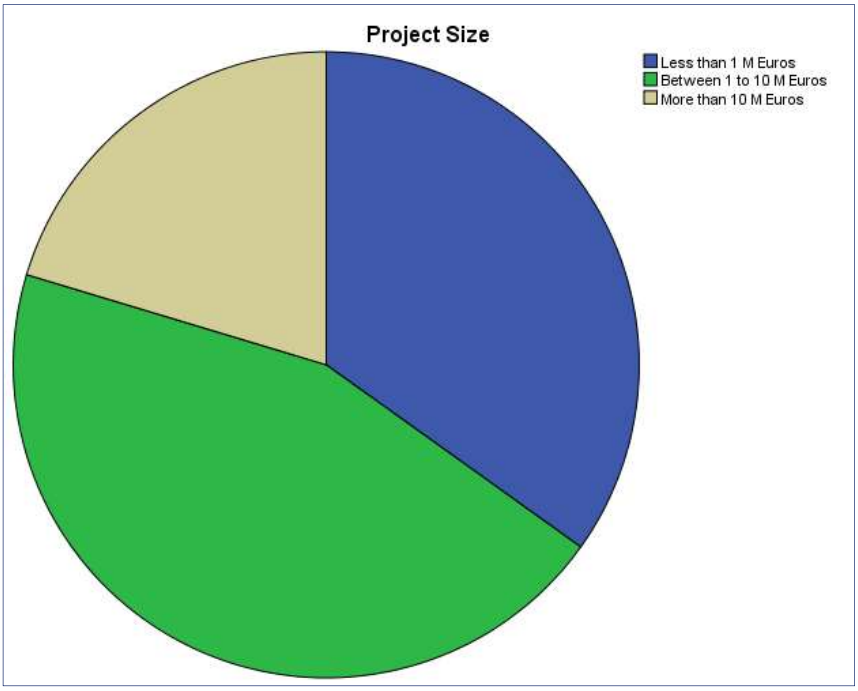

Figure 9: graphical representative of the project sizes

- **Software used**

The next variable under qualitative examination is the Software platforms employed by users to manage the supply chain in their projects. In this study, 142 instances of users have utilized 16 different systems, and in 30 instances, no information has been provided, which is considered missing data. The diversity of the software was good and is a sign that we have the responses of different groups using a diverse range of software platforms to manage their supply chains. Among these systems, Primavera has the highest frequency percentage (12.8), surpassing all other systems used by ISCP users. Following that, Oracle Fusion Cloud and NetSuite, with frequencies of 12.2% and 11% respectively, have garnered the most attention from ISCP users. Subsequently, a bar and circular chart for this variable is presented to schematically understand it.

Table 8: Software platforms used by the project organizations

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Ariba Procurement	2	1.2	1.4	1.4
	Anypoint Platform	1	.6	.7	2.1
	Buyco	17	9.9	12.0	14.1
	Cargoson	1	.6	.7	14.8
	Invent Analytics	10	5.8	7.0	21.8
	Jira	1	.6	.7	22.5

	NetSuite	19	11.0	13.4	35.9
	Oracle Fusion Cloud	21	12.2	14.8	50.7
	Primavera	22	12.8	15.5	66.2
	Procore	1	.6	.7	66.9
	Saas	1	.6	.7	67.6
	SAP	18	10.5	12.7	80.3
	Tipalti	1	.6	.7	81.0
	Transmate	17	9.9	12.0	93.0
	Trimble Connect	1	.6	.7	93.7
	View Point	9	5.2	6.3	100.0
	Total	142	82.6	100.0	
Missing	System	30	17.4		
Total		172	100.0		

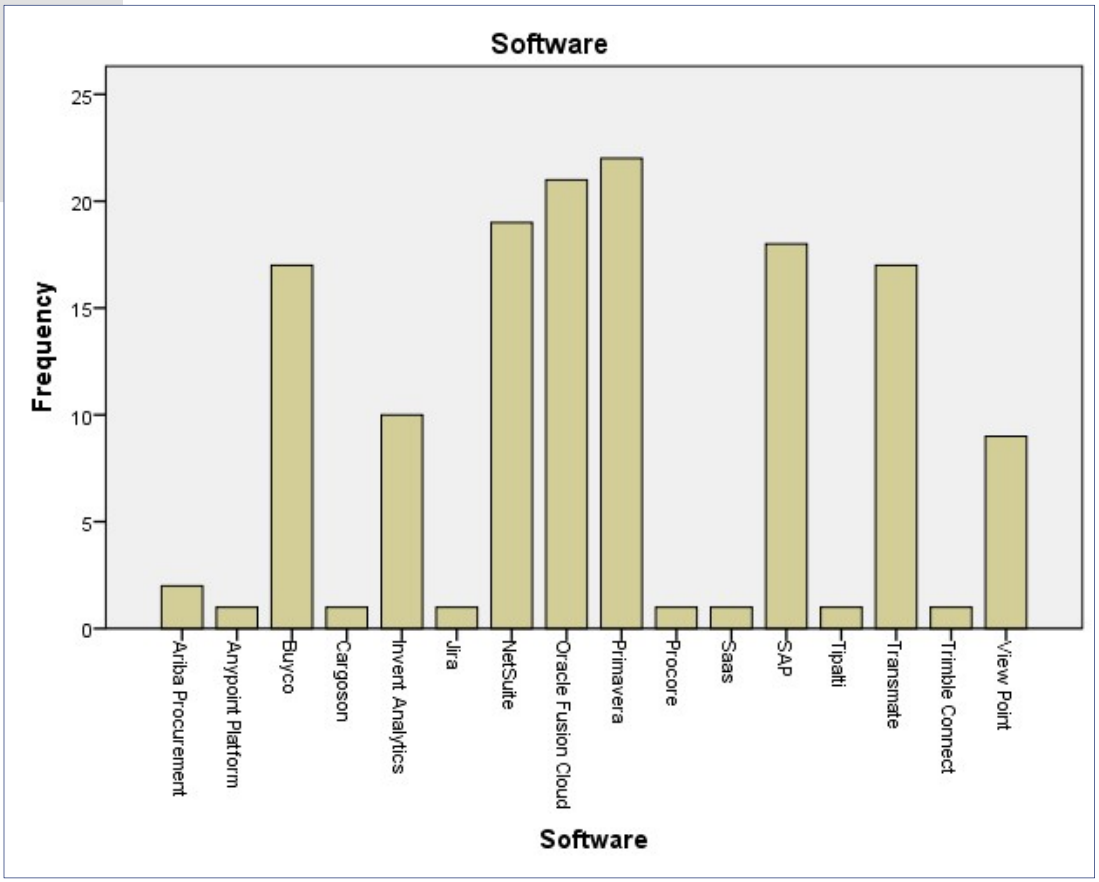

Figure 10: Distribution of the software platforms used by the respondents

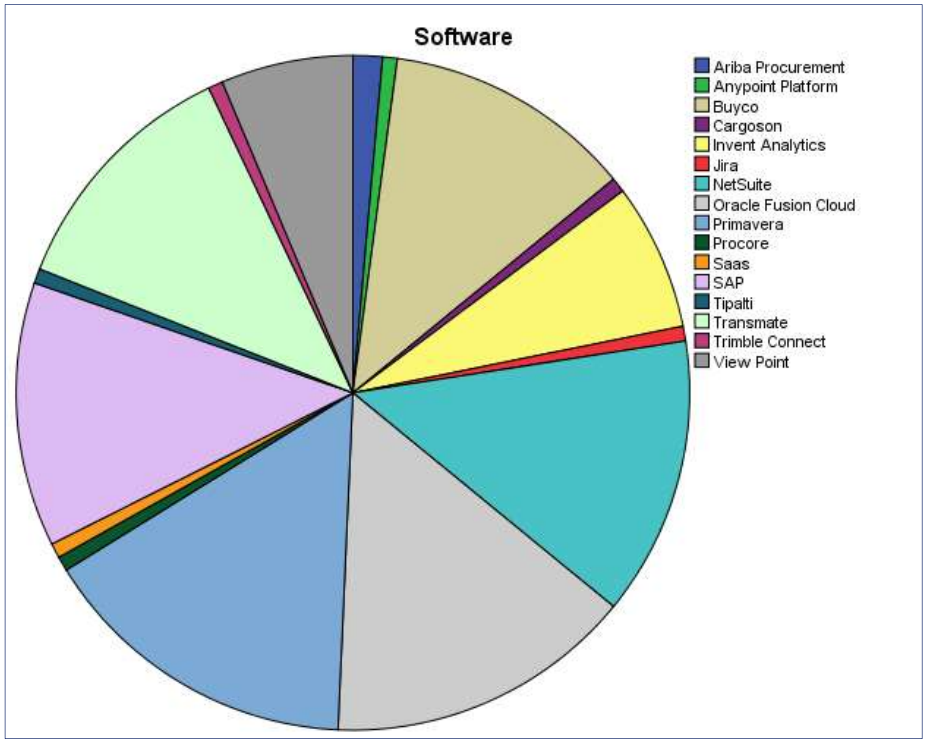

Figure 11: graphical representation of the software platforms being used by the respondents

- **ISCP Adaptation Time**

The duration of ISCP adoption is another crucial variable and has been considered in the present study for its significance. The reason was that we believed the longer the time of the adaptation, the probable hurdles of using and integrating the software being resolved within the organization and people might have a better understanding of the results. For this purpose, the duration of adoption has been categorized into four groups: less than 1 year, between 1 to 3 years, between 3 to 5 years, and more than 5 years. The results from the frequency table indicate that the majority of users, 89.8%, have utilized ISCP for more than 1 year, with the highest adoption period being between 1 to 3 years at 35.5%, followed by between 3 to 5 years at 30.8%. It is noteworthy that the bar chart also illustrates the frequency of each category separately.

