



Factors Affecting Construction Transport Efficiency in a Developing Country
Context: The Case of Mega Projects Office

By

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A THESIS SUBMITTED TO ADDIS ABABA UNIVERSITY, COLLEGE OF BUSINESS
AND ECONOMICS IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE
DEGREE OF MASTERS IN MANAGEMENT (TRANSPORT MANAGEMENT)

JANUARY, 2026

ADDIS ABABA ETHIOPIA



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ACKNOWLEDGEMENTS

First of all, I give thanks to God almighty for giving me the direction I need in my life, courage and endurance. Then my gratitude is extended to my adviser, Dr. Yohannes Workaferahu, for his steadfast assistance in checking and providing valuable feedback, I would also like to express my sincere appreciation to Addis Ababa city Administration Mega projects construction office cooperation for facilitating things for me, so that I can easily access respondents, even after providing the necessary data from their office.

Lastly, I would like to express my warm gratitude to my family and friends, for their unwavering understanding and encouragement which sustained me through every challenge and success of my academic journey.

DECLARATION

I hereby declare that this MSc thesis entitled “**Factors Affecting Construction Transport Efficiency in a Developing Country Context: The Case of Mega Projects Office**” is my original work and has not been presented for any kind of degree award in any other universities and all sources of materials used for this thesis have been duly acknowledged.

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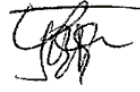
ADVISORS' APPROVAL SHEET

This is to certify that the thesis entitled “**Factors Affecting Construction Transport Efficiency in a Developing Country Context: The Case of Mega Projects Office**” submitted in partial fulfillment of the requirements for the degree of master’s with specialization in Transport management, the graduate program of the department of management, and has been carried out by Befikir Ashenafi Biratu ID. No GSR/3364/15, under our supervision. Therefore, we recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

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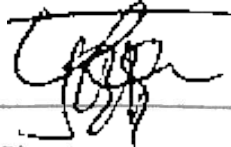


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ABSTRACT

The main aim of this study was to identify factors affecting the efficiency of construction transport in projects administered by Mega Projects Office. To achieve the objectives of the study, the research adopted quantitative research approach employing descriptive and inferential analysis. The information was obtained through a questionnaire survey administered to 108 respondents in the four departments participating in Mega projects office projects and a total of 96 (88.8%) complete responses. The collected data were analyzed using the statistical package for social sciences (SPSS) 27. This research utilized census sampling method which includes all targeted population which were contractor professionals in the four departments which have the knowledge in the study area. Data were analyzed using descriptive statistics, relative importance index and inferential statistics to identify the relationship of independent variables, which are information sharing, digital tools and technology, logistics services and transport management practices with dependent variable, construction transport efficiency. The main findings suggested that information sharing had the greatest impact on transport efficiency, followed by logistics services and transport management practices, however digital tools and technology had no meaningful impact. Based on these findings, the research suggests that contractors institutionalize internal communication, improve logistical planning, formalize transport management systems, devise contingency plans, and invest prudently in useful digital tools. It is advised that project stakeholders and authorities standardize logistics procedures, provide incentives to assist digital transformation, enhance logistical capacity through targeted training and incorporate transport key performance indexes into project performance frameworks. The study adds to construction logistics and transport research by emphasizing the importance of human and organizational coordination.

Keywords: Construction transport efficiency, Information Sharing, logistics services, Digital tool and technology, Transport management practices.

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ABBREVIATIONS

CLS	Construction Logistics Setups
CSC	Construction Supply Chain
CTE	Construction Transport Efficiency
LC	Lean Construction
LSP	Logistics Service Provider
VMI	Vendor Management Inventory
LMD	Logistics Main Department
SCM	Supply Chain Management
NVA	Non-Value Added
VA	Value Added
LDM	Lean Design Management
LPS	Last Planner System
LBMS	Location Based Management System
RBV	Resource-based view
KPIs	Key Performance Index

CHAPTER ONE

1. INTRODUCTION

1.1 Background of the Study

The construction industry is one of the key sectors contributing significantly to economic development and affecting the lives of nearly every individual (Sears et al., 2015). The construction industry includes the building of structures such as offices, hospitals, airports, shopping centers, housing, and factories, as well as civil engineering works like infrastructure for water supply, irrigation, transportation, and power generation (United Nations International Standard Industrial Classification (ISIC, 2008)).

According to Razak Bin Ibrahim et al. (2010), construction development projects are critical to making society goals and requirements a reality. While, Rangelova (2015) highlights that the construction industry is complex due to the involvement of multiple stakeholders and its integration with various sectors such as equipment, material handling, energy, finance, and labor.

Since the late 1980s, the construction industry has implemented several supply chain management (SCM) initiatives to enhance internal and external efficiency, minimize waste, and add value throughout the supply chain (Vrijhoef & Koskela, 2000). An essential component of SCM, Logistics is concerned with the movement of materials, machines or equipment, tools and personnel from their source to and within the construction site, including reutilizing and waste management to maintain a circular economy.

The construction sector has experienced rapid growth, mostly due to government led infrastructure expansion in roads, railways and buildings (Ministry of Urban Development and Construction ([MUDC], 2015). Despite its growth, construction logistics and transportation practices remain underdeveloped, resulting in inefficiencies that raise costs and environmental consequences (Gebrehiwot & Demeke, 2019). At the continental level, African cities such as Addis Abeba encounter logistical difficulties due to insufficient infrastructure, urban congestion, and poor coordination among transport chain actors (Agyekum et al., 2021).

Transport, which refers to the flow of goods from one point to another in the supply chain, is a major function in the field of logistics (Britannica, 2019). According to Arvidsson et al. (2013), transport efficiency is the generating of transport services with less use of resources without undermining costs or service quality. Factors that make up transport efficiency include the reduction of fuel consumption, delivery time optimization, and improvement in environmental and societal aspects (Sternberg, 2011; Moen, 2016). Economic aspects include a reduction in labor costs and lower costs associated with maintenance (Janne & Fredriksson, 2020). Environmentally, it minimizes CO2 emissions (Aronsson & Brodin, 2006), whereas socially, it addresses traffic congestion problems and improves safety (McKinnon, 2018).

Within the contexts of construction industry, the two major trends in transport are delivery to site and removals (Fredriksson, Sezer, et al., 2022). These trends include incoming such as labor, materials, and equipment transport as well as outbound activities such as damaged goods and waste removal (Sezer & Fredriksson, 2021a). Various suppliers such as materials suppliers, contractors, and service providers are involved in these flows (Proverbs & Holt, 2000). Vehicle and load carrier selection for transporting materials depends on the nature and size of construction projects (Sezer & Fredriksson, 2021a). Naz (2022) describes construction transport efficiency as “performing transport operations from loading to unloading with less use of resources such as time and fuel as well as less effect on environment.”

In Ethiopia, there are inefficiencies in logistics and transport planning. Delays in project implementation are linked by Abebe & Worku (2020) to factors such as a lack of road infrastructure, a lack of coordination, and a lack of logistics systems. The inefficiencies in the logistics sector include a lack of reliability in delivery, a lack of information flow as well as a lack of logistics services in the public as well as private construction projects (Gebrehiwot & Demeke, 2019).

According to Shakir and Sattar (2022), the transport issues in the urban area such as the limited road capacity and congestion of traffic increase the risk of accidents and delays in the construction site. Furthermore, the presence of heavy trucks in the urban area as pointed out by Russo and Comi (2010), is associated with safety issues because of the interaction of these trucks with pedestrians, tramways, and other vehicles. Delays in the delivery of construction materials

from suppliers or storage directly affect the productivity of the project (Sezer and Fredriksson, 2021a).

Naz (2022) also mentions a lack of effective management of logistics as one of the factors determining low efficiency in transport and as a result overuse of resources like time and fuel as well as low productivity take place in construction projects. Factors such as unreliable delivery schedules, coordination problem and unavailability of construction materials are very common (Fredriksson et al., 2021; Ekeskär and Rudberg, 2020; Dubois et al., 2018). The aforementioned researches clarify that there is low productivity in construction projects around the globe and also in Ethiopia due to influences from poor logistics and transport systems.

In spite of these difficulties, modern technologies and logistics solutions are now being developed and implemented across the world to improve construction transport efficiency. However, in the Ethiopian context, such advancements are not yet fully adopted or integrated (Gebrehiwot & Demeke, 2019). Therefore, this study seeks to investigate the factors affecting construction transport efficiency of projects in Addis Ababa by collecting and analyzing the perception of contractors on transport efficiency and its dimensions. A quantitative approach will be employed to identify key influencing factors and propose strategies for improvement.

1.2 Statement of the Problem

Transport management, according to Garcia-Arca, Prado-Prado, and Fernandez-Gonzalez (2018), has grown to be a significant concern for the construction industry from an economic standpoint of cost reduction and service improvement as well as from other aspects like reducing resource consumption, carbon emissions, and traffic congestion. According to Valenciaport Foundation (VPF) (2017), one of the largest producers and consumers of transportation in urban areas is the construction sector. It also emphasizes how important transportation has become as a result of the building industry's fragmentation and the involvement of several stakeholders (Janné, 2018; Fellow and Liu, 2012; Ekeskär and Rudberg, 2016; Berden, 2017; and Dubois, Hulthén, Sundquist, 2019).

Janne, (2018) also states the construction industry is frequently viewed as outdated, ineffective, and disorganized due to its fragmentation and resistance to change. Therefore, convincing stakeholders to implement improvements to construction logistics thus becomes

challenging (Goshu and Kitaw, 2017). Andersson et al. (2019) suggest that it is remarkably challenging to predict and model the effects of novel solutions on transportation networks because of the intricate nature of the construction supply chain as mentioned above. Wegelius-Lehtonen (2001) highlights the necessity of transport performance measurements in the construction industry as a result. According to Latiffi et al. (2014), the construction sector has to understand the significance of transport performance measurements in order to promote sustainability and improvement. While as reported by Jensen (2017), the construction sector has not embraced the established advantages of supply chain management and logistics. Similarly, Sullivan et al. (2010), highlights that while the construction industry incurs significant expenses as a result of inadequate logistics management, every major business, including manufacturing (primarily automotive), retailing, shipping, and third party logistics, gains from using logistics. They further suggest that successful logistics management is essential for contemporary firms, especially those that rely on extensive supplier networks and just in time delivery. Sullivan et al. (2010) also suggests market pressures and labor relations will ultimately need to spur the construction industry's embrace of logistics.

There are different transport-related activities involved in construction projects, which contribute 39-58% to the overall supply chain expenses (Ying et al., 2018 and Dubois et al., 2019). According to Sullivan et al. (2010), transport is very essential in supply chain management as it helps move goods and services to the construction site. The reason why construction is not adopting logistics and why this is not becoming a reality is a question that still remains despite other sectors such as manufacturing, retail and shipping having adopted logistics and performed best-in-class results and efficiency and best practices examples having been established by them already. The construction industry is also unaware of how these efficiencies and reductions can be attained and implemented, apart from the research gap in the area as well as understanding and appreciating benefits and advantages resulting from logistics applications and implementation. To address this challenge and requirement, there is a need to guide and fully inform decision-makers (developers or clients and contractors) on how construction logistics should be managed and implemented. Decision-makers are also unaware or have a vague idea about optimizing transport flow, plan transportation or use construction logistics applications to attain optimum efficiency and best practices examples and results. There is therefore a need to clearly and precisely determine

and pinpoint the basic performance measures for transport flow to be able to manage, regulate and improve construction logistics.