Table 9: the adoption period of the current ISCP in the project organizations

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 1 year	18	10.5	10.5	10.5
	1-3 years	61	35.5	35.5	45.9
	3-5 years	53	30.8	30.8	76.7
	More than 5 years	40	23.3	23.3	100.0
	Total	172	100.0	100.0	

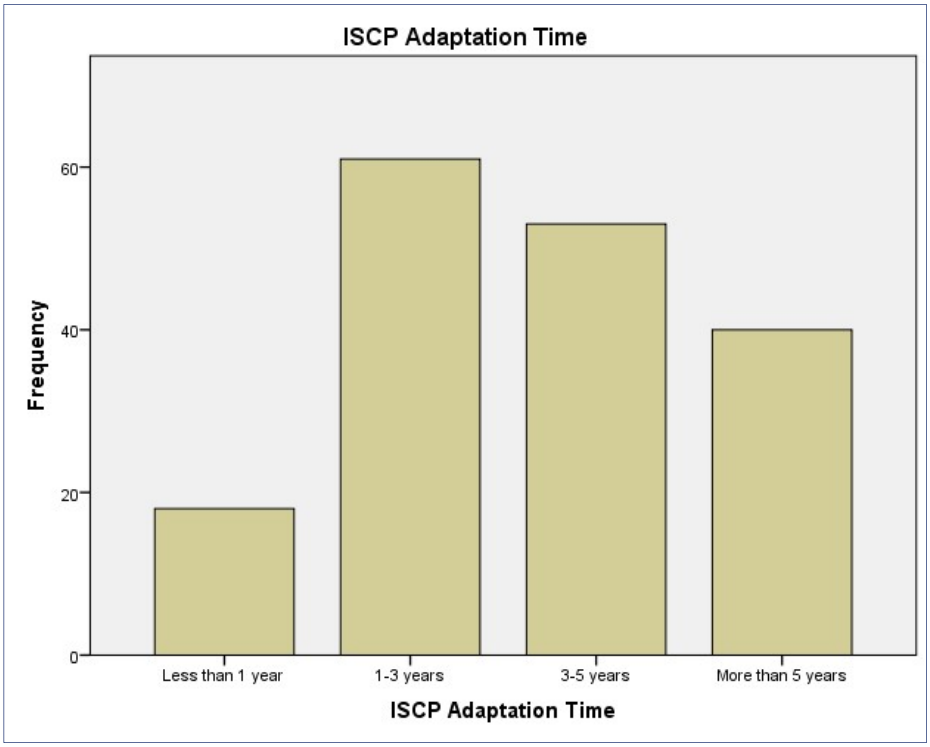

Figure 12: Distribution of ISCP adoption period

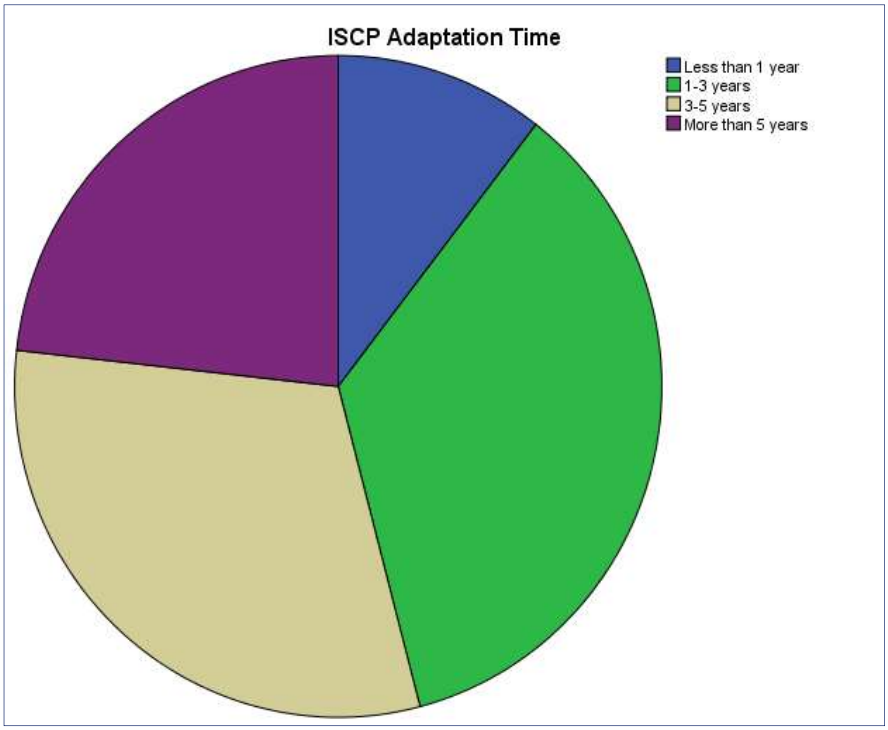

Figure 13: The duration of the adaptation of the ISCP in the organization

4.4.2 Description of Research Variables

In this section, we will examine the statistical analysis of the main research variables. In the current study, three variables—time management, risk management, and cost management—are under investigation. Each of these variables has been addressed through questions in the questionnaire administered to ISCP users. Two additional variables, ISCPA and Performance, have also been assessed through questions in the questionnaire. In this study, we aim to investigate the impact of the ISCPA variable on these three management variables, the impact of management variables on each other, and their collective influence on the overall performance of ISCP users. To achieve this, in the first stage, we present a summary of statistical information for the variables under examination.

Firstly, we will explore the frequency of responses given by ISCPA users to each of the questions, separately for each variable. The chart below illustrates the frequency of responses given by ISCPA users to questions related to project performance. For each question, the number of individuals who provided responses ranging from 1 to 5 is examined, and categorized based on the questions posed. This indicates that, descriptively, ISCPA users have relatively high satisfaction with the improvement of the system's performance, as most users have assigned responses of 4 and 5 to performance-related questions.

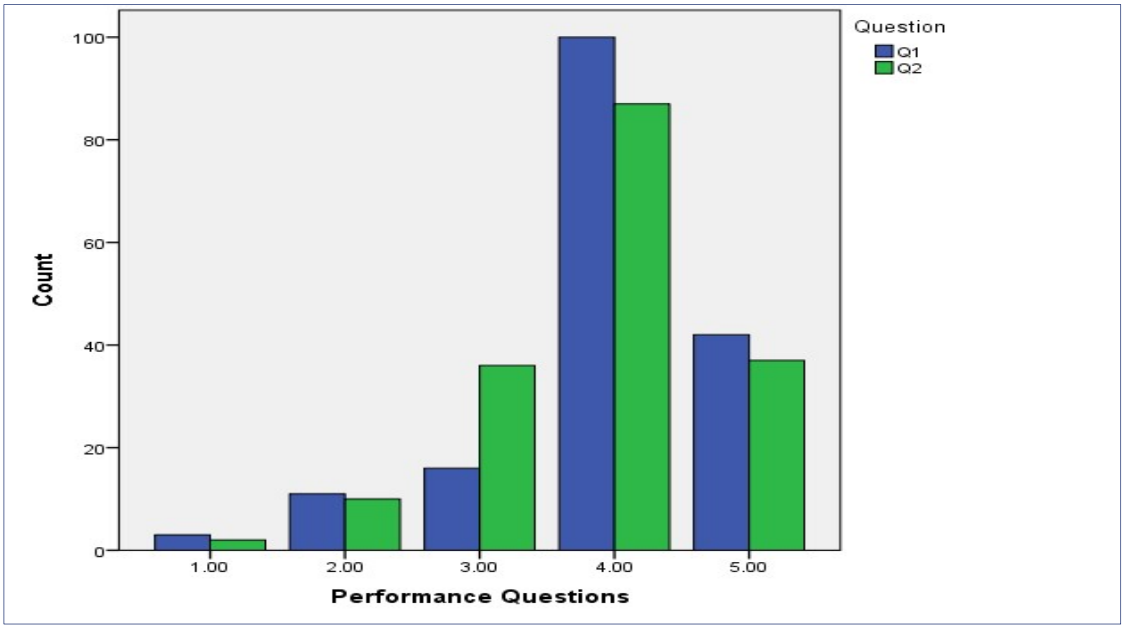

Figure 14: Frequency of responses regarding the overall performance

Figure 15 depicts the frequency of responses given by ISCPA users to questions related to the ISCPA itself. For each question, the number of individuals who provided responses ranging from 1 to 5 is examined, and categorized based on the questions posed. This illustrates that, descriptively, ISCPA users have relatively high satisfaction with the implementation of the ISCPA system, as most users have assigned responses of 4 to the ISCPA-related questions.