Late delivery of ordered materials and logistical challenges related to materials handling and distribution further contribute to construction delays (Mossie, 2024). According to Arijeloye & Akinradewo (2016) and Enshassi, Mohamed, & Abushaban (2009), challenges related to materials handling and distribution, such as inefficient transportation routes or inadequate handling equipment and or poor quality of available equipment and raw materials, can result in delays, damages, or loss of materials. Vidalakis and Sommerville's (2013) study shows that vehicle loading efficiency levels are particularly lower than those estimated in other sectors and reveal the prevalence of empty vehicle runs during backhauling. Leadership Commitment, Coordination & Information Flow, Internal Process and Procedures, Legal & Political Factors, and Technological Factors were found to be positively and significantly related with the overall performance of road freight transportation (Dessalegn, 2020). Legese (2023) study result indicate that transportation factors, inadequate cargo handling, slow delivery speed, high freight forwarding service costs, and a cumbersome customs clearance process are the primary reasons for inefficient freight forwarding operations (Legese, 2023). According to Gedamu (2019), both customer requirement strategy and carrier management practice were implemented to a limited extent, while freight payment and audit practice, as well as transport performance monitoring practice, were implemented to a moderate extent. Gedamu further found that a strong relationship exists between transport management practices and logistics performance in the logistics main department (LMD). Gedamu also found out that there are challenges that limit the effectiveness of the transportation implementation process. Gedamu thus concludes that an increase in transport management practice would result in enhanced logistics performance. The author recommends that management at LMD conduct an evaluation of these strategies and how they are precisely implemented.

To the researcher's knowledge, there is no research in the area of construction transport efficiency. Therefore this study explore influencing factors and construction transport efficiency in Addis Ababa across various projects from contractors' perspective.

1.3 Research Questions

1. What are the factors affecting construction transport efficiency in projects administered by Mega projects office?
2. What are the most important factors that influence construction transport efficiency based on respondent perceptions?
3. What recommendations can be drawn to improve transport efficiency?

1.4 Research Objectives

1.4.1 General Research Objective

The general objective of the research is to identify and analyze factor influencing construction transport efficiency of projects in a developing country, Addis Ababa, Ethiopia in the case of Mega Projects Offices.

1.4.2 Specific Research Objectives

The aim of the current research involves:

1. To identify factors that affect construction transport efficiency in Addis Ababa projects administered by Mega projects office.
2. To identify the most significant factors affecting construction transport efficiency in Addis Ababa projects based on respondent perceptions.
3. To propose recommendation based on research findings.

1.5 Scope of the Study

This study focuses on the factors affecting construction transport efficiency in building construction projects, specifically targeting contractors who predominantly utilize road transport. The Construction transport to and from the construction site is the primary focus, which is limited to the movement of materials to and from the construction site, two transport flows that is material and waste flow. For instance, mostly for delivering material to site vehicles such as vans, trucks, crane trucks etc. are used as well to remove waste from site dump trucks are utilized. The contractor were the participant in this study because the construction is coordinated by constrictors including the management of movement of materials to or from the construction site. The reason

for focusing on building construction was the extensive differentiation in construction logistics of building and infrastructure projects and because it allow the relatedness of the results as most previous studies of construction transport logistics have focused on building projects.

The geographical coverage was only Addis Ababa, excluding rural projects and non-road transportations. Methodologically, the study uses a quantitative approach using a structured likert scale survey administered to contractors on projects managed by Mega projects office. The data analysis shall be conducted utilizing statistical techniques such as use of the relative importance index (RII) to prioritize key factors, descriptive statistics and inferential statistics through the use of SPSS v27 were employed to establish patterns regarding transport efficiency factors. The study analyses four predefined factors: information sharing, digital tools & technologies, logistics services, transport management practices and while explicitly excluding external variables like political instability.

1.6 Significance of the Study

This research, named “Factors Affecting Construction Transport Efficiency in a Developing Country Context: The Case of Mega Projects Office” is significant in investigating the factors like information sharing, digital tools & technologies, logistics services and transport management practices which affects the construction transport efficiency. Identifying the uninvestigated factors which affects the construction transport efficiency and the relative importance of the factors in Mega projects office.

Theoretically, this study has significant theoretical value as it confirms the findings of exiting studies related to this study on the effect of information asymmetry on delays and the effect of logistics services on on-site congestion. This study has also significant value in advancing the body of knowledge by exposing the relationship between digital tools and construction transport efficiency measures in the area of lean construction and supply chain management in Ethiopia. Practically, the study also has significant value as it offers actionable recommendations on construction transport efficiency that contractors can use to be productive. The study also has value as it offers recommendations on construction transport efficiency that policymakers can use in line with city logistics for sustainable development. Environmentally, this study has significant value as it supports sustainability by confirming that construction transport efficiency has a positive

effect on the reduction of fuel consumption and mismanagement of construction waste. Socially, it promotes safer worksites through efficient material handling. By bridging exploratory case studies with empirical validation, this study informs scalable strategies for sustainable construction logistics globally.

1.7 Operational Definitions

Construction transport is defined as “the delivery of materials, machinery and equipment to construction sites as well as the transportation of waste, soil and rock masses away from the sites” (Sezer & Fredriksson, 2021a).

Construction transport efficiency is defined as performing all construction transport activities from the point of loading to the point of unloading materials either from or to the construction site while utilizing the minimum number of resources including, but not limited to fuel consumption and time taken, while ensuring minimum environmental impact (Naz, 2022).

Construction logistics can be defined as providing a construction site with resources in the form of materials, machines and personnel in an efficient manner along with managing resources efficiently on the construction site itself as well as ensuring efficient recycling and waste management that enables circular economy and durability (Janné and Fredriksson, 2018).

Logistics management is defined as “that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customers’ requirements” (CSCMP, 2013).

Logistics services are defined as activities that organize and manage the movement of goods (Mentzer et al., 1999).

Vendor Management Inventory (VMI): Vendor management inventory is an inventory management practice where the user of a product provides information to the supplier of a product and then the supplier ensures the availability of the product usually at the place of consumption.

Freight Forwarder: Generally, freight forwarder is an entity that organizes shipments for individuals or corporations from the supplier to a market, customer or final point of distribution.

Construction supply chain (CSC): CSC refers to the planning, coordination and optimization of the flow of materials, information and finances across construction. It involves managing the sourcing, procurement, logistics and delivery of construction materials and services required for the construction (Naz, 2024).

Information asymmetry: Information asymmetry refers to a situation in which one actor has access to more or better information than another actor (Clarkson et al., 2007), or that no actor has access to all the information needed to carry out their tasks efficiently (Aben et al., 2021).

Terminal is type of construction logistics solution which is defined as a place where long distance transport is converted into short distance transport and consignments are also sorted and packaged here (Russo and Comi, 2010).

Main contractor: The main contractor is a company who oversees the building process according to the terms and conditions outlined in the construction contract. This role involves engaging personnel to carry out different construction activities (Naz, 2024).

On-site vs off-site logistics: On-site logistics is the management of logistics activities directly on the construction site, whereas off-site logistics involves the management of logistics activities related to the transport of resources to and from the construction site (Ghanem et al., 2018).

Subcontractor: A subcontractor is a company hired by the main contractor to perform specific tasks or provide specialized services e.g. electrical work, plumbing, etc. within construction (Naz, 2024).

Transporter: A transporter refers to a company responsible for moving items from one location to another. Ownership of vehicles by the transporter is optional (Naz, 2024)

Waste collector: A waste collector is a company that deals with the collection of waste, transporting, sorting and recycling (Naz, 2024).

Contingency plans: Contingency plans are predefined strategies and actions that companies implement to respond to potential unexpected events or emergencies that could disrupt normal operations e.g. alternative delivery routes, backup material suppliers, additional labor etc.

Construction logistics setups (CLS) is defined as “the way that the logistics system, including elements, components, information system etc. are designed and arranged to handle logistics in a construction project” (Ekeskär & Rudberg, 2020, p. 1).

Logistics Service Provider (LSP): Logistics service provider is a company which specializes in providing logistics service as its core business. Some types of logistics services include distribution, storage, transportation, packaging, material handling etc.

1.9 Organization of the Study

Chapter one of the study consists of the general introduction, which includes the background of the study, the statement of the problem, the objectives of the study, the research questions, the significance of the study, the scope of the study, operational definitions of the study, and the organization of the study.

Chapter two is the literature review, which evaluates the works of other researchers on the subject of the study, their approaches and also identifies gaps in the existing literature and establishes the theoretical and conceptual frameworks used to guide the research.

Chapter three discusses the methodology employed in the study, including the research design, population and sample size, sampling techniques, data collection methods, and the tools used for data analysis. This chapter ensures the transparency and reproducibility of the research process.

Chapter four presents the results and discussions of the study and provides a detailed analysis and interpretation of the findings in relation to the research objectives and questions. This chapter then connects the findings to the theoretical and conceptual frameworks outlined in chapter two.

Finally, chapter five concludes the study by summarizing the key findings, discussing their implications and providing recommendations for practice, policy, and future research. This chapter also includes a reflective discussion on the limitations of the study and their potential impact on the results

CHAPTER TWO

REVIEW OF RELATED LITERATURE

This chapter synthesizes existing research on theories related to the study, construction transport efficiency, examining key themes such as logistics and transport management, supply chain coordination also explores foundational concepts like construction processes under in the basics of construction industry and operational challenges ending with a conceptual framework to guide the study.

2.1 Lean Construction Theory

In the construction industry, lean construction (LC) evolved from Koskela's construction production theory which combines lean production principles classified under transformation, flow and value views. The transformation-flow-value (TFV) method places greater emphasis on the transformation view of waste reduction by dividing construction process activities into non-value added (NVA) and value added (VA) activities. Under TFV, transformation which is accomplished using resources, equipment and labor, material flow, and customer focus are recognized to represent three separate production views. The limitations of conventional project management approaches led to the development of lean construction achieving great improvement in management approaches and project outcomes. Founded on the idea of waste reduction, lean construction has embraced various principles to reduce cycle time, product/service variability, encourage continuous improvement and improve transparency (Santos, 1999; Koskela, 2000). For example, lean thinking principles in the UK construction industry seem to focus on improvement of quality and efficiency, along with other principles such as mapping for value stream, establishing pull planning and structuring the construction process into flows.

In the early stages of LC implementation, the 'map for value stream' is the first strategy utilized (Dave 2013). Lean Design Management (LDM) regulates the link between the procurement, designers, and builders to extract, translate, compare, and determine value. LDM streamlines design processes and eliminates waste for architects, structural, and MEP engineers. The VSM2 tool visualizes NVA, including cycle time, queue time, and work-in-progress for information and material flows (Rother and Shook 2003). According to Rosenbaum, Toledo, and González (2014) and Vilventhan, Ram, and Sugumaran (2019), NVA indicators can help reduce

manufacturing waste and associated environmental, economic, and societal losses in the supply chain.

According to Vrijhoef and Koskela (2000) and Bortolini, Formoso, and Viana (2019), effective lean supply chain management requires a just in time system that forecasts based on production signals rather than demand. Production signals can be obtained from lean planning and control solutions, such as the last planner system (LPS) and location based management system (LBMS), are used to raise stakeholders' situational awareness of waste. The LPS is a context specific a socio-technical system that aims to improve planning reliability through successive collaborative sessions to shield the downstream from upstream variability (G Ballard 2000; Glenn Ballard 2020). LBMS is a spatial-temporal and socio-technical system that plans and structures building operations based on location (floor, zones, sections, and floors). It also handles activity handoffs for many trades (Björnfot and Jongeling 2007). LPS and LBMS can be used together to reduce waste from work in progress, waiting, space congestion, and overproduction. Finally, relational contracts ensure awareness among stakeholders regarding their responsibilities towards elimination of waste, acting as a legal guideline for encouraging involved parties regarding the use pull planning, value stream mapping and resolve disputes about waste (Forbes and Ahmed, 2010; Sacks et al., 2018). Waste elimination along with the implementation of pull based logistics systems can improve construction transport efficiency.

2.2 Resource Based Theory

One of the most widely accepted theoretical perspectives in strategic management literature is resource-based view (RBV) which was contributed by Wernerfelt's in 1984. RBV has emerged as a key concept to explore the potential impact of resources on the competitive advantage and performance of a firm. Therefore, RBV is widely utilized as a tool to generate conceptual frameworks (CF) in construction project management (CPM; Kabue and Kilika, 2016). According to the RBV assumption, organizations can enhance their performance and competitive advantages through the effective application of valuable resources and capabilities.

The resource-based view conceptual frameworks includes crucial elements such as resources, capabilities, competitive advantage, and performance. Other factors are required to explain the effect of resources on performance; capabilities and competitive advantage have emerged as

mediators in the relationship between performance and resources (Carrick, 2016). Regarding firm resources, resources are needed for the initial function, and without those factors, the firm may be impossible to develop. Wernerfelt (1984), who is credited with being the first to develop RBV theory, defined resources and products as two sides of the same coin. Returns can be raised by identifying and obtaining important resources, and the resources employed in production influence the firm's performance indirectly (Newbert, 2007). Which are also the research's focus areas. In terms of company capabilities, Teece, Pisano, and Shuen (1997), the other theoretical approach under RBV, believe that the effect of resources on performance requires additional components. Teece, Pisano, and Shuen (1997) dynamic capabilities research led to the classification of resources as well as capabilities. According to this classification, resources were described as factors managed or owned by the organization; these resources could be transformed into the end product/service via the organization's assets and machinery. Capabilities were defined as the organization's ability to deploy resources to achieve the intended outcome (Ismail et al., 2014). As a result, firm performance is the most significant and most used dependent variable in the RBV-CF. Previous research has included several types of performance in their frameworks, such as operational performance, firm performance, and others (Yang, Jia, and Xu, 2019). In this research, Transport efficiency relates to operational which is derived from the efficient use of firm specific resources.

2.3 Logistics Management and Transport

The concept of logistics is one that is in a state of constant evolution (Tudor et al., 2012). The earliest manifestations of this evolution can be observed in the lack of coordination among the various functions of an organization, with each function operating in its own silo (Tudor et al., 2012). This fragmented approach was subsequently transformed into an integrated approach, with different functions being aligned to achieve organizational goals (Azmi et al., 2017).

Logistics involves a wide range of tasks, including raw material storage, work-in-process and finished inventories, material handling, transportation, packaging, and administration (McKinnon et al., 2015; Naz, 2022). Management, on the other hand, is a set of principles that govern the functions of planning, organizing, directing, and controlling, as well as the application of these principles in the efficient use of physical, financial, human, and informational resources

to achieve organizational goals (Kaehler & Grundei, 2018). Accordingly, the term logistics management is typically defined as follow:

That part of supply chain management that plans, implements and controls the efficient, effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customers' requirements (CSCMP, 2013).

In alignment with the notion that transport constitutes a pivotal element within the realm of logistics, it can be defined as "the movement of goods between different points in the supply chain" (Britannica, 2019).

Transport can be considered one of the most crucial elements a city infrastructure. It plays an essential role in ensuring sustained economic growth and competitiveness in the global marketplace (Rehnlund, 2019; Vassallo & Bueno, 2021). For this reason, transport operations are deemed one of the essential elements in modern society (Cahill, 2010). Nevertheless, transport, which enables productivity and efficiency in various economic and social frameworks still impacts society in significant ways including congestion, delays, accidents, and environment related factors including air pollution and noise pollution among others (Vassallo & Bueno, 2021). For this reason, it can be considered that transport infrastructure and operations in today's world play an important role in shaping the physical environment and societies in addition to their impacts on the environment related factors (Rehnlund, 2019).

The issue of efficiency, as well as adherence to environmental standards is one of the key considerations in the realm of transport planning. According to Upton (2018) the increasing rate of urbanization has led to a corresponding increase in travel demand, as a result there is a need for the expansion of transport infrastructure. This shows a great need for effective transport planning for the smooth flow of people and goods, a fact that is currently being threatened by the increased congestion and increased transport demand on the road network (Vassallo & Bueno, 2021). Transport planning is described as "The planning required in the operation, provision and management of facilities and services for the modes of transport to achieve safer, faster, comfortable, convenient, economical, and environment friendly movement of people and goods" (Banister, 2002, cited in Naz, 2022). According to Vassallo & Bueno (2021) for effective transport

planning, a collaborative platform needs to be created involving all stakeholders such as transport planners, the government, the land use authorities and other parties.

Rogerson and Santén (2017) suggest that not only transport provider, but transport buyer can also play significant role in reducing the environmental impact from transports. As Santén (2013) observes, the actions of transport buyers exert a significant influence on the operations conducted by transport providers. For example, fast transport time and low price of transport demands by transport buyers will allow transport provider to be able to act more efficiently and environmentally. This example illustrates that both the transport buyer and the transport provider exert an influence on one another and have the capacity to act (Eriksson, 2019). According to Naz (2022) the transport buyer is the entity that purchases logistics services in exchange for money, while the transport provider is the actor that provides efficient logistics services to the buyer. Furthermore, when logistics activities are purchased in exchange for money, they are transformed into services (Naz, 2022).

2.4 Transport Efficiency

The definition of transport efficiency is different as perceived by the different researcher depending upon who is asked and it lacks clear definition which is why it is called fuzzy concept (Arvidsson, 2011 & Sanchez-Diaz, Palacios-Argüello, Levandi, & Mardberg, Basso, 2020). According to (Arvidsson, Woxenius & Lammgård 2013) transport efficiency is defined as “producing a service with less resource consumption without reducing the logistics performance in terms of costs and delivery service”. (And Markovits 2011) define efficiency “as a ratio between the outputs and the inputs of a given activity”. Thus, efficiency is affected by how well the resources are being utilized and how well the utilization of the resources affect efficiency (Dubois & Gadde, 2000). In essence, efficiency pertains to maximizing output from a predetermined set of resources (Sanchez-Diaz et al, 2020).

Transport system efficiency depends on “how resources are utilized within the system. These resources include business models, vehicles, drivers, information technology, and infrastructure” (Moen, 2016, p. 871). Transport efficiency encompasses the evaluation of resource utilization, the coordination of transport activities, and the interactions among the various stakeholders involved (Eriksson, 2019).

In the field of transportation, time efficiency plays a pivotal role. From a transport perspective, time efficiency is defined as "the distribution of daily deliveries using the shortest possible time" (Sanchez-Diaz et al, 2020). In accordance with the findings of preceding studies, Naz, Fredriksson, and Ivert, (2022) defines transport efficiency as the maximization of goods moved from one location to another in the shortest possible time.

Transport efficiency can be achieved through the implementation of technology, the organization of transport in the most suitable way possible, the maximization of resource utilization, and the coordination of transport activities, among other methods (McKinnon, 1999 and Eriksson, 2019). According to Arvidsson, Woxenius, and Lamngård, (2013), in transport efficiency behavioral and operational aspects are also of considerable importance so is not solely determined by technical improvements. The enhanced time efficiency of transport activities engenders cost savings for transport operators, enabling them to engage in more value adding activities throughout the day while maintaining the same level of resources (McKinnon, 2015). For instance, a reduction in the time allocated to planning, loading, unloading, and driving results in increased availability for truck drivers to engage in additional activities (Levandi & Mårdberg, 2016 and Sullivan, 2010). Consequently, the transport service provider can achieve a reduction in the number of trucks without compromising service quality (Sternberg, 2011). Moreover, this approach contributes to the modification of congestion and the reduction of environmental impact.

2.5 Basics of Construction Industry

Construction is defined as the process of creating, repairing or enhancing fixed assets as well as the facilities that are associated with them. Razak Bin Ibrahim et al. (2010) explained that an activity that involves the development of structures like schools, homes, hospitals, airports, railways, factories, and shopping centers. This is in line with the view offered by Hughes et al. (2015) that construction is a form of economic activity that is aimed at the development, renovation, repair or extension of fixed assets like buildings, land improvements, roads, bridges and dams.

The construction industry encompasses a wide range of activities. Razak Bin Ibrahim et al. (2010) argue that this industry encompasses firms involved in building construction, heavy infrastructure, as well as firms involved in addition, alteration, reconstruction, installation,

maintenance or repair. In addition to this, firms involved in demolishing of buildings, clearance of construction sites as well as firms that sell construction debris are part of the construction industry. In this regard, this definition fits well with that provided by United Nations (2013) which defines a construction industry as a part of a nation's economy that regulates land preparation as well as land development activities including remodeling of properties.

According to Sears et al. (2015), a number of parties are involved in a construction project, and these include architects, engineers, skilled labor, material suppliers, designers, project managers, main contractors, specialty contractors and clients/owners. The authors observe that contractors with different levels of expertise and specialization undertake construction projects. General contractors are generally responsible for overseeing overall construction work, while specialty contractors focus on particular project aspects. Often, general contractors hire specialty contractors and this forms a network of professionals in the construction industry.

The construction industry carries out its operations in environments that can be regarded as dynamic and to a large extent unpredictable mainly due to the outdoor nature of the operations. Razak Bin Ibrahim et al. (2010) emphasize the unpredictability of the environment as being particularly significant in influencing the operations in the construction industry. Peiffer (2015) further classifies the construction industry into three major sectors, which include building construction, heavy construction and special trade construction. According to Fredriksson et al. (2024), the construction projects covered in their research involve house building projects similar to offices, housing, new construction, renovation, and extension. It is, therefore, the study focused on the building construction sector, which involves operations related to the development and upgrading of structures for residential, commercial, and institutional purposes.

2.5.1 Construction Process

The authors Sears et al. (2015) describe construction projects as being inherently complex and time consuming, usually involving a series of stages: planning and definition, design, procurement, construction, and project completion. Each of the stages requires intensive management, observation, and specialized services such as electrical tasks, concrete pouring, excavation, piping, and roofing.

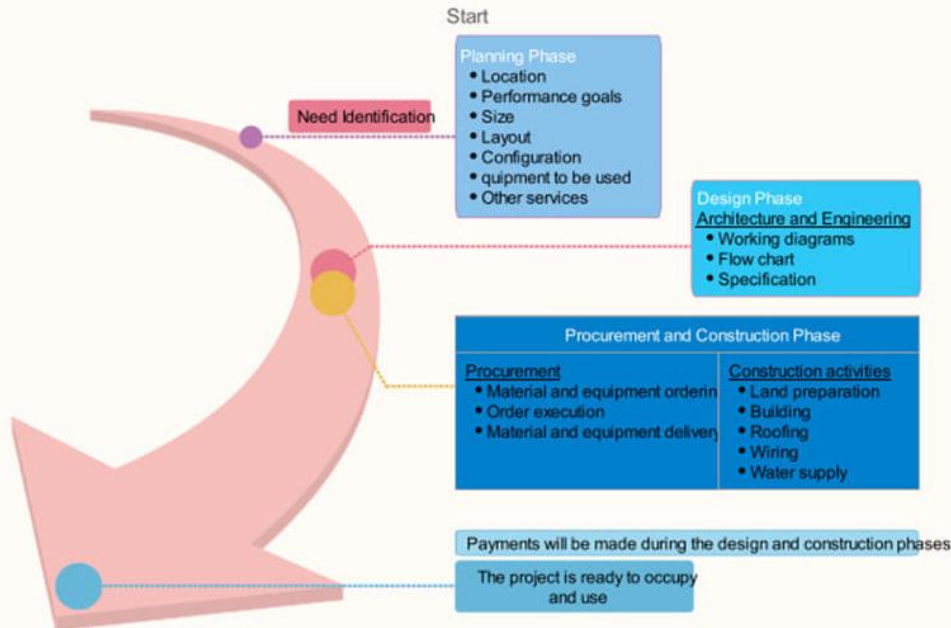
According to Odeh (2019), the construction process begins with the initiation stage where the initial concept is communicated from the client or owner to the consultant or designer. Sears et al. (2015) emphasize the crucial part played by the client or owner in the initiation stage of the project where they identify the need for the project and set parameters for the project. This stage ends at the planning stage where general project features are identified, which include location, performance requirements, size, layout, configuration and equipment.

After the conceptual planning phase, the preliminary design phase begins as indicated by Odeh (2019). In this phase, Sears et al. (2015) pointed out the architecture and engineering aspects of the proposed project are developed. After the proposed design has been approved by the client, the design becomes definitive and the next phase which involves the procurement and the execution of the proposed project takes place as indicated by Odeh (2019).

Sears et al. (2015) describe procurement as the process of ordering, acquiring, and delivering the required material and equipment. The resources in addition to labor, management, and supervision, enables the execution of the construction process. After the completion of the construction process, the project is then handed over to the client for occupation, use and the contract is closed (Sears et al., 2015). The construction process is shown in Figure 2.1 below.