Figure 16 below illustrates the frequency of responses provided by ISCPA users to questions related to risk management. For each question, the number of individuals who provided responses ranging from 1 to 5 is examined, categorized based on the questions posed. This indicates that, descriptively, ISCPA users have relatively high satisfaction with the improvement of the system's performance in risk management, as most users have assigned responses of 4 to the risk management-related questions.

The next chart displays the frequency of responses given by ISCPA users to questions related to time management. For each question, the number of individuals who provided responses ranging from 1 to 5 is examined, categorized based on the questions posed. Among these, users have predominantly assigned responses of 4 to questions Q3 and Q5 related to time management. This suggests that, descriptively, ISCPA users have relatively high satisfaction with the improvement of the system's performance in time management. In another question, more responses are from users who did not express specific opinions in this regard.

The following chart, Figure 17, illustrates the frequency of responses given by ISCPA users to questions related to cost management. For each question, the number of individuals who provided responses ranging from 1 to 5 is examined, categorized based on the questions posed. This indicates that, descriptively, ISCPA users have relatively high satisfaction with the improvement of the system's performance in cost management, as most users have assigned responses of 4 to the cost management-related questions.

In the table, a summary of descriptive statistical information related to the main research variables is provided.

Table 10: Summary of descriptive statistical information

	ISCPA	Time Management	Risk Management	Cost Management	Performance
Mean	3.6308	3.6105	3.6725	3.5872	3.9128
Median	3.5000	3.6667	3.6667	3.7500	4.0000
Variance	.601	.507	.446	.357	.454
Skewness	-.503	-.524	-.262	-.423	-.924
Kurtosis	-.153	.092	-.373	-.008	1.642

As observed in the table, the variables do not contain missing information. For each variable, values of mean, median, variance, skewness, and kurtosis are reported. For example, in time management, the mean is 3.61, the median of the numbers is 3.66, and its skewness is reported as 0.092. In the next step, histograms for each of the variables have been plotted. It's noteworthy that a representation of the normal distribution overlay on each of the histograms is also included, serving as a visual tool to inspect the fit of the normal distribution to each variable.