Figure 1 Different phases of construction process (Adopted from Naz, 2019)

Construction Process



2.5.2 Construction Flows

Sacks (2016) argues that the essence of the construction sector, which is intrinsically complex and dynamic makes it difficult to manage and control various flows that occur within a project. According to Kalsaas and Bolviken (2010), the meaning of “flow” is a sequence of events that involves uninterrupted movement, creation of value and smooth flow. Sacks (2016) further explains that the flows that occur in the construction sector can be classified into “physical flows,” which involve the movement of materials and equipment, and “immaterial flows,” which involve information flow, labor, space, and other factors like weather or approval of regulatory. Sacks (2016) highlights that the most visible flows that occur in the construction sector are the flows that involve labor and equipment, since the end product, which is the building, is fixed.

According to Alves and Formoso (2005), planning and control of construction process flows regarding labor movement, material transportation, and equipment movement can greatly improve process transparency. This can potentially result in cost savings, time savings, waste reduction and reduction in variability to improve the entire project process efficiency.

2.5.2.1 Physical and Information Flow in Construction Industry

According to Alves and Formoso (2005), the physical flow process involves material flows and production unit flows. This distinction in the physical flow process was noted in the context of construction activities. Sacks (2016) argues that the measurement of physical flow is challenged by the absence of a flow oriented perspective in traditional construction management practices. Patel and Vyas (2011) emphasize the importance of effective physical flow in providing adequate materials for the construction activities on time and in correct quantity.

As explained by Patel and Vyas (2011), the physical flow process begins with the identification of material requirements on site. The material is then ordered from the store, wherein an indent described by Merriam-Webster (2019) as an official order or requisition prepared for procurement from multiple suppliers is created. The availability of material is then verified once the indent is created. If the material is not found, suppliers are selected based on the approved vendors list of the client. The material is then inspected and any excess and non-essential material is shipped back to the suppliers. The material is then issued to the respective department and subsequently to the point of use using suitable modes and equipment (Patel and Vyas, 2011). The above steps can be summarized as follows in Table 1.

Table 2. 1 Physical flows steps (Adopted from Patel and Vyas, 2011)

Steps involved in physical flows
• Material required on-site
• Indent generated for in-store ordering.
• Checking in-store material availability
• Choosing a vendor from the client's approved list
• Inspecting received stock
• Return of unnecessary stock
• Issuing material to the appropriate department

- Delivering material to the correct location using appropriate equipment and transportation.

Alves and Formoso (2005) suggest that uncertainty in physical flows can be minimized through improved planning and control at various hierarchical levels of the construction process. For instance, at the strategic level, the development of a comprehensive site layout is necessary, whereas at operational level, workflows of repetitive processes should be prepared and at tactical level, the management of cleanliness and workplace order should be done (Alves and Formoso, 2005).

According to Golyani & Yan Hon (2010), incorrect and late information flow has remained an important issue in the construction industry. Information flow has been found to happen in a structured sequence with reference to its source or endpoint, its path or interaction as well as its driving force defined as mutual relevance by Phelps (2012). Otjacques, Post, & Feltz (2005) found hundreds of information flow instances arising from the involvement of various stakeholders in construction projects. Golyani & Yan Hon (2010) identify some of the essential elements of construction information to comprise design drawings, specifications, schedules, calculations of budget, minutes of meetings, invoices as well as flowcharts, while construction information has been found to change during construction as a result of constant updates during the planning phase of construction projects.

According to Otjacques, Post, and Feltz (2005), information sharing refers to a number of processes and elements, which provide relevant knowledge and evidence to the required stakeholders. This information may comprise updates, measure of cost control, documentation, risk analysis and schedules. The authors argue that both formal and informal information-sharing mechanisms have a significant impact on project quality, cost, and timely completion. As multiple stakeholders are involved, efficient and effective information sharing is crucial for informed decision making and successful project execution.

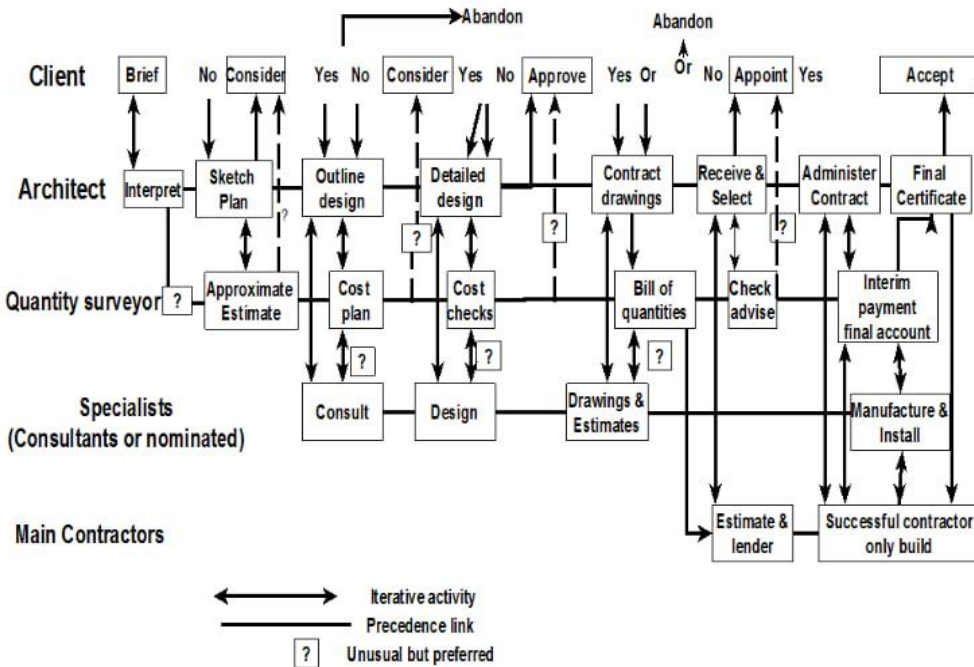
Forcada Matheu (2005) describes the general sequence of the flow of information in a construction project. It starts with sharing the requirements of the client with the project manager and the designer. As soon as the idea of the project from the point of view of the client is clear, a "strategic brief" is developed that includes the planning of the procedures, the project's setup, the

consultants involved in the process, etc. The following step includes the development of a "full brief," which narrows the focus of attention to cost estimates and procurement issues. After that, "production information" is developed that can support the process of tendering (Forcada Matheu, 2005).

Tribelsky and Sacks (2010) emphasize the need for complete and clear information to be provided in the tender stage. According to Kenton (2019), the tender is "a method of inviting supplier to submit bids, structure invitation in which the terms and conditions of the contract are clearly stated." On the other hand, the bid is "an offer to supply something, usually in return for payment that shows the price and the value of the product or service." After the tender, potential contractors and subcontractors are assessed. Later, Contractors are appointed and the construction begins. According to Ndekugri and McCaffer (2006), the need for information to be transferred effectively in the construction and design stages cannot be overstated, as timely information transfer is necessary for the effective coordination of the stakeholders. When the construction is complete the "handing over" stage is where the inspections and settlements are conducted as discussed in the context of the information flow in the construction project lifecycle (Ndekugri & McCaffer, 2006).

Bröchner (2005) visualized the flow of information in a general construction project, adapting the framework established in Bishop's information flow model (1972), as illustrated in Figure 2.2:

Figure 2 Information flow in general construction project (Adopted from Bröchner, 2005)



2.5.3 Construction Site Organization

According to Merriam-Webster (2019), a construction site refers to land that has been designated as an area of construction activity or that has an existing structure under construction. Holland (2014) argues that the proper organization of construction sites is a thorough process that remains vital in maintaining a safe and healthy working environment throughout the construction phase. According to Vidovszky (2015), site preparation involves a variety of tasks such as traffic management, public safety assurance, storage of construction materials, proper disposal of wastes, preparation of requisite documentation and adherence to legal requirements.

Holland (2014) emphasizes the importance of the segregation of pedestrian and vehicular traffic in the site to avoid accidents. It is recommended that there should be designated points for the entry and exit of pedestrians and vehicles, along with walkways and crossings for the prevention of slips. The factors considered for the effective management of the site include the visibility, obstruction and barriers. It is further recommended that the movement of vehicles should be restricted within the site by avoiding the parking of vehicles for workers and visitors near the site, restricting the entry areas, and designating a separate area for the delivery vehicles carrying goods to avoid unnecessary trips across the construction site.

Vidovszky (2015) highlights the need to maximize visibility on construction sites. This may be achieved in a number of ways, such as the use of mirrors, reverse alarms, closed-circuit television (CCTV) cameras and adequate lighting. It is also essential to demarcate the boundaries of a construction site to prevent unauthorized persons from accessing the site thus improving safety. In order to minimize accidents on construction sites there is a need to keep stored materials in designated areas as well as covering manholes or pits with lids.

Holland (2014) suggests that it is advisable to handle inflammable items with caution. These items should be stored away from the construction site in order to avoid any accidental fire or contamination. The author further stresses the need to provide facilities such as toilets, washrooms, drying rooms, kitchen facilities, dining facilities, rest rooms, soundproof telecommunication booths, etc., which can cater to the needs of the workers. There should also be proper security arrangements made in order to prevent theft of items, vandalism, etc., so that the construction site can function smoothly.

2.6 Supply Chain Management in Construction Industry

Lee (2002) underline that supply chain management (SCM) has developed as a key driver of competitive advantage. Dubois et al. (2019) describe SCM in the construction industry as "the planning and management of activities with channel partners coordinating and collaborating which include suppliers, intermediaries, third parties and customers." Four basic SCM functions in construction are identified by Andersson and Nilsson (2018) and Dubois et al. (2019), which can be applied from a supply chain and a construction site perspective. The four functions initially traced back to Koskela and Vrijhoef's in 2000 and are outlined in Table 2.

Table 2.2: Four roles of supply chain management in construction (Adopted from Naz, 2019)

Roles of SCM in Construction	From which perspective/focus	To achieve	Beneficial for
First role	Focus on impact of supply chain on site activities	- To reduce time consumption from activities and cutting overall costs on site	Main contractor

		- To ensure dependable material and labor flows to the site to avoid disruption to the workflow	
Second role	Focus on impact of supply chain on itself	-To reduce costs not only on-site as well as along whole supply chain such as logistics, lead time and inventory	Material and component supplier
Third role	Focus on transferring activities from site to early stages of supply chain	-To avoid interference between on-site activities -To achieve wider concurrency between activities	Contractors and suppliers
Fourth role	Focus on integrated management and entire supply chain	-To improve supply chain and sit production	Clients, suppliers or contractors

The Construction Supply Chain (CSC), however, exhibits unique and complex characteristics (Koskela and Vrijhoef, 2000). Firstly, the CSC behaves like a converging chain

since all resources and materials are directed towards the construction site to be assembled into the building from the incoming resources. Secondly, the CSC is a “temporary chain” since its existence is only during the period of the construction project.

Moreover, the construction supply chain has been characterized as unstable, fragmented and complex. The CSC has also been further classified as a make-to-order supply chain because of the idea that a new product or prototype tends to be developed through the process of completing a given construction project. There is very little repetition of projects in the construction industry because most projects undertaken in the industry can be considered unique with significant variations. However, there are some exceptions that can be considered standardized projects.

2.6.1 Role of Coordination and Collaboration within Construction

According to Bankvall et al. (2010), the construction supply chain has both sequential and pooled interdependencies and these interdependencies need to be considered in the planning and coordinating process. The concept of sequential interdependencies refers to the situation in which the outcome of one task is used as an input for the next task, while the concept of pooled interdependencies refers to tasks that are interdependent and contribute to the achievement of a common outcome (Bankvall et al., 2010). These interdependencies in the construction supply chain contribute to the challenges in the management and efficiency of the construction supply chain a domain considered complex owing to various factors, including the temporary nature and characteristics of the construction projects and the involvement of numerous interdependent actors in the construction projects who operate at arm’s length relationships (Ekeskar & Rudberg, 2020; Janne, 2018; Thunberg & Fredriksson, 2017).

As a result, a temporary form of organization emerges in which the parties collaborate on a multifaceted task for a limited period (Bygballe & Ingemansson, 2014). The construction industry has a wide range of stakeholders, which include major contractors, subcontractors, material suppliers, logistics providers, developers, designers, consultants, clients, and government organizations. The stakeholders participate in the various phases of the construction process which include the design phase, construction, procurement, among others, where designers and consultants participate in the design phase, plus material suppliers, main contractors, among

others, participate in the construction phase (Brusselaers et al., 2021; Fredriksson et al., 2021; Janne & Fredriksson, 2020; Osipova, 2007; Sears et al., 2015; Vrijhoef & Koskela, 2000).

For instance, poor performance in supply chains in the construction industry has been linked to a lack of coordination and communication between various stakeholders (Bankvall et al., 2010). Bengtsson (2019) also emphasized the importance of coordinated construction logistics in increasing efficiency in the supply chain by reducing waste associated with building materials. According to Bengtsson (2019), coordination in supply chains can increase production while at the same time reducing costs. Vanagas and Stankevic (2014) described coordination as a process that ensures alignment of various components of an organization or multiple organizations to attain a common goal efficiently. It involves the alignment of goals, information sharing and management of interdependencies between tasks. Effective coordination can potentially improve efficiency in resource utilization, reduce redundancies and enhancing performance (Vanagas & Stankevic, 2014). While formal mechanisms like contracts and organizational hierarchies have traditionally ensured coordination, informal aspects like trust and shared norms are also important in encouraging cooperation (Donato et al., 2015; Elsner et al., 2010). However, conflicts can also occur between main contractors, subcontractors, and suppliers of building materials. For instance, main contractors can view subcontractors and suppliers of building materials as key actors in achieving cost reduction leading to unfair practices that can undermine trust. (Donato et al., 2015).

In order for these issues to be addressed, literature has suggested that collaborative partnerships may improve the construction supply chain (Bygballe et al., 2010; Crespín-Mazet et al., 2015; Donato et al., 2015). Performance of construction supply chains may also be improved by implementing construction logistics setups (CLS) that may facilitate coordination between actors, resources, and activities (Ekeskar et al., 2022). These configurations may include checkpoint-based configurations that may be operated by third-party logistics providers as well as terminal-based configurations that may accommodate storage of materials. However, it is essential for further study of interactions between contractors and third-party logistics providers in order for these logistical arrangements to be improved (Ekeskar et al., 2022).

2.7 Construction Logistics and Transport

2.7.1 Construction Logistics

The aim of any construction project is to complete it within the stipulated period, budget, and in accordance with established standards of quality. Achievement of this aim requires that a substantial amount of materials and resources is delivered in time to the right location in compliance with site management legislation (Kim and Nguyen, 2018). The construction industry, nevertheless, is characterized by a unique project requirement, which calls for contractors, subcontractors and suppliers for each project (Seth et al., 2018). Navon and Berkovich (2005) argue that this varying environment often leads to ineffective management or neglect of logistics. Ying et al. (2018) observe that logistics management in building projects has in the past been managed in an ad hoc manner where logistics requirements are being fulfilled in a day-to-day approach. For this reason, construction logistics has not been viewed as having great promise area for improvement (Ying et al., 2018). However, some researchers have pointed out that it is possible to improve the general performance of this industry by effectively managing logistics (Dubois et al., 2019).

Construction logistics has been defined as “the supply of resources to the construction site in an efficient way along with the management of resources at the construction site such as materials, machinery and labor as well as promoting resourceful recycling/waste management with the aim of creating a circular economy with enhancing product durability” (Janné & Fredriksson, 2018). Moreover, construction logistics has been defined as “the coordination of materials/resources to, from, and at construction sites” by Janné & Fredriksson (2020). Ghanem et al. (2018) suggested a dual approach for managing construction logistics as there are two important aspects of construction logistics: (1) “the management of logistics activities at construction sites” and (2) “the transport of resources/materials to/from construction sites.” Moreover, logistics at construction sites relates to “the physical flow planning as well as material handling at construction sites,” whereas logistics off-sites relates to “the specification, procurement, transport, as well as delivery of materials to/from construction sites”. It has also been found that “the integration of off-sites logistics with on-sites logistics plays a significant role in improving construction projects’ productivity” (Fadiya et al., 2015).

In a similar manner, Lundesjö (2015) suggests that the process of managing and scheduling the delivery of goods to construction sites by large vehicles which is known as lorry delivery is a key part of construction logistics. This includes the delivery of equipment such as hoists or cranes as well as the management of crane hook times operation. In addition, the storage of goods on construction sites is a domain of construction logistics, which further emphasizes its multifaceted nature. Moreover, construction logistics has been argued to comprise activities such as packaging, relocation to storage points, relocation to storage, loading on a vehicle or a truck, transport to the construction site, unloading on the site, storage on the site, relocation to the point of use as well as the return of waste or recyclable materials to their original point. In terms of the volume of activities, Lundesjö (2015) argued that logistical activities comprise more than 80% of all construction activities.

2.7.2 Construction Transport

Construction transport is the process of delivering the construction materials from supplier to construction site and from site to waste storage areas (Fredriksson, and Sezer, et al., 2022). It is about transporting construction tools to the construction site and from the construction site (Ibid). In broader term, construction transport includes transportation of construction materials, equipment, and labor to the construction site and returning dysfunctional and waste materials to the mass storage areas (Sezer & Fredriksson, 2021a). In due process of delivering the construction materials to the construction site, suppliers may use different vehicles and load carriers (Fredriksson, Janne, Nolz, et al., 2021). At the first stage of the construction project, suppliers prioritized the transportation of excavation materials such as sand, soil and rock to and from the construction site. In this connection, Fredriksson, Janne, Nolz, et al., (2021) identified pallets, packages and wastes as the construction materials that the suppliers transported in the last stages of the construction project. Transporting construction materials to the construction site involved various actors such as material suppliers, equipment suppliers, sub-contractors, specialists, and service providers (Proverbs & Holt, 2000). Vrijhoef (2020) and Vrijhoef and Koskela (2000) classified construction transportations into four categories: long distance transport (representing heavy truck and heavy construction materials); medium distance transport (mostly involving excavation materials); short distance transport (pickup or delivery services using small trucks) and return transport (including construction materials such as waste, packaging and pallets transported

by dump trucks). For the current research Naz, (2024) definition of construction transport efficiency is used i.e.

“Construction transport efficiency can be defined as performing all construction transport activities from the point of loading to the point of unloading materials either from or to the construction site while utilizing the minimum number of resources including, but not limited to fuel consumption and time taken, while ensuring minimum environmental impact.”

2.7.2.1 Construction Transport Activities

According to Naz (2024) report, "construction transport" refers to the movement of materials to, from, and within a construction site. The author investigated two different transport flows: material flow and waste flow. These tasks were further divided into three types: value adding, non-value adding, and necessary but non-value adding activities. Value adding activities, according to Sternberg (2011), are those that add value to the end product while also benefiting customers. Non-value adding activities, on the other hand, have no positive impact on the end product's value and may even have a negative effect. According to Koskela (1993), while all activities cost money and take time, only value adding activities directly contribute to the achievement of desired outcomes. As a result, the lean methodology stresses process redesign with two primary goals: first, to eliminate or decrease non-value adding tasks, and second, to devote more time and resources to activities that provide value.

Customer perception determines whether an activity is value adding or not. These activities are grouped under a general term “waste” from a producer's point of view. According to Bølviken et al. (2014) there are three types of waste: material waste, time loss and value loss. Material waste, as defined by Bølviken et al. (2014) is the inefficient use of resources such as material, machinery, energy and labor. Time loss in a flow perspective includes wasteful movements, unproductive work, waiting, unused space, unprocessed resources, unnecessary transportation, etc (Bølviken et al., 2014; Kurdve & Bellgran, 2021). According to Bølviken et al. (2014), value loss may be caused by inadequate quality, lack of use, harmful emissions, injuries, etc.

Based on the literature of Sternberg (2011) and Villarreal et al. (2017), the implementation of a lean system has the capability of improving transportation performance through the removal of

non-value added operations. Non-value added operations include waiting during loading/unloading, unnecessary vehicle movements, poor routing, ineffective information exchange, repetitive operations paperwork, excess travel, inappropriate equipment usage as well as inadequate workforce availability among others. In a similar perspective, according to Naz (2024) value-added operations of the materials' flow process include loading, transporting as well as unloading which are all important for the movement of materials. On the contrary, non-value-added operations of the materials' flow process include searching for the appropriate address, searching for the unloading location, contacting relevant individuals, and waiting for unloading among others as they are not important for improving the movement of materials. In fact, non-value-added operations of the materials' flow process result in waste of resources, which consequently create room for improvement, as mentioned earlier. Moreover, value-added operations of the waste flow process include loading waste containers, transporting waste containers, discarding waste materials as well as returning empty waste containers which are all important for the waste flow process as discussed earlier.

Furthermore, the presence of non-value-added activities such as the time taken to await filled waste containers and the need to visit the construction site to drop off empty containers contributes to the inefficient use of resources. These are the types of problems that the mitigation of will contribute to the improvement of the overall efficiency of the construction waste flow. Moreover, the need to weigh the containers and complete the necessary paperwork are all important and necessary tasks. These are also classified as essential and non-value-added tasks and are important and necessary for the improvement of the overall construction efficiency. However, as discussed by Pérez and Costa (2018), there is a need to maintain a balance when it comes to the transportation of materials. This is because an excessive amount of time devoted to transportation will be to the loss of the time available for other important and value-added activities. On the other hand, an excessive reduction of the time devoted to transportation will be to the loss of the construction transport process itself. According to Naz et al. (2022), about 43% of the overall time is devoted to non-value-added and required but non-value-added activities related to the flow of materials and wastes.

2.8 Challenges in Construction Transport

According to Naz and Fredriksson (2023), barriers to successful construction transport include a lack of planning, communication, and standard operating procedures (SOPs). The biggest cause of non-value adding activities in the construction transport sector is a lack of planning and inadequate communication among stakeholders. Such activities include extended loading and unloading periods, increased waste accumulation on-site, extra waste collection trips, and conflicts between incoming and leaving transportation. Furthermore, the lack of standard operating procedures (SOPs), such as clearly indicated loading and unloading zones and systematic waste collection, affects efficiency even more..

Naz, Fredriksson, and Ivert (2022) and Naz & Fredriksson (2023) emphasize that the current state of construction transport execution is suboptimal. The researcher also posit that the majority of deliveries at the construction site are not planned in advance, which results in numerous issues. For instance, prolonged waiting periods, conflicts arising between inbound and outbound transportation, extended queues at entry and exit points, and general congestion within the construction site are common challenges. In addition, Naz & Fredriksson's (2023) study indicates that unplanned deliveries frequently result in material damage, thereby leaving the main contractor with insufficient time to arrange for material storage. Consequently, materials are often unloaded in arbitrary locations rather than in designated storage areas proximate to their intended use. This phenomenon, as identified by Naz & Fredriksson's (2023), leads to frequent material handling, which, in turn, increases the risk of damage each time the material is relocated. This phenomenon not only resulted in non-value adding activities but also leads to a waste of valuable resources, including time, cost, labor, effort, and energy.

Furthermore, as indicated by Naz & Fredriksson (2023), materials that have been improperly stored are more prone to damage in the presence of severe weather conditions since the proper storage of materials (i.e. usually heavy and voluminous) is challenging at construction site with a limited space. Furthermore, an analysis of the interface between the construction site and the supply chain reveals a degree of ambiguity. This ambiguity often arises from the interaction of multiple actors, such as the main contractor, the transporter, the waste collector, and the transporter and waste collector, respectively. This observation underscores a deficiency in clarity regarding

the respective responsibilities of these actors in enhancing Construction transport efficiency (Naz & Fredriksson, 2023).

2.9 Construction Logistics Setups

According to Ekeskär & Rudberg (2020) Construction logistics setup (CLS) is defined as “the way that the logistics system, including elements, components, information system etc. are designed and arranged to handle logistics in a construction project” it is a structured approach to organizing logistics in one or several construction projects (Janné & Fredriksson, 2018; Fredriksson, Nolz, et al., 2021). The one activity in CLS is distribution, consolidation, and transportation which is included under off site logistics (Önden et al., 2018). The other one is on site activities which involves logistics-based site plans, material handling, and storage, loading and unloading (Janné, 2018; Janné & Fredriksson, 2020). Furthermore, according to Janné (2018) CLS provide services like waste management and provide clear guidelines in in executions of deliveries (Ekeskär & Rudberg, 2020).