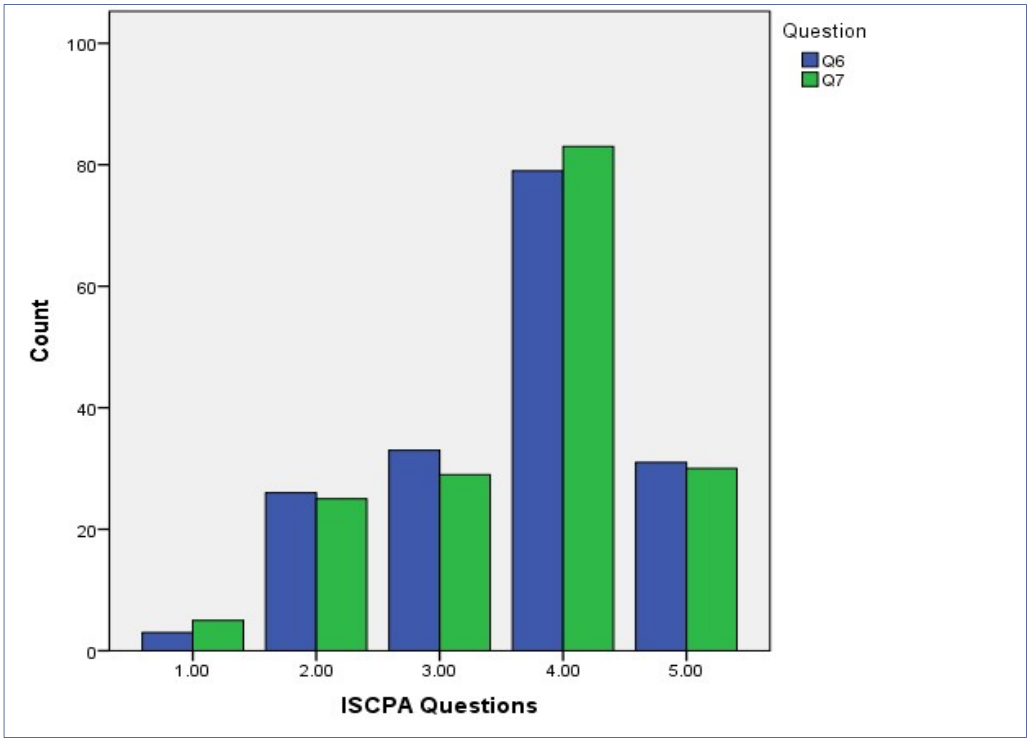

Figure 15: Responses to the ISCP implementation questions

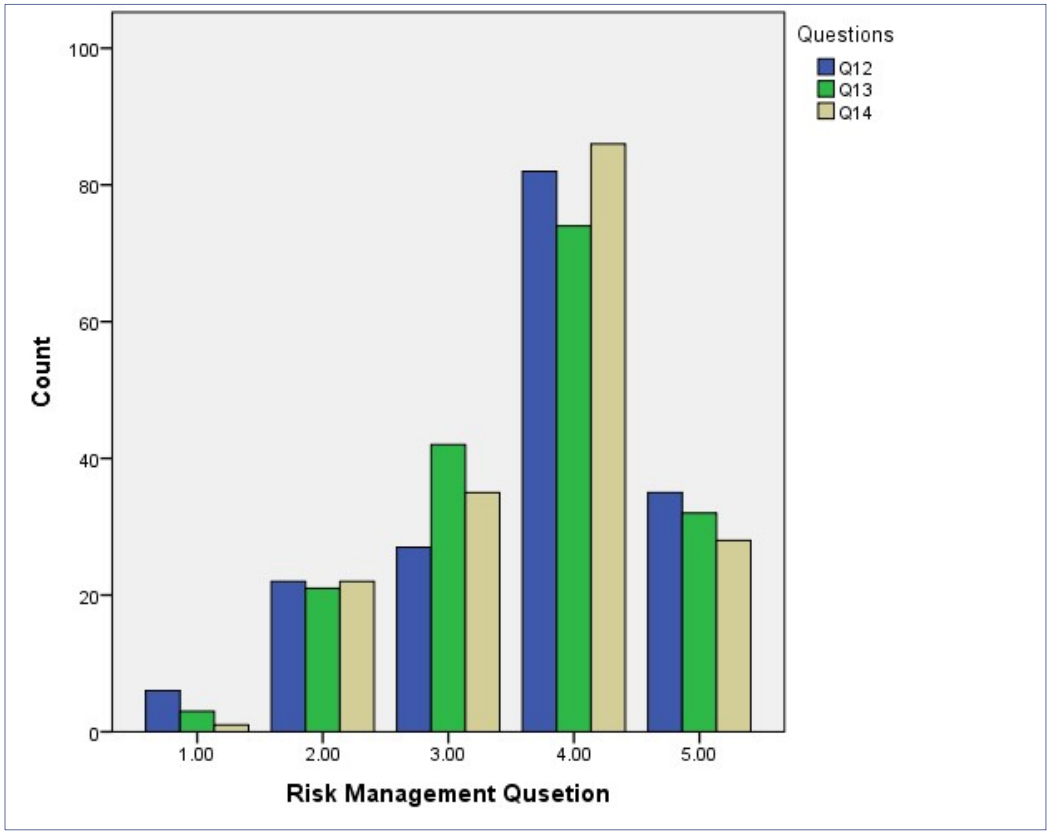

Figure 16: Responses related to the Risk Management questions

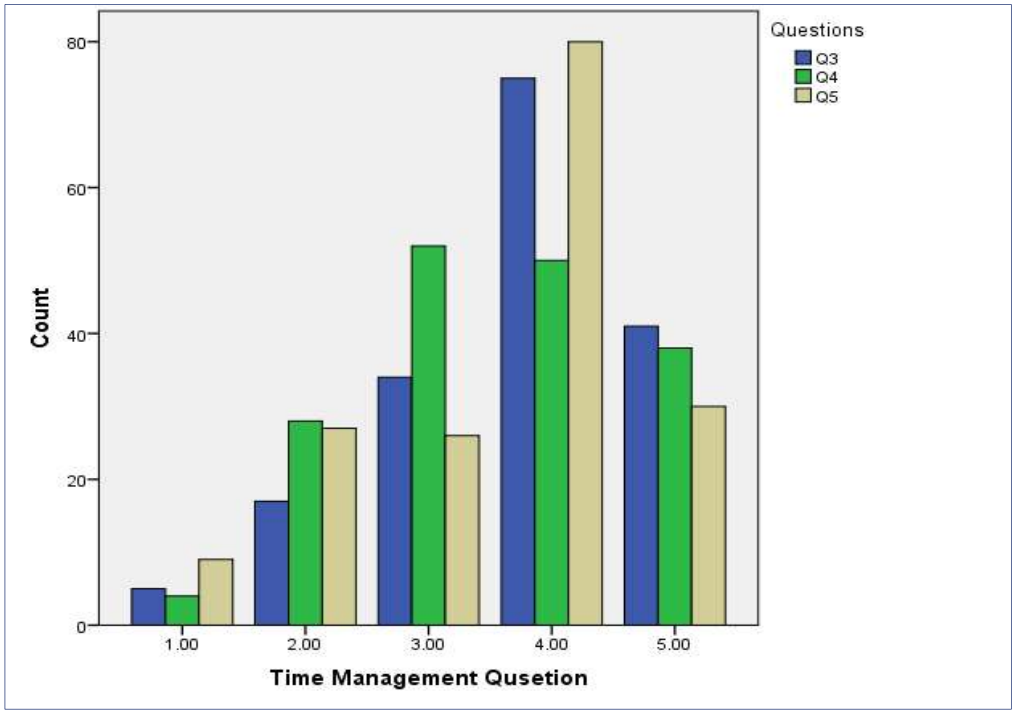

Figure 17: Responses to the Time Management questions

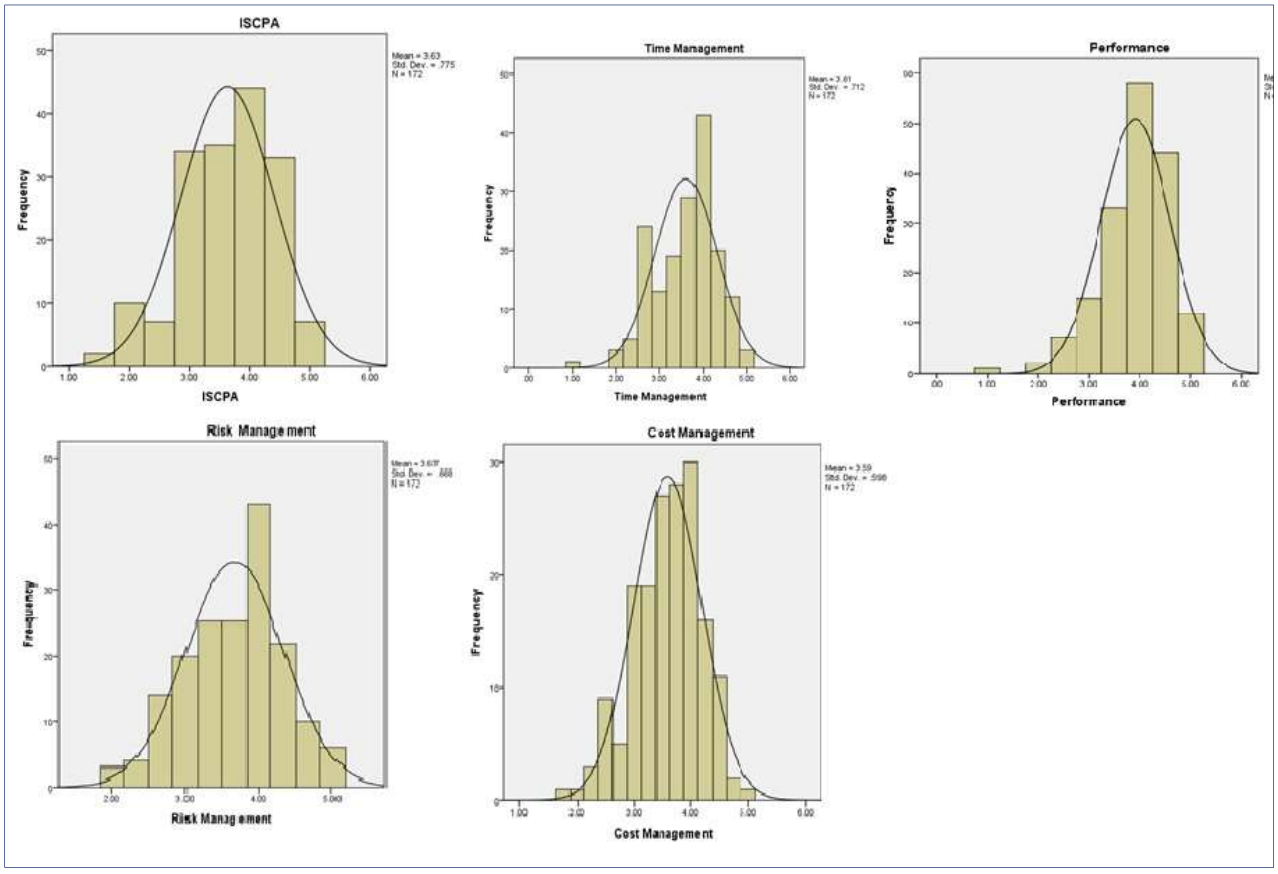

Figure 18: Histogram and normal fitting of the variables

4.4.3 Inferential Findings

Initially, Pearson correlation tests were employed to analyze the statistical significance of the relationships between variables. The Pearson correlation coefficient is a measure of the linear relationship between two variables. In the table below, the correlation coefficients for each pair of variables are calculated, and the P-value for the test of zero correlation between the two variables is provided in each row. This P-value is compared to 0.01 (0.05), and if P-value < 0.01 (0.05), there is sufficient scientific evidence to reject the null hypothesis of no linear relationship between the two variables.

It is noteworthy that a positive correlation indicates a direct relationship (meaning that as one variable increases (decreases), the other variable also increases (decreases)), while a negative correlation indicates an inverse relationship (meaning that as one variable increases (decreases), the other variable decreases (increases)). As shown in the table below, significant relationships between variables at the 0.01 level are denoted with **, and at the 0.05 level with *.

Table 11: Correlation coefficient based on the Pearson test

		ISCPA	Time Management	Risk Management	Cost Management	Performance
ISCPA	Pearson Correlation	1				
	Sig. (2-tailed)					
Time Management	Pearson Correlation	.361**	1			
	Sig. (2-tailed)	.000				
Risk Management	Pearson Correlation	.172*	.435**	1		
	Sig. (2-tailed)	.024	.000			
Cost Management	Pearson Correlation	.261**	.470**	.428**	1	
	Sig. (2-tailed)	.001	.000	.000		
Performance	Pearson Correlation	.397**	.233**	.218**	.262**	1
	Sig. (2-tailed)	.000	.002	.004	.001	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

The analysis of the table above reveals a significant and direct relationship between each pair of variables studied in the research. To analyze the final model, two stages need to be considered. First, measurement models must be examined, and fit indices for each measurement model should be calculated. The quality and appropriateness of the indicators in fitting each component must be evaluated. In the next stage, the fit of structures in the structural equations of the final model is crucial. By examining fit indices, validity, and reliability of the final model, the appropriateness and accuracy of the model fit will be assessed.

For this purpose, in Section 4.4.4, an analysis of measurement models along with the fit criteria for each model will be presented. In Section 2-3, hypothesis testing and structural analysis of the final model will also be provided.

4.4.4 Fit of Structural Equation Model

In this section, the fit of the intended structural equation model and the examination of its results have been addressed. In this model, the final dependent variable is the overall performance of the ISCPA system. The study model investigates the impact of implementing the ISCPA system on users' projects and its role in the intermediary variables of management, including time, cost, and risk management. Subsequently, the role of management variables on the overall project performance will be evaluated. To analyze the final structural equation model, two stages must be considered.

Firstly, measurement models need to be examined, and the quality and appropriateness of indicators in fitting variables such as ISCPA and management variables, including time, risk, cost, and project performance, should be assessed. In the next stage, the fit of structural

equations in the final model is crucial. By examining fit indices, validity, and reliability of the final model, the appropriateness and accuracy of the model fit will be assessed.

To fit the structural equation model, Smart PLS 3 software has been utilized, and the analysis steps include:

1. Drawing the model and estimating regression coefficients.

2. Examining the significance of the effect of each factor and sub-factors.

3. Assessing the reliability of the structural equation model (using Cronbach's alpha and composite reliability coefficient).