CLS acts as an intermediary between the construction supply chain and the construction site (Ekeskär & Rudberg, 2020; Vrijhoef & Koskela, 2000), and booking calendars help to support this intermediary by serving as a method for coordinating operations. The booking calendar takes a personalized approach, therefore data collected from booking calendars varies from project to project (Sezer & Fredriksson, 2021a). A CLS can be initiated by a variety of actors, including developers (Ekeskär, 2016), municipalities (Transport for London, 2013), main contractors (Mbachu, 2008), and logistics service providers (Lundesjo, 2011; Lindén & Josephson, 2013; Sundquist et al., 2017). Conflicts and disputes later emerge among the various actors involved due to divergent objectives and intentions regarding onsite and offsite logistics (Fredriksson, Janne, & Rudberg, 2021). The logistics plan may work for the construction site but not for the transporter.

The contribution of construction logistics setups to the performance of logistics services is well-documented. In addition to this, they provide economic, social, and environmental benefits in terms of storage capacity, traffic safety, efficient transport, and less CO2 emissions (Janné & Fredriksson, 2020). The type of construction logistics setup is determined by the services it offers. The two predominant types of construction logistics setups are terminal and checkpoints (Janné, 2018).

Terminals are logistical setup that combine numerous small shipments into a single load, lowering transportation distance and costs (Fredriksson, Sezer, et al., 2022). This convergence of transportation reduces congestion, which can help to improve the construction industry's image. Currently, it is thought that construction transportation adds to the already heavy congestion in existing metropolitan centers (Behrends, 2016). The order can be delivered in two ways: directly to the site or to the terminal (Brunge, 2013; Lundesjo, 2011). Concurrently, the contractor enters the delivery into a collaborative planning system managed by the terminal operator for material delivery (Lundesjo, 2011). Materials arrive at the terminal from multiple sources and are received, inspected, documented, and then stored (Lundesjo, 2011). When the need arises, the contractor requests the materials, which are collected, packed, and delivered (Lundesjo, 2011; Transport for London, 2013). Terminals also offer value adding services, such as the combining and repackaging of materials for expedited installations (Lundesjo, 2011). According to Bergman (2016), the implementation of a terminal can result in a reduction of up to 40-60% in the number of transports between the terminal and the construction site. In a separate simulation study, Guerlain et al. (2019) found that utilizing a terminal can lead to a 30% decrease in CO2 emissions. However, it is important to note that terminals generally necessitate substantial physical infrastructure and increased handling, which can make their implementation costly (Janné & Fredriksson, 2020).

Checkpoints represent a distinct type of logistics configuration aimed at ensuring the timely and efficient execution of Just-In-Time (JIT) deliveries. These checkpoints involve the systematic allocation of time slots for material arrivals, the type of delivery vehicle utilized, and the necessary handling equipment, among other considerations (Sundquist et al., 2017; Voordijk et al., 2000). Typically, these checkpoints are positioned at the access points of the construction site, with the objective of maximizing the efficiency of material movement into the site (Ekeskär & Rudberg, 2020). According to Sezer & Fredriksson (2021a), It has been demonstrated that the number of transports is reduced through improved planning. It has been further suggested that the enhanced planning is achieved by utilizing a booking calendar for transportation bookings (Ekeskär & Rudberg, 2020).

The checkpoint is activated when the contractor placed an order with the supplier (Ekeskär and Rudberg, 2020). The contractor then schedules the expected delivery using an online planning tool offered by the logistics service provider (LSP) (Ekeskär and Rudberg, 2020). As a result, additional

information such as the designated unloading time period, the delivery's characteristics (e.g., the number of pallets, their dimensions, and the nature of the material), and the unloading resources required (e.g., forklifts or cranes) are also entered (Ekeskär & Rudberg, 2020). It is imperative to acknowledge that neither the material supplier nor the logistics service provider (LSP) possesses access to the online planning tool. The contractor bears the responsibility of notifying the suppliers of the delivery's scheduled arrival (date and time slot) (Ekeskär & Rudberg, 2020).

2.10 Factors Affecting Construction Transport Efficiency

Construction transport efficiency plays a vital role in the timely and cost-effective delivery of materials and equipment to project sites. As highlighted by Naz (2022), common issues such as waiting to load and unload, difficulty locating site contacts, and lack of proper unloading spaces significantly disrupt the smooth flow of construction logistics. These inefficiencies often result in material delivery delays, increased costs, and reduced on-site productivity. To understand these challenges more comprehensively, the following four critical factors are discussed in light of their impact on construction transport efficiency: (1). Information Sharing: Effective and timely information exchange among suppliers, transporters, site managers, and contractors is essential for smooth logistics. According to Naz (2022), transporters often waste considerable time searching for site addresses and responsible contact persons due to poor communication. This inefficiency could be reduced by establishing centralized communication systems and ensuring real-time updates regarding delivery schedules and contact points. (2). Digital Tools & Technologies: The lack of digital integration in construction logistics contributes to poor coordination and delays. Digital tools such as GPS tracking, mobile communication apps, and real-time delivery status systems can significantly enhance visibility and reduce uncertainties in transport operations (Naz, 2022). For example, digital platforms could provide instant directions to construction sites or alert receivers about incoming deliveries, reducing wait times and queuing. (3). Logistics Service: The quality of logistics services, including warehousing, loading/unloading facilities, and fleet management, directly affects transport performance. Naz (2022) observed that frequent queuing and long waiting times are often caused by inadequate unloading zones and limited logistics capacity. Improving logistics infrastructure and integrating third-party logistics providers can help streamline operations. And (4). Transport Management Practices: Sound transport management practices, such as optimized route planning, effective scheduling, and fleet utilization, are

fundamental to efficient delivery. Inefficiencies highlighted by Naz (2022) such as extended delays during loading/unloading and miscommunications can be traced to the absence of coordinated transport planning. Implementing structured transport management frameworks could reduce redundancy and improve reliability.

2.11 Improving Construction Transport Efficiency

According to Naz (2022) on-site logistic management and logistics services improved construction transport efficiency. Logistics service add value through material delivery management, on-site Vendor managed inventory (VMI), waste management. Material delivery management involves the material delivery time and the unloading spaces on-site, in this case booking of material delivery time slot and designated unloaded places plays significant role in improving construction transport efficiency. On-site VMI improves construction transport efficiency through reducing the number of transport, which in return leads to the reduction of CO2 emission. Concerning waste management on site the waste material shall be transported at nighttime in order to keep the daily site production as per the plan.

The other factor contributing to improving construction transport efficiency digital tool and information sharing. Naz (2022) found that digital tools improve communication, increase visibility, and increase transparency. The author also indicate that information sharing reduce uncertainty and information asymmetry.

2.12 Performance Measures

Performance reflects the ability of an organization in the management of projects and other services. Hove and Banjo (2015) posit that the term "performance" is challenging to define, describe, and measure due to its multi-faceted and subjective nature. They further posit that, in the traditional sense, "performance" is described as efficiency, effectiveness, improvement, growth, and success. According to Dubois et al. (2019), the term "efficiency" is defined as "how well the resources expended are utilized," whereas "effectiveness" is defined as the extent to which established goals are accomplished.

According to Zetterberg and Minges (2017), "performance measures" are metrics that are used to assess how effective or efficient a course of action is. Additionally, the authors contend that

performance metrics assist managers and decision makers in comparing projected and actual performance in terms of efficiency, effectiveness, and quality. the thesis paper also explain that if there is a discrepancy between desired and actual performance, performance metrics can be used to gather information for corrective action. Furthermore, Goshu and Kitaw (2017) suggest that in order for an organization to stay competitive, it must understand how well its operations are being conducted, how well its resources are being used, how to achieve its goals and objectives, and how to improve the efficiency and effectiveness of its present processes. Also, According to Cain (2004), the first step in making improvements that benefit all parties concerned is creating performance measures. In order to enhance outcomes, Takim, Akintoye, and Kelly (2014) advise organizations to assess both financial and non-financial components and compare performance metrics with those of other companies in the industry.

Although Data availability and quality is crucial in order to calculate performance measures (Panahy et al., 2013) performance measurement identify inefficiencies practices to promote corrective actions (Anderson & McAdam, 2004; Costa et al., 2006) According to Latiffi et al. (2014), performance measures are crucial, but they can also be difficult to implement. They go on to say that it is challenging to create performance measures since it can be challenging to find reliable information sources, particularly when the variables or constructs being measured are changing. The paper further suggest that proficiency with the appropriate tools and appropriate knowledge of performance measurement techniques are also necessary. Data quality involves facets such as completeness and accessibility (Pipino et al., 2002). Data quality can also be reflected as a measurement of how fit a data set is to serve the specific needs of an organization. (Pipino et al., 2002; Panahy et al., 2013). In the other word reliable and trusted solutions require high quality data (Pipino et al., 2002). Shafagatova (2016) also points out that because performance metrics are organization-dependent, it is challenging to replicate from one organization to another. The authors suggest that because different companies utilize varying best practices, it is difficult to choose the right performance metrics.

According to Eriksson (2019), there are two main reasons why measuring transport performance in the construction sector is extremely difficult. The first is the structure of the construction industry, which includes several stakeholders and is carried out in temporary

organizations on a project by project basis (Dubois & Gadde, 2002). The second is the availability of data of extremely low quality. According to McKinnon (2018), one aspect that generally restricts the potential for increasing transport efficiency is a lack of data. This is a legitimate worry in the construction sector, which is one of the least digitalized and still collects, records, and communicates the majority of information manually (Ko et al., 2016). This reduces the quality of the data and takes a lot of time and resources.

2.12.1 Logistics Performance Measures

The performance of Logistics in construction is important as it helps in improving transport efficiency. However, Fauske et al. (2007) suggested that instead of having performance measurement for the sake of having them, the existence of holistic thinking should be considered. Performance metrics should be expanded to encompass the entire value chain (beyond the confines of the organization) and should be oriented toward both the present and the future. According to Naz (2022) it is impossible to enhance construction transportation without also enhancing construction logistics management. Hence, Naz also highlights that the measures: perfect order fulfillment, timely, reliable, and lead time delivery, number of wastes or returns, late and damaged deliveries are identified logistics performance measures from the perspective of contractor. According to Zetterberg and Minges (2017) Perfect order fulfilment is described as percentage of orders that satisfy all client requirements, have accurate and comprehensive documentation, and are delivered undamaged. On-time delivery performance measure determines to see if the order is delivered within the allotted period (Keebler and Plank, 2009; Marion, 2019; Vrijhoef, 2020; & Sundstrom and Tollmar, 2018). Whereas, Forslund and Jonsson, 2010 define Delivery reliability as consistent in delivery before or on the agreed date and time. In addition in relation to Delivery, duration between order receipt and delivery is defined as Delivery lead time (Sundstrom and Tollmar, 2018). The Number of the material returned is important logistics performance measure (Vrijhoef, 2020), how many days and hours the order is late (Keebler and Plank, 2009; Marion, 2019), and the damaged number of the product is also crucial for performance measure (Domingues et al., 2015 and Albert et al., 2021).

2.12.2 Transport Performance Measures

The efficiency of transport logistics in construction is often evaluated through various performance measures from the perspectives of transporter, each providing unique insights into operational effectiveness. For instance, transport per day is a crucial metric that evaluates how

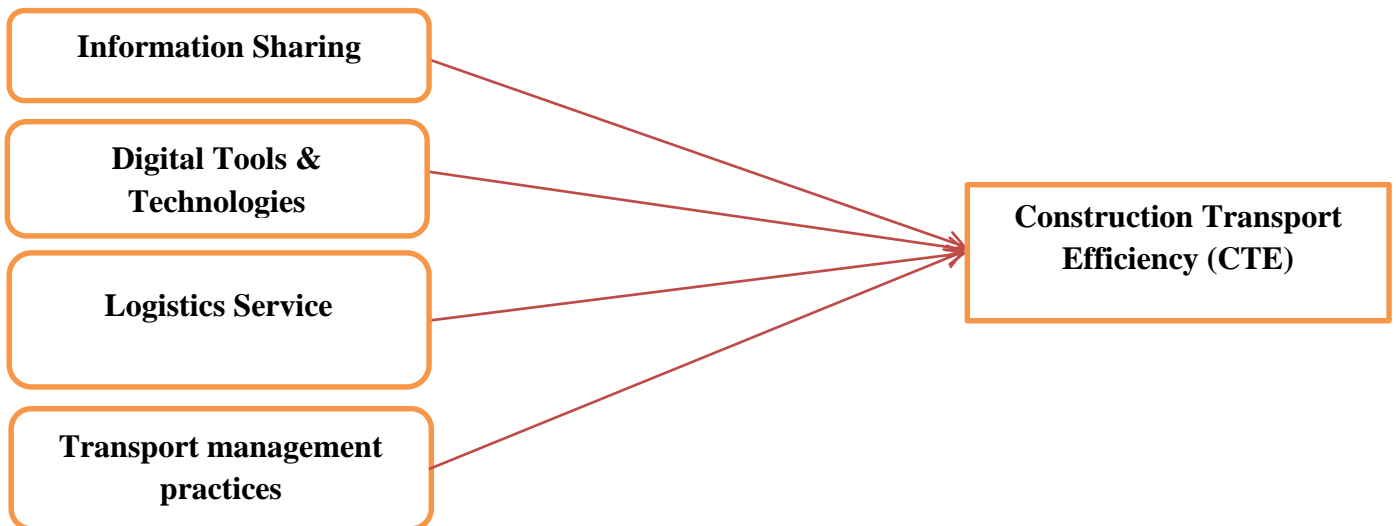
often vehicles enter and leave a site, thereby reflecting the overall activity level and how much traffic is produced (Sezek and Fredriksson, 2021a; Lundesjo, 2011). Another significant measure is vehicle capacity utilization, which assesses how effectively the total vehicle capacity is utilized, expressed in terms of space or load (Malacarne, 2018; Hosseini and Shikrani, 2011). This metric is essential for identifying potential inefficiencies in load management. Additionally, the concept of planned versus unplanned delivery highlights the proportion of deliveries that are scheduled compared to those that occur unexpectedly, revealing the degree of unpredictability in transport operations (Tacla et al., 2008; Pitera et al., 2017). Vehicle turnaround time measure is also important because it is the entire duration between the beginning of loading at the source and the completion of unloading at the destination, where either the source or the destination must be a construction site (van der Spoel et al., 2016; Vrijhoef, 2020).

Moreover, the number of empty drives is a critical performance indicator, as it measures the frequency of vehicles returning without payloads, which can significantly impact cost efficiency (Krauth et al., 2005). Environmental considerations are also important; the CO₂ emissions per trip measure provides insight into the environmental footprint of transport activities (Sichwardt, 2011; Vrijhoef, 2020). Number of empty miles driven per vehicle is an important metric that measure the distance a vehicle travel while it is empty. Furthermore, vehicle movements analyzing stops and starts help assess route efficiency and operational flow (Ying et al., 2018). The concept of Vehicle kilometres measure is used to analyze environmental quality, fuel consumption, and fuel efficiency by the measuring total kilometers driven by a vehicle over a specified time period (Sezer and Fredriksson, 2021a; Hensher, 2008). Finally, tonne-kilometres, which measures the total distance moved while carrying cargo from point A to point B, is a vital indicator for understanding the overall logistics performance (Sezer and Fredriksson, 2021a; McKinnon, 2010). These measures collectively contribute to a comprehensive understanding of transport efficiency in construction, enabling stakeholders to identify areas for improvement and optimize logistics operations.

2.13 Conceptual Framework

The conceptual Framework mainly depicts about the major identified factors of construction transport in Mega projects office projects.

Figure 2.3 Conceptual framework



Source: Authors' own creation

2.14 Research Hypothesis

The relationship between construction transport efficiency and its dimensions was hypothesized based on the conceptual framework.

- 1) (H1): There is a significant positive relationship between information sharing and construction transport efficiency.
- 2) (H1): There is a significant positive relationship between digital tool and technology and construction transport efficiency.
- 3) (H1): There is a significant positive relationship between the logistic service measure and construction transport efficiency
- 4) (H1): There is a significant positive relationship between transport management practice and construction transport efficiency.

CHAPTER THREE

METHODOLOGY

3.1 Research Approach

In order to answer the research objectives or determine the variables that contribute to construction transport efficiency this study employed quantitative research approach. According to Kent (2007), quantitative research approach allows for the systematic evaluations of variables using numerical data. The rationale for using a quantitative research method includes the research require rank able or comparable data to prioritize the key contributing factor using relative importance index (RII), utilized quantitative tool (e.g., liker scale questionnaire) that ensure standardized and replicable results across construction projects and finally the quantitative research strength in generalizing results from structured datasets.

3.2 Research Design

This study employs a quantitative descriptive research design with an explanatory component to investigate factors influencing construction transport efficiency in building projects in Addis Ababa. Following Ghauri and Gronhaug's (2005) framework for structured research problems, the design utilizes self-administered Likert-scale questionnaires distributed to contractor professionals in Mega Projects Office. The descriptive approach captures standardized, quantifiable data about the four predefined factors (e.g., information sharing, Digital tool and technology, Logistics services, and transport management practices to profile and rank critical challenges.

To enhance analytical strength, the research incorporates an explanatory design part by exploring relationships between variables. Therefore, explanatory analysis is conducted to explore relationships between independent variables and construction transport efficiency as guided by theoretical relationships established in literature (Rodrigue et al., 2016; UNCTAD, 2020; Christopher, 2016). By doing so, the objectives of the study are well covered including describing perceived challenges and explaining observed data to facilitate interventions.

3.3 Study Area

This study focuses on Addis Ababa, Ethiopia and building construction projects of Mega Projects office. In order to improve the city and the lives of its citizens, Addis Ababa City Administration created a new Mega Projects Construction Office and allocated more than a one billion birr budget for each project (Addis Gazeta Negarit, 2020). Zewditu hospital, women's rehabilitation center, industry clusters, agriculture centers, and so on are among the existing projects under Mega construction projects office. The construction of such public and social places is the focus of these projects, and it has significant influence. Addis Ababa is the capital city of Ethiopia and used as the best study area due to its rapid urbanization, locations for large-scale construction projects and documented transportation challenges in the construction sector. The study is limited to Addis Ababa does not include rural areas and non-building projects such as infrastructures. The city's unique characteristics including traffic congestion, fragmented logistics systems and centralized project control make it a critical case for investigating construction transport efficiency.

3.4. Target Population and Sampling

According to Zikmund et al. (2010) and Kothari (2004), a population refers to all items in any field of inquiry and is also known as the "universe". Polit and Beck (2003) refer to population as the aggregate or totality of those conforming to a set of specifications. The target population of this study was 1 billion and above with 9 ongoing building construction projects, implemented by 6 main contractors and administered by Mega Projects office in Addis Ababa. The reason for this was that building and infrastructure project transport logistics differ extensively, and as most previous studies of construction transport logistics have focused on building construction projects, it would be more interesting to cover building as well, allowing for a comparison of results. In the 9 projects, the contractor's professionals managing and working in the four departments such as Construction Department, Equipment/Machinery Administration and Maintenance Department, Procurement Department and Property Administration & Supply Department were targeted. The major reason for targeting the professionals participating in four departments in the projects is that they are believed to have a better understanding of construction transport and factors affecting transport efficiency. This resulted in 108 potential participants.

3.4.1 Sampling and Sampling Techniques

Sampling involves selecting a subset of respondents to represent a population, allowing for accurate depiction of its characteristics. Studying a sample of a population can accurately depict its characteristics. The sample size is the number of items chosen from the universe to create a sample. For small populations, it's best to use the entire population as a sample size. Larger sample sizes lead to more accurate results. The study took contractors professionals from four departments in the 9 projects using a census sampling technique. Hence the study takes contractor professionals working in 9 construction projects as a population and draw a sample by using a census sampling. Census method is the process of collecting data from every member of a population and useful for small populations. The total number of targeted respondents in the study were 108 construction professionals out of which 96 responses were used for analysis.

3.5 Data Type and Sources

The data for this study came from both primary and secondary sources. Kothari (2004) defines primary data is data obtained for the first time, thereby having an original nature. Louis, Manion and Morrison (2007), highlight primary data are items that are unique to the subject being studied. The investigation will use quantitative data. The quantitative data will include objective items gathered through questionnaires. The study will also make use of secondary materials. Ember (2009) defines secondary data as information gathered by others and discovered by the comparative researcher in ethnographies, censuses, and histories. As a result, the secondary data was gathered from various sources and/or databases.

3.6 Data Collection Procedures

The data collection procedure includes preparing, testing, and utilizing the instruments and implement the following process: (1) The questionnaires were created based on a review of relevant literature to the subject and specific objectives and utilized closed question, and five point likert type scale. (2) The tools were evaluated for validity and reliability by experts in the field and a pilot test. (3) The researcher administered the five likert-scale to the four departments participating in each of the nine Mega project office projects. And (4) Ethical concerns raised during each stage of the research were carefully examined and resolved by the researcher. An

online survey was delivered via Telegram and text message, with three reminders given and printed version also used for some participants.

3.7. Validity and Reliability Test

Reliability and validity are very important aspects required in the assessment of research instruments or instruments used as tools in research. This is the extent an instrument measures what it is designed to measure in an accurate manner. In the view of Zikmund et al. (2013), face validity pertains to the expert judgment that the measure makes a reasonable approximation of what's truly being measured. Reliability pertains to the confidence or confidence level in the data collected using an instrument as well as the extent any measuring tool accounts for any error in a random manner. The pilot test of a research acted as a trail run for testing the questionnaire through testing wordings of questions, clarifying problematic questions in research studies as well as methods of data extraction. Prior to engaging in a research, a pilot test of the research was employed using some of its prospective respondents. The other test regularly used to determine research instrument reliability is called cronbach's alpha.

3.7.1. Reliability Test

According to Tavakol and Dennick (2011), Cronbach's alpha (α) is deemed as unacceptable for $\alpha < 0.5$, poor for $\alpha \leq 0.6$, questionable for $\alpha < 0.7$, acceptable for $\alpha < 0.8$ and $\alpha \geq 0.7$, good for $\alpha < 0.9$ and $\alpha \geq 0.8$, and excellent for $\alpha \geq 0.9$. To determine the study's reliability the researcher made use of the measurement of Alpha as presented in Table 3.1.

Table 3.1 Cronbach's Alpha for Reliability Check

No.	Construct	Coefficient Of Cronbach's Alpha	Items
1	Information Sharing	0.877	8
2	Digital Tools and Technologies	0.833	6
3	Logistics Service	0.722	9
4	Transport Management Practices	0.828	9
5	Construction Transport Efficiency	0.829	10

3.8 Methods of Data Analysis

The quantitative data obtained was analyzed using a combination of descriptive and inferential statistical analyses to provide a comprehensive understanding of the factors affecting the efficiency of construction transport. Descriptive statistical analysis techniques which entails the calculation of central tendency and dispersion measures were first conducted using SPSS software. This approach enabled the generation of tables, percentages, mean and standard deviations to summarize and provide an overview of the data. On the basis of the results obtained using descriptive statistical analysis techniques, the relative importance index (RII) approach was utilized to provide a systematic ranking of the different factors that influence the efficiency of construction transport. This approach provided an understanding of the different factors that influence the efficiency of construction transport on the basis of the respondents' perceptions using the 5-point likert scale. In order to build upon the ranking process and establish a predictive relationship multiple linear regression models were created to determine whether the variables indicating information sharing, the use of digital tools, the use of logistics services, and the use of transportation management practices collectively affect the efficiency of transportation in construction projects. This approach provided estimates of the coefficients that measure the impacts and the relationship direction of the different variables on the efficiency of construction transport while controlling for the impacts of the different variables included in the multiple regression models. Further diagnostic testing including multicollinearity assessment using Variance Inflation Factors (VIF) and residual analysis was done to ensure the strength of the regression analysis. This integrated approach that combine the ranking of RII with regression testing provides not only a prioritized perspective on the influential factors but also provides empirical evidence of the quantified effects of such factors on transport efficiency in construction projects.

$$IRR = \frac{\sum W}{AN}$$

Where: W is the weighting given to each indicator by the respondents (ranging from 1 to 5)

A is the highest weight (i.e., 5 in this case)

N is the total number of respondents

To establish the level of importance of factors the relative important index (RII) Value rankings are classified based on the RII classification table 3.2 below.