4. Checking the convergent validity of the model (using AVE index).

5. Investigating discriminant or divergent validity (cross-loading coefficients and Fornell-Larcker criterion).

6. Evaluating the goodness-of-fit indices for the structural equation model.

In the first stage, the final structural equation model has been fitted as follows:

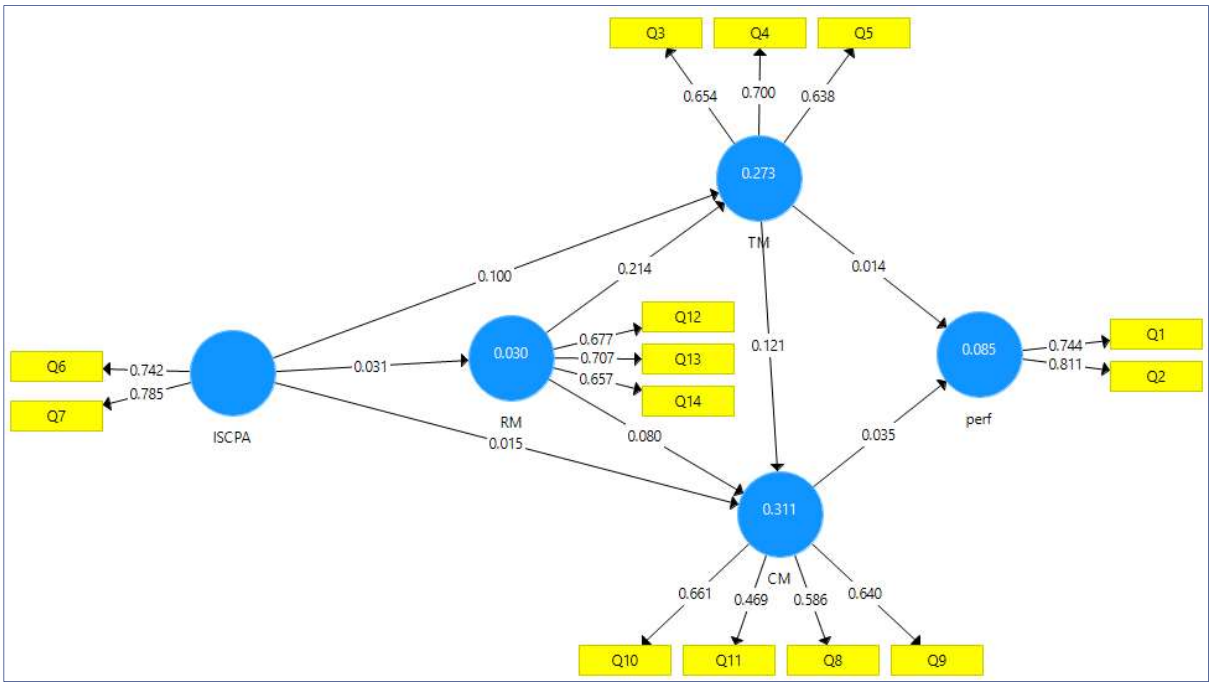

Figure 19: Structural Equation Model for Analyzing the Role of Management Variables and ISCPA on Project Performance

In Figure 19, yellow rectangles represent the items (questions in the questionnaire), and blue circles represent latent variables. The numbers on the arrows between latent variables and items are standardized factor loadings, and the numbers on the arrows connecting two latent variables are standardized path coefficients.

After drawing the structural equation model and estimating regression coefficients, the results of fitting the proposed structural equation model, separated by variables, are as follows.

We examined the factor loadings related to the studied constructs. If these values exceed the critical value of 0.4, it indicates the appropriateness of the item (the question in question) in measuring the latent variable. As observed, appropriate values for standardized factor loadings have been obtained for all constructs, and all considered items in the structural equation model for measuring ISCPA, risk management, time management, cost management, and performance are sufficient. This conclusion is supported by the provided p-value in the following tables. Therefore, it can be said that the proposed constructs have an appropriate structure.

Table 12: ISCPA model measurement parameters

	Coefficient	Standard Deviation	T Statistics	P-value	Significance
ISCPA->Q6	0.742	0.119	6.978	**0.000**	accepted
ISCPA->Q7	0.785	0.113	6.978	**0.000**	accepted

In the ISCPA structure, the factor loadings for questions Q6 and Q7 are 0.742 and 0.785, respectively. It's worth mentioning that these questions related to project size and project deployment time have been included in the measurement model of the ISCPA variable. However, due to the low factor loadings (coefficients) in the model, they have been excluded from the model. This indicates that the deployment time of the system and the project size employed do not play an influential role in measuring ISCPA. The provided p-values in the table also suggest that the proposed structure, with the inclusion of questions Q6 and Q7, has an appropriate configuration. It should be noted that we had considered some controlling variables to be assigned to the ISCPA, such as the time of adaptation of the ISCPA, the size of the projects, and experience level of the project team. However, surprisingly their coefficients were lower than the threshold of acceptance, meaning that these variables had no significant effect on the outcomes and did not differentiate the results when we considered them.

Table 13: Time management variable measurements in the model

	Coefficient	Standard Deviation	T Statistics	P-value	Significance
Time Management->Q3	0.654	0.082	7.943	**0.000**	accepted
Time Management->Q4	0.700	0.092	7.571	**0.000**	accepted
Time Management->Q5	0.638	0.090	7.066	**0.000**	accepted

In the Time Management structure, the factor loadings for questions Q3, Q4, and Q5 are 0.654, 0.700, and 0.6378, respectively. The provided p-values indicate that all the considered questions in this structure are significant, and the proposed structure, with the inclusion of questions Q3, Q4, and Q5, has an appropriate configuration.

Table 14::Cost management variable measurements in the model

	Coefficient	Standard Deviation	T Statistics	P-value	Significance
Cost Management->Q8	0.586	0.106	5.534	**0.000**	accepted
Cost Management->Q9	0.640	0.090	7.115	**0.000**	accepted
Cost Management->Q10	0.661	0.089	7.408	**0.000**	accepted
Cost Management->Q11	0.469	0.131	3.590	**0.000**	accepted

In the Cost Management structure, the factor loadings for questions Q8, Q9, Q10, and Q11 are 0.586, 0.640, 0.661, and 0.469, respectively. The provided p-values indicate that all the considered questions in this structure are significant, and the proposed structure, with the inclusion of questions Q8, Q9, Q10, and Q11, has an appropriate configuration.

Table 15: Risk management variable measurements in the model

	Coefficient	Standard Deviation	T Statistics	P-value	Significance
Risk Management->Q12	0.677	0.087	7.751	**0.000**	accepted
Risk Management->Q13	0.707	0.074	9.603	**0.000**	accepted
Risk Management->Q14	0.657	0.083	7.890	**0.000**	accepted

In the Risk Management structure, the factor loadings for questions Q12, Q13, and Q14 are 0.677, 0.707, and 0.657, respectively. The provided p-values indicate that all the considered questions in this structure are significant, and the proposed structure, with the inclusion of questions Q12, Q13, and Q14, has an appropriate configuration.

Table 16: Performance variable measurements in the model

	Coefficient	Standard Deviation	T Statistics	P-value	Significance
Performance ->Q1	0.744	0.142	5.233	**0.000**	accepted
Performance ->Q2	0.811	0.149	4.442	**0.000**	accepted

In the Performance structure, the factor loadings for questions Q1 and Q2 are 0.744 and 0.811, respectively. The provided p-values indicate that all the considered questions in this structure are significant, and the proposed structure, with the inclusion of questions Q1 and Q2, has an appropriate configuration.

Examining the reliability of the structural equation model (using Cronbach's alpha and composite reliability)

Cronbach's alpha and composite reliability indices are used to examine the reliability of the structures. The proximity of these indices to 1 and values greater than 0.7 indicate internal reliability within the structures. Composite reliability, being more reliable than Cronbach's

alpha, should ideally exceed 0.7. As observed, the structures under study are reliable based on these indices. Therefore, the considered structures in this structural equation model, namely ISCPA, Time Management, Risk Management, Cost Management, and Performance, are reliable.

Table 17: Indices of reliability of the construct structure

	Cronbach's Alpha	Composite Reliability
Cost Management	0.788	0.702
ISCPA	0.702	0.737
Risk Management	0.725	0.721
Time Management	0.773	0.703
Performance	0.751	0.754

Convergence reliability of the model:

AVE (Average Variance Extracted) is used to assess the convergent validity of the model. It measures the amount of variance captured by the latent constructs about the measurement errors. AVE values close to or greater than 0.5 generally indicate good convergent validity.

The calculation of AVE involves taking the average of the squared factor loadings for each construct's indicators. If the AVE for each construct is above the recommended threshold, it suggests that the indicators of each construct converge well, indicating good convergent validity.

The discussion revolves around two types of validity: convergent and discriminant validity. Convergent validity is represented by the AVE (Average Variance Extracted) index, indicating the correlation among items related to a construct. To confirm convergent validity, it is expected that the AVE index exceeds 0.5. In all studied constructs, namely ISCPA, Time Management, Risk Management, Cost Management, and Performance, the presence of convergent validity is confirmed among the items of each construct.

	Average Variance Extracted (AVE)
Cost Management	0.553
ISCPA	0.584
Risk Management	0.504
Time Management	0.541
Performance	0.606

Examination of discriminant validity (Fornell-Larcker index)

Discriminant validity is also examined using the Fornell-Larcker method in the structures, and the results are presented in the table below.

Table 18: Divergent reliability based on Fornell-Larcker

	Cost Management	ISCPA	Risk Management	Time Management	Performance
Cost Management	**0.594**				
ISCPA	0.271	**0.764**			
Risk Management	0.434	0.173	**0.681**		
Time Management	0.494	0.344	0.448	**0.664**	
Performance	0.269	0.391	0.212	0.231	**0.778**

As evident in Table 8, in the sections highlighted in dark color (bolded), the value of the square root of AVE for each factor is greater than its correlation with other factors. For example, in the Risk Management structure, the value of 0.681 is higher than the values of 0.448, 0.212, 0.173, and 0.434, confirming the discriminant validity of this structure. Therefore, the discriminant validity of factors related to all studied structures, namely ISCPA, Time Management, Risk Management, Cost Management, and Performance, is confirmed using the Fornell-Larcker method.

Examination of Goodness-of-Fit Indices for the Structural Equation Model

The final step involves examining the goodness-of-fit indices for the structural equation model. These indices are used to evaluate the model's performance and its conformity with the data. Here, measures such as the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and the Chi-square index are employed to assess the model's fit to the data quality. The results of this examination indicate...

In this section, an evaluation of the overall structural equation model is conducted by examining two indices: R^2 and Q^2 for each dependent variable. The R^2 index is one of the goodness-of-fit indices in structural equation models using the partial least squares method. A higher R2 value for inner model constructs indicates a better fit. Threshold values of 0.19, 0.31, and 0.67 are introduced as benchmarks for weak, moderate, and strong R^2 values, respectively.

Table 19: The R^2 indicator of the model fit

	R Square	Results
Cost Management	0.311	Moderate
Risk Management	0.330	Moderate
Time Management	0.373	Moderate
Performance	0.385	Moderate

As observed in Table 19, the R^2 index for all inner model variables falls within the moderate range. Thus, from the perspective of this index, the appropriateness of the structural model constructs is confirmed.

The Q^2 index is another measure that can be calculated for each of the inner model variables. This criterion indicates the predictive power of the model. Introduced by Stone and Geisser, this measure assesses the predictive ability of the model for inner constructs. According to their belief, models with an acceptable structural fit should have the capability to predict inner model variables effectively. In other words, if the relationships between the constructs are accurately defined in a model, the constructs should sufficiently influence each other, and hypotheses should be confirmed. Based on Henseler et al. values of 0.02, 0.15, and 0.35 indicate weak, moderate, and strong predictive power for a construct, respectively.

Table 20: The Q^2 result of the model fit

	Q Square	Results
Cost Management	0.183	Moderate
Risk Management	0.173	Moderate
Time Management	0.159	Moderate
Performance	0.196	Moderate

According to Table 20, the Q^2 index for all constructs in the research model is greater than 0.15. This indicates that the model has strong predictive power and confirms the appropriate fit of the structural model.

Assessment of the overall model fit index

In the structural equation modeling approach using partial least squares, the Goodness of Fit (GOF) index is the most comprehensive measure for evaluating the performance of the overall model. This criterion, introduced by Tenenhaus, is calculated using the following formula.

$$GOF = \sqrt{\overline{AVE} \times \overline{R^2}}$$

In this formula, the average values of AVE and R^2 are used. According to Tenenhaus, for assessing the overall model fit using this index, three values of 0.1, 0.25, and 0.36 are suggested as thresholds for weak, moderate, and strong fit, respectively.

Table 21: Overall model fir index

	Value	Results
GOF	0.441	Moderate

Based on the reported GOF value in Table 21, the goodness-of-fit index for the overall model is 0.441. This value indicates an acceptable fit for the overall model. Now that the adequacy of the structural equation model has been confirmed based on the important indices in this area, we will proceed to examine the statistical hypothesis tests related to the study. This requires investigating the significance of regression pathways, which we will address next.

Examination of the Significance of Regression Paths:

In this section, the aim is to investigate the relationships between the independent and dependent variables of the study. To achieve this, the significance of the regression effects of the model pathways on ISCPA users' performance will be examined.

Table 22: Regression Effects of the Structural Equation Model of ISCP

	Coefficient	Standard Deviation	T Statistics	P Values	Result
Cost Management -> Performance	0.205	0.096	2.128	0.034	accepted
ISCPA -> Cost Management	0.109	0.092	1.186	0.236	rejected
ISCPA -> Risk Management	0.173	0.077	2.241	0.025	accepted
ISCPA -> Time Management	0.274	0.091	3.029	0.003	accepted
Risk Management -> Cost Management	0.263	0.079	3.348	0.001	accepted
Risk Management -> Time Management	0.400	0.092	4.335	0.000	accepted
Time Management -> Cost Management	0.339	0.085	3.977	0.000	accepted
Time Management -> Performance	0.129	0.110	1.177	0.240	rejected

Regarding the results in Table 22, we analyze the hypothesis of the research.

Hypothesis One: ISCPA affects cost management.

As presented in Table 22 and Figure 19, the standardized path coefficient estimate between ISCPA and cost management is 0.109, with a standard error of 0.092. The test statistic value is less than the critical value of 1.96, and the significance level is 0.236, which is greater than $\alpha = 0.05$. Therefore, statistically, at a 95% confidence level, it cannot be concluded that there is a significant relationship between ISCPA and cost management. Hence, there is no significant relationship between ISCPA and cost management.

Hypothesis Two: ISCPA affects risk management.

The standardized path coefficient estimate between ISCPA and risk management in Table 22 is 0.173, with a standard error of 0.081. The test statistic value is 2.142, which is greater than the critical value of 1.96, and the significance level is 0.033, which is less than $\alpha = 0.05$. Therefore, statistically, at a 95% confidence level, it can be concluded that there is a significant

relationship between ISCPA and risk management. Hence, there is a significant relationship between ISCPA and risk management, and ISCPA plays an explanatory role in determining project risk management. The direct effect of ISCPA on risk management is 0.173, meaning that with an increase of one unit in ISCPA, risk management increases by 17.3%.

Hypothesis Three: ISCPA affects time management.

Based on the values presented in Table 22 and Figure 19, the standardized path coefficient estimate between ISCPA and time management is 0.274, with a standard error of 0.093. The test statistic value is 2.142, which is greater than the critical value of 1.96, and the significance level is less than $\alpha = 0.05$. Therefore, statistically, at a 95% confidence level, it can be concluded that there is a significant relationship between ISCPA and time management. Hence, there is a significant relationship between ISCPA and time management, and ISCPA plays an explanatory role in determining time management. The direct effect of ISCPA on time management is 0.274, meaning that with an increase of one unit in ISCPA, time management increases by 27.4%.

Hypothesis Four: Risk management affects cost management.

As shown in Table 22 and Figure 19, the standardized path coefficient estimate between risk management and cost management is 0.263, with a standard error of 0.078. The test statistic value is greater than the critical value of 1.96, and the significance level is 0.001, which is less than $\alpha = 0.05$. Therefore, statistically, at a 95% confidence level, it can be concluded that there is a significant relationship between risk management and cost management. Hence, there is a significant relationship between risk management and cost management, and risk management plays an explanatory role in determining cost management. The direct effect of risk management on cost management is 0.263, meaning that with an increase of one unit in risk management, cost management increases by 26.3%.

Hypothesis Five: Risk management affects time management.

Based on the values presented in Table 22 and Figure 19, the standardized path coefficient estimate between risk management and time management is 0.4, with a standard error of 0.096. The test statistic value is 4.160, which is greater than the critical value of 1.96, and the significance level is less than $\alpha = 0.05$. Therefore, statistically, at a 95% confidence level, it can be concluded that there is a significant relationship between risk management and time management. Hence, there is a significant relationship between risk management and time management, and risk management plays an explanatory role in determining time management. The direct effect of risk management on time management is 0.4, meaning that with an increase of one unit in risk management, time management increases by 40%.

Hypothesis Six: Time management affects cost management.

Based on the values presented in Table 22 and Figure 19, the standardized path coefficient estimate between time management and cost management is 0.339, with a standard error of 0.083. The test statistic value is 4.065, which is greater than the critical value of 1.96, and the significance level is less than α= 0.05. Therefore, statistically, at a 95% confidence level, it can be concluded that there is a significant relationship between time management and cost management. Hence, there is a significant relationship between time management and cost management, and time management plays an explanatory role in determining cost management. The direct effect of time management on cost management is 0.339, meaning that with an increase of one unit in time management, cost management increases by 33.9%.

Hypothesis Seven: Time management affects project performance.

As shown in Table 22 and Figure 19, the standardized path coefficient estimate between time management and project performance is 0.129, with a standard error of 0.107. The test statistic value is less than the critical value of 1.96, and the significance level is 0.226, which is greater than α= 0.05. Therefore, statistically, at a 95% confidence level, it cannot be concluded that there is a significant relationship between time management and project performance. Hence, there is no significant relationship between time management and project performance.

Hypothesis Eight: Cost management affects project performance.

Based on the values presented in Table 22 and Figure 19, the standardized path coefficient estimate between cost management and project performance is 0.205, with a standard error of 0.093. The test statistic value is 2.194, which is greater than the critical value of 1.96, and the significance level is less than α= 0.05. Therefore, statistically, at a 95% confidence level, it can be concluded that there is a significant relationship between cost management and project performance. Hence, there is a significant relationship between cost management and project performance, and cost management plays an explanatory role in determining project performance. The direct effect of cost management on project performance is 0.205, meaning that with an increase of one unit in cost management, project performance increases by 20.5%.

Chapter 5
Discussion and Conclusion

In this chapter, the findings of the conducted research are summarized and discussed to depict a clear picture of the findings and possible explanations for them, in addition to that, limitations and suggestions for the next research will be provided. First, it should be reminded that the current study, is a part of a vast similar study in different European countries and the final results will provide a basis for comparison of the same study in different geological locations. As we know and suggested by the literature, the outcome of management solutions depends on the work culture of the firms and the comparison of these related studies would give us a perspective on whether the perception of the integrated supply chain software is the same in these countries or not.

The previous studies on ERP systems in general were mainly focused on customizations and selecting the proper modules for each firm. Similar studies were conducted in other non-European countries, however, having a clear picture of the conditions in Europe was the main purpose of the current study. Our main question was to check how the integrated supply chain platforms, being backed by the advancements of the information system can help in delivering proper project execution in the construction industry. Here we summarize and discuss the main findings.

- One main surprising initial finding was that the descriptive variables had no significance in our study. In other words, there is no significant difference between the different groups of respondents. Basically it was belived that the longer time of the adaptation of the software system, the more productive it could be. It was based on the notion that any change in the routines of the firms and introduction of new methods takes time to be completely put into practice by the employees. Especially if we consider integrated systems that need collaboration of different functions in the companies. Also, the experience of the respondent could be considered as a factor to influence the usage of the system or the perception of the benefits and drawbacks associated with it. Another factor that was considered to be important was the size of the projects of the firms. Our proposition was that there might be a difference between small projects versus the projects that cost multiple times more. Surprisingly, the findings show that no significant difference exists for these groups of descriptive variables.

  One probable explanation for this could be referring to the notion that the information systems are considered commodities now, meaning that no matter how big is the projects or the firms, all of these entities who are utilizing the software solutions get almost similar results and the benefits are not more significant in one area versus the other. Another point worth mentioning is that our findings shows that the new software solutions, in the targeted population, can be dealt with by the employees rapidly and without much turbulences to the system. This idea might be in compliance with the current IT advancements and the fact that today people have no difficulty adapting to new IT systems in a way that the ISCP could work with the same efficiency regardless of the adaptation time.

  In general, it could be stated that the IT solutions in the supply chain management helped the conformity among the firms, regardless of the descriptive variables that were considered in the research

- From our model it can be concluded that the adaptation of the supply chain software positively affects the risk management in the industry. The idea of integrating different functions in the firm from engineering, procurement, logistics, finance,… helps to face less risk in performing construction projects. This was also one of the hypotheses of the thesis which was confirmed and accepted by the collected data.

- In addition to the previous point, improved risk management positively affects both time management and cost management in the construction firms in the Nordic countries. In other words, ISCP results in better risk management which in second tire will result in better cost management and time management in the targeted population. This could be considered one of the main reasons that the firms tend to use integrated software platforms to control and monitor their supply chain to prevent related risks which shows it in better time and cost management.

- The ISCP has positive effect on the time management. As stated by the collected data and based on our SEM model, time management befits from the use of the ISCP. Better management of the procurements and delivery of the goods, timely delivery and tracking of the orders helps the construction companies to have a better control over the time management in their supply chain. It was one of the main hypothesis of the research which was accepted by the study.

- The ISCP is not perceived to have positive effect on the cost management. One of the hypothesis of the research was that the ISCP would help managing the cost of the construction projects better, however, our findings show that our respondents do not see a direct effect of the ISCP on the cost management whereas they see positive effects on the time management. In other words, the ISCP does not directly result in a better cost management practices in the construction firms. It can be concluded that based on the data the ISCP only positively affects the time and risk management but no direct effect on how the firms practice the cost management.

- Time management results in a better cost management. One of our hypothesis which was accepted by the model was that better time management results in a better cost management. As we know, time and cost are intertwined in the project management. Here it is confirmed that the ISCP indirectly affects the cost management through better risk and time management practices. This indirect path is amazing in the sense that however the respondents see no direct effect of the ISCP on the cost management they see they presume that the cost management is positively affected by utilizing the ISCP but in an indirect way, through preventing supply chain risks and more efficient time management in the construction industry.

- Based on the data and our model, it is not perceived that the time management affects the overall project performance. This is a peculiar finding of the research because the notion is that time is a decisive factor in any project management practice. It worth mentioning that the time management here, is in fact, the time management resulted from the ISCP and not dealing with the general concept of TM. We can say that the ISCP results in a better time management practice, however this better time management resulted from the ISCP is not consider a major gain for better project performance. The better explanation of this point can be described with the help of the following finding.

- Cost management, resulted from the ISCP is positively influencing the project performance. It should be reminded that the ISCP did not directly affect the cost management but by means of

the time and risk management. This improved cost management is perceived to have a positive effect on the overall performance.

Now the interesting relationship is among the time, cost and performance which needs to be discussed deeply. Based on our findings, the ISCP indirectly and through time management (along with the risk management) result in a better cost management which in turn delivers better project performance. On the other hand the time management not directly related to the project performance but indirectly and through cost management. In order to explain this relationship, we need to focus on the specific industry that we are dealing with, the construction industry. One possible explanation could be that in the construction industry, majority of the consumable goods that need a supply chain are commodities and not specific to just limited producers. So, most of the failed deliveries by the suppliers can be noticed in time thanks to the ISCP, and can be procured from other sources albeit at a higher cost. This shows that the ISCP does not directly help lower cost of the project and also the time management practice does not result in the shorter project time. The ISCP helps to identify the failed orders in time, and make up for it by spending more, so it affects the cost management indirectly an its practice and time management effects, reflects itself in the cost. So overall, the project performance is positively affected but through an amazing chain of phenomenon.

References

[1] S. Alimohamadian and F. Abdi, "Analyzing the effects of information technology on supply chain integration: The role of ERP success mediator," *Management Science Letters*, vol. 4, no. 4, pp. 799–806, 2014, doi: 10.5267/j.msl.2014.2.003.

[2] M. Mashreghi and N. Nahavandi, "The Role of Information Technology on Supply Chain Performance with an Emphasis on the Integration and Flexibility Case Study of Automobile Parts Company.," in *First International Conference on Management, Innovation and Entrepreneurship.*, 2010.

[3] M. Adaileh and K. Abu-alganam, "The Role of ERP in Supply Chain Integration.," *Journal of Computer Science and Network Security,* 2010.

[4] M. M. Habib, "Supply Chain Management: Theory and its Future Perspectives," 2010. [Online]. Available: https://www.researchgate.net/publication/323166975

[5] A. Kashyap, "Impact of ERP implementation on Supply Chain Management.," *Journal of Computer Applications in Engineering Sciences,* 2011.

[6] P. Ifinedo and N. Nahar, "Interactions between contingency, organizational IT factors, and ERP success.," *Industrial Management & Data Systems,* vol. 10, 2009.

[7] W. Delon and E. McLean, "Information systems success: the quest for the dependent variable. Information Systems Research," 1992.

[8] Gabel G. and D., Sedera, "Enterprise systems success: a measurement model. Association for Information Systems.," in *Twenty-Fourth International Conference on Information Systems,* 2003.

[9] A. , Cox and P. Ireland, "Managing Construction Supply Chains: The Common Sense Approach," *Engineering Construction & Architectural Management,* 2009.

[10] D. M. Lambert and M. C. Cooper, "Issues in supply chain management. Industrial Marketing Management ," *Industrial Marketing Management*, pp. 65–83, 2000.

[11] J. D. Wisner and K. C. Tan, "Supply chain management and its impact on purchasing," *Journal of Supply Chain Management* .

[12] X. Zhao, B. Huo, B. Flynn, and J. Yeung, . "The impact of power and relationship commitment on the integration between manufacturers and customers in a supply chain," *Journal of Operations Management*, 2008.

[13] F. Iddris, "Digital Supply Chain: Survey of the Literature," 2018. [Online]. Available: https://www.researchgate.net/publication/326446285

[14] P. Farahani, C. Meier, and J. Wilke, "Digital Supply Chain Management Agenda for the Automotive Supplier Industry," in *Shaping the Digital Enterprise*, Cham: Springer International Publishing, 2017, pp. 157–172. doi: 10.1007/978-3-319-40967-2_8.

[15] M. S. S. Jajja, K. A. Chatha, and S. Farooq, "Impact of supply chain risk on agility performance: Mediating role of supply chain integration," *Int J Prod Econ*, vol. 205, pp. 118–138, Nov. 2018, doi: 10.1016/j.ijpe.2018.08.032.

[16] A. Rai, R. Patnayakuni, and N. Seth, "Firm performance impacts of digitally enabled supply chain integration capabilities," *MIS Quarterly,* 2006.

[17] J. Collis and R. Hussey, *Business research. A practical guide for undergraduate and postgraduate students*. Palgrave Macmillan, 2013.

[18] A. G. Deloitte, " Industry 4.0 Challenges and solutions for the digital transformation.," 2015.

[19] K. Lindgren, "How Digitalization Is Changing the Face of Business.," 2015.

[20] G., Büyüközkan and F. & Göçer, "Digital supply chain: Literature review and a proposed framework for future research.," *Comput Ind*, vol. 97, 2018.

[21] B., Bhargava, R. R., B., and Ben Othmane, "Secure information sharing in digital supply chains.," *Proceedings of the 2013 3rd IEEE International Advance Computing Conference, IACC 2013.*, 2013.

[22] J. . Kinnet, "Creating a Digital Supply Chain: Monsanto's Journey.," 2015.

[23] M. E., Porter and J. E. Heppelmann, "How smart, connected products are transforming companies.," *Harv Bus Rev*, vol. 93, 2015.

[24] D., Isaksson and K., Wennberg, "Digitalization and Collective Value Creation.," 2016.

[25] Q. , Corver and G. Elkhuizen, "A Framework for Digital Business Transformation.," 2014.

[26] M. Hugos, "Key Concepts of Supply Chain Management," in *Essentials of Supply Chain Management*, Wiley, 2018, pp. 1–39. doi: 10.1002/9781119464495.ch1.

[27] R. J. Arbulu, I. D. Tommelein, K. D. Walsh, and J. C. Hershauer, "Value stream analysis of a re-engineered construction supply chain," *BUILDING RESEARCH & INFORMATION*, vol. 31, no. 2, pp. 161–171, 2003, doi: 10.1080.

[28] Babak Daneshvar Rouyendegh, "Selecting the best supplier using analytic hierarchy process (AHP) method," *African Journal of Business Management*, vol. 6, no. 4, Feb. 2012, doi: 10.5897/ajbm11.2009.

[29] M. K. Moorthy *et al.*, "A Study on Factors Affecting the Performance of SMEs in Malaysia," 2012. [Online]. Available: www.hrmars.com/journals

[30] D. M., Lambert and M. C. Cooper, "Issues in supply chain management," 2000.

[31] K. L. Croxton, S. J. García-Dastugue, D. M. Lambert, and D. S. Rogers, "The Supply Chain Management Processes," *The International Journal of Logistics Management*, vol. 12, no. 2, pp. 13–36, Jul. 2001, doi: 10.1108/09574090110806271.

[32] R. M. Monczka, *Purchasing, and supply chain management.* South-Western, 2009.

[33] P. Kelle and A. Akbulut, "The role of ERP tools in supply chain information sharing, cooperation, and cost optimization," in *International Journal of Production Economics*, Jan. 2005, pp. 41–52. doi: 10.1016/j.ijpe.2004.06.004.

[34] E. M. Haacke *et al.*, "Characterizing iron deposition in multiple sclerosis lesions using susceptibility weighted imaging," *Journal of Magnetic Resonance Imaging*, vol. 29, no. 3, pp. 537–544, Mar. 2009, doi: 10.1002/jmri.21676.

[35] R. M. Da Silva Gomes, "Contributions of the PMBok to the Project Management of an ERP System Implementation," *Revista de Gestão e Projetos*, vol. 4, no. 2, pp. 153–162, Aug. 2013, doi: 10.5585/gep.v4i2.37.

[36] F. Amaro and L. Domingues, "PMBOK 6th meets 7th: How to link both guides in order to support project tailoring?," in *Procedia Computer Science*, Elsevier B.V., 2023, pp. 1877–1884. doi: 10.1016/j.procs.2023.01.486.

[37] X. Wei, V. Prybutok, and B. Sauser, "Review of supply chain management within project management," *Project Leadership and Society*, vol. 2. Elsevier Ltd, Dec. 01, 2021. doi: 10.1016/j.plas.2021.100013.

[38] R. M. Wideman, "Total Project Management of Complex Projects Improving Performance with Modern Techniques," 1990.

[39] T. Mandičák, P. Mésároš, A. Kanáliková, and M. Špak, "Supply chain management and big data concept effects on the economic sustainability of building design and project planning," *Applied Sciences (Switzerland)*, vol. 11, no. 23, Dec. 2021, doi: 10.3390/app112311512.

[40] J. Utomo, D. Hatmoko, and S. Scott, "Association of Researchers in Construction Management."

Annex A.

The questionnaire was sent out for gathering the responses.

Demographics

- Name (Optional):
- Email (Optional):
- Position/Role:
- Company/Organization:
- Country:
- Number of Years in the Construction Industry:
- Size of the project:
    - less than 1 MM
    - 1 to 10 MM
    - More than 10 MM

Section 1: Integrated Supply Chain Platform Adoption

Have you or your organization adopted an integrated supply chain platform for construction projects?

Yes

No

If yes, please specify the name or type of the platform:

How long have you been using this integrated supply chain platform?

Less than 1 year

1-3 years

3-5 years

More than 5 years

What motivated the adoption of the integrated supply chain platform? (Check all that apply)

Improved communication and collaboration among stakeholders

Enhanced project data management

Real-time project monitoring and reporting

Cost reduction

Improved risk management

Compliance with industry standards/regulations

Other (please specify):

Section 2: Construction Project Management Criteria

1. In your experience, how has the adoption of the integrated supply chain platform impacted overall performance considering factors such as meeting project timelines, achieving project scope, and staying within the budget in construction projects?

   Significantly improved

   Moderately improved

   No significant impact

   Moderately deteriorated

   Significantly deteriorated

2. In your experience, how has the adoption of the integrated supply chain platform impacted the overall project success rate, based on your company-specific metrics, and factors like stakeholder engagement and satisfaction?

   Significantly improved

   Moderately improved

   No significant impact

   Moderately deteriorated

   Significantly deteriorated

3. In your experience, how has the adoption of the integrated supply chain platform impacted overall time management in construction projects?

   Significantly improved

   Moderately improved

   No significant impact

Moderately deteriorated

Significantly deteriorated

4. In your experience, how has the adoption of the integrated supply chain platform improved (reduced) lead times for materials?

Significantly improved

Moderately improved

No significant impact

Moderately deteriorated

Significantly deteriorated

5. In your experience, how has the adoption of the integrated supply chain platform impacted project delays that are the direct result of the supply chain activities?

Significantly improved

Moderately improved

No significant impact

Moderately deteriorated

Significantly deteriorated

6. In your experience, how has the adoption of the integrated supply chain platform impacted the reduction in order errors?

Significantly improved

Moderately improved

No significant impact

Moderately deteriorated

Significantly deteriorated

7. In your experience, how has the adoption of the integrated supply chain platform helped to eliminate unnecessary management processes related to supply chain activities?

Significantly improved

Moderately improved

No significant impact

Moderately deteriorated

Significantly deteriorated

8. In your experience, how has the adoption of the integrated supply chain platform impacted overall cost management in construction projects in your organization?

Significantly improved

Moderately improved

No significant impact

Moderately deteriorated

Significantly deteriorated

9. In your experience, how has the adoption of the integrated supply chain platform impacted the reduction in unnecessary inventory?

Significantly improved

Moderately improved

No significant impact

Moderately deteriorated

Significantly deteriorated

10. In your experience, implementing ISCP in projects has prevented cost overruns, keeping the project budget within the scheduled budget.

Significantly improved

Moderately improved

No significant impact

Moderately deteriorated

Significantly deteriorated

11. In your experience, in the case of expenditures exceeding the budgeted cost, how has the adoption of the integrated supply chain platform impacted improved project cost control, especially in bringing back the cost to the scheduled budget?

Significantly improved

Moderately improved

No significant impact

Moderately deteriorated

Significantly deteriorated

12. In your experience, how has the adoption of the integrated supply chain platform impacted overall risk management in construction projects?

Significantly improved

Moderately improved

No significant impact

Moderately deteriorated

Significantly deteriorated

13. In your experience, how has the adoption of the integrated supply chain platform improved real-time project tracking enabling timely responses to any risk that becomes more probable to occur?

Significantly improved

Moderately improved

No significant impact

Moderately deteriorated

Significantly deteriorated

14. In your experience, how has the adoption of the integrated supply chain platform, if they help the risk identification, can help in the mitigation as well?

Significantly improved

Moderately improved

No significant impact

Moderately deteriorated

Significantly deteriorated

Section 3: Challenges and Recommendations

What challenges or obstacles have you encountered in the adoption and implementation of the integrated supply chain platform for construction projects?

Based on your experience, what recommendations or best practices would you suggest to optimize the use of integrated supply chain platforms for improved project management?

Section 4: Additional Comments

Please share any additional comments, insights, or observations related to the adoption of integrated supply chain platforms and their impact on construction project management.

Thank you for taking the time to complete this questionnaire. Your feedback is invaluable to our research efforts.