Table 3.2 RII Classification Table (adopted from Tarek et al., 2022)

RII Classification	
Importance level	
Very low	$0.0 \leq \text{RII} \leq 0.2$
Low	$0.2 < \text{RII} \leq 0.4$
Average	$0.4 < \text{RII} \leq 0.6$
High	$0.6 < \text{RII} \leq 0.8$
Very High	$0.8 < \text{RII} \leq 1.0$

Regression Model Specification

This study also adopts multiple regression model, linear regression to analyze the relationship between the independent variables (e.g., information sharing, digital tools, logistics service and transport management practice) and Construction Transport Efficiency (CTE). Regression equations let researchers better describe, interpret, predict, and regulate variables.

Model Equation: $Y = a + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_n X_n$

Where: $CTE = \beta_0 + \beta_1(X_1) + \beta_2(X_2) + \beta_3(X_3) + \beta_4(X_4) + \varepsilon$

Y = Construction Transport Efficiency (dependent variable).

β_0 = Constant or intercept

β_1 = coefficient associated with the independent variables

X_1 = independent variables (e.g. Information Sharing, Digital Tools & Technology, Logistics Service and Transport Management Practices)

ε = Error term (unexplained variance).

3.9 Ethics and Confidentiality

To alleviate concerns regarding the submission of their personal data and confidential information, the researcher provided them with a letter outlining the study. Participants were told that their information would remain private and that their identities would not be disclosed. It's made clear to participants that they are free to refuse participation as well as withdraw from the study.

CHAPTER 4

RESULT AND DISCUSSION

This section provides an overview of the demographic and backgrounds of the respondents involved in the study on factors affecting construction transport efficiency in projects administered by the Mega Projects Office. This section then proceeds with the descriptive statistics, regression analysis and a discussion of the findings.

4.1 Respondent Demographics and General Information

This part presents the demographic and background of the respondents who participated in the study. Understanding such characteristics is necessary in order to contextualize the responses and also get a sense of how representative and reliable the data is. It also includes the information on the size of the organization, the use of the transport performance measure and use of logistics solution for construction projects.

Table 4. 1 Demographic Characteristics of the Respondents

Demography		N	%
Gender	Male	84	87.5%
	Female	12	12.5%
Highest Education Level	Degree	65	67.7%
	Masters	31	32.3%
Department	Construction Department	53	55.2%
	Equipment/Machinery Administration and Maintenance Department	15	15.6%
	Procurement Department	16	16.7%
	Property Administration & Supply Department	12	12.5%
Years of experience in construction	Less than 5 years	13	13.5%
	6-10 years	37	38.5%
	11-15 years	26	27.1%
	16-20 years	15	15.6%
	More than 20 years	5	5.2%
Years of Experience with the Current Company	Less than 2 years	27	28.1%
	2-5 years	54	56.3%

	6 -10 years	10	10.4%
	11-15 years	3	3.1%
	16-20 years	2	2.1%
Construction company size	Medium organizations (51-250 employees)	4	4.2%
	Large organizations (more than 250 employees)	92	95.8%
Presence of a measure for the performance of transport to or from site	Yes	70	72.9%
	No	26	27.1%
Use of Construction logistics solutions in projects	Yes	65	67.7%
	No	20	20.8%
	Don't know	11	11.5%
Types of Construction logistics solutions used for projects	respond no & don't know	31	32.3%
	Checkpoint	10	10.4%
	Checkpoint, Consolidation terminal, & Logistics coordinator on site	11	11.5%
	Checkpoint, & Logistics coordinator on site	3	3.1%
	Logistics coordinator on site	30	31.3%
	Don't know	11	11.5%

Source: Survey data, May 2025

Among a total number of 96 responses and as depicted in Table 4.1 table above, 84 (87.5%) were males, while 12 (12.5%) were females in this study. Which is dominated by male respondents within the construction company. Regarding academic qualifications, 65 (67.7%) of the respondents held a Bachelor's degree, while 31 (32.3%) had attained a Master's degree.

Respondents was obtained from four departments. A wider number came from the Construction Department 53 (55.2%), followed by Procurement Department 16 (16.7%), then Equipment/Machinery Administration and Maintenance Department 15 (15.6%). and Property Administration & Supply Department 12 (12.5%). Such a spread ensures a comprehensive view of construction transport from both engineering and logistical perspectives.

When it comes to the size of the organization of the respondents, 92 (95.8%) belonged to Large organizations (more than 250 employees) and 4 (4.2%) belonged to Medium organizations (51-250 employees). This verifies that the study predominantly centers on large-scale contractors

functioning under the Mega Projects Office, hence enhancing the relevance of the findings to high capacity infrastructure development contexts.

Concerning the years of experience in construction industry, Table 4.1 shows that 37 (38.5%) of respondents has 6-10 years of experience, 26 (27.1%) had 11-15 years of experience, 15 (15.6%) 16-20 years, 13 (13.5%) had Less than 5 years and 5 (5.2%) had more than 20 years of experience in the construction industry. When it comes to working experience in the current contractor company, 54 (56.3%) which is the majority of the respondents had between 2-5 years of experience, followed by 27 (28.1%) had Less than 2 years, 10 (10.4%) between 6 - 10 years, 3(3.1%) between 11 - 15 years and 2(2.1%) between 16-20 years. These results indicate that the majority of respondents possessed sufficient knowledge concerning transportation in construction projects.

As depicted in the table above 70 (72.9%) of participants confirmed the presence of transport operation performance measurement, whereas 26 (27.1%) disagreed. The existence of the transport measure information in the study finding us crucial because it linked with good transport efficiency.

Table 4.1 also demonstrates that 65 (67.7%) indicated that their firms employ construction logistics solutions, whilst 20 (20.8%) answered they do not, and 11 (11.5%) were doubtful. The data shows that the industry is moving towards better logistic practices despite existing knowledge gaps and adoption challenges. The most commonly used type of logistics solutions among those who claimed the use of logistics solutions were 30 (31.3%) logistics coordinators on project site, then 11 (11.5%) used checkpoint, consolidation terminal, & logistics coordinator on site, which is a combined solution followed by 10 (10.4%) used checkpoint then 3 (3.1%) used the two solutions such as checkpoint, & logistics coordinator on site with 11 (11.5%) report they don't have awareness of which solution were utilized in their project while 31 (32.3%) responded either there is no logistics solution in projects or no clue on the existence of this solution. These results show that the projects administered by the Mega Projects office are mostly aware of the logistics solution used.

4.2 Descriptive Statistics of Variables

4.2.1 Descriptive Statistics on Information Sharing

This section of the study will pertain to descriptive analysis. The study will illustrate the findings based on frequency, percentage, mean, and standard deviation from the participant level of agreement or response.

Following the classification approach proposed by Boone, H. N., & Boone (2012), respondent showed different levels of agreement based on the computed mean scores. If the mean score was between 1.00 and 1.79, respondents strongly disagreed. Scores from 1.80 to 2.59 indicated disagreement. A mean score between 2.60 and 3.39 reflected uncertainty or moderate agreement. Scores ranging from 3.40 to 4.19 indicated agreement, and those from 4.20 to 5.00 represented strong agreement.

Table 4. 2 Descriptive Analysis for Information Sharing

Items	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree		Mean	Std. Deviation
	N	%	N	%	N	%	N	%	N	%		
Accurate transport related information is consistently shared with all involved parties (e.g., suppliers, transporters, contractors).	5	5.2 %	11	11.5 %	14	14.6 %	45	46.9 %	21	21.9 %	3.69	1.098
All involved parties (e.g., suppliers, transporters, contractors) have adequate access to transport related information.	1	1.0 %	17	17.7 %	8	8.3 %	53	55.2 %	17	17.7 %	3.71	0.994
All transport related updates are shared quickly with all parties.	2	2.1 %	17	17.7 %	19	19.8 %	42	43.8 %	16	16.7 %	3.55	1.035
There is sufficient communication between transporters and contractors regarding transport operations.	3	3.1 %	14	14.6 %	16	16.7 %	46	47.9 %	17	17.7 %	3.63	1.039
Regular transport evaluation reports are provided to all relevant bodies.	3	3.1 %	18	18.8 %	19	19.8 %	48	50.0 %	8	8.3 %	3.42	0.991

Contractors maintain an adequate level of internal information sharing regarding transport activities.	0	0.0 %	10	10.4 %	15	15.6 %	58	60.4 %	13	13.5 %	3.77	0.814
Real-time info is shared during transport (e.g., live vehicle location tracking)	2	2.1 %	25	26.0 %	15	15.6 %	41	42.7 %	13	13.5 %	3.40	1.081
Delivery times are communicated clearly (e.g., the supplier informs the contractor of exact arrival time).	1	1.0 %	21	21.9 %	19	19.8 %	42	43.8 %	13	13.5 %	3.47	1.015

Source: Survey data, May 2025

Effective information sharing is essential for ensuring coordinated, timely, and efficient construction transport operations. In this study, eight items were included to measure perceptions of information sharing among contractors. Table 4.2 presents the descriptive statistics for this construct. The mean scores of information sharing attributes range from 3.40, for Real-time info is shared during transport to 3.77, for the attribute adequate level of internal information sharing regarding transport activities within the company. Accurate transport related information is consistently shared received a mean of 3.69 (SD = 1.098) with 46.9% agreeing and 21.9% strongly agreeing. All involved parties have adequate access to transport related information scored a mean of 3.71 (SD = 0.994) with agreement of 55.2% strong agreement 17.7%, the second highest among the items in this section. This suggests that information accessibility is relatively strong, with 72.9% expressing agreement and strong agreement. All transport related updates are shared quickly and sufficient communication between transporters and contractors had a mean score of 3.55 and 3.63 with 43.8% and 47.9% agreeing plus 16.7% and 17.7% strongly agreeing respectively.

Regular transport evaluation reports are provided produced a lower mean of 3.42, suggesting that while this is practiced, it is less consistently implemented compared to other forms of communication. Only 8.3% strongly agreed, and nearly 40% were neutral or disagreed. Similarly Real-time information is shared (e.g., live tracking) showed a mean of 3.40, reflecting a moderate application of real-time digital communication tools. This supports findings in digital tool utilization, reinforcing the idea that technological integration still has room to improve.

Contractors maintain adequate internal information sharing received a high mean score of 3.77 (SD = 0.814), indicating that internal communication within the firms is the most consistently practiced aspect of information sharing with agreement of 60.4% strong agreement of 13.5%. This could be attributed to centralized control over internal logistics reporting. Delivery times are communicated clearly scored 3.47, a modest mean indicating that while contractors and suppliers often inform each other of delivery timelines, this communication is not yet communicated evidently or always timely.

Overall, information sharing items have a mean score of 3.58 as in the table 4.7 below, which is the range between 3.40 and 4.19. Items with the highest scores reflect good internal information sharing and general data accessibility, while areas needing improvement include real-time data sharing and regular reporting practices.

4.2.2 Descriptive Statistics on Digital Tools and Technology

Table 4. 3 Descriptive Analysis for Digital Tools and Technology

Items	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree		Mean	Std. Deviation
	N	%	N	%	N	%	N	%	N	%		
GPS tracking systems are used effectively to control and trace trucks during transport operations.	7	7.3 %	26	27.1 %	10	10.4 %	34	35.4 %	19	19.8 %	3.33	1.270
Transport and logistics management software is utilized for scheduling and monitoring material deliveries.	5	5.2 %	29	30.2 %	20	20.8 %	29	30.2 %	13	13.5 %	3.17	1.158
Data from transport operations is digitally stored, recorded, and analyzed using tools such as digital scanners.	2	2.1 %	29	30.2 %	24	25.0 %	34	35.4 %	7	7.3 %	3.16	1.009
There is adequate investment in upgrading digital tools for managing material transport operations.	6	6.3 %	26	27.1 %	28	29.2 %	32	33.3 %	4	4.2 %	3.02	1.015

Digital tools are well-integrated into the existing construction and transport workflow.	5	5.2 %	27	28.1 %	28	29.2 %	28	29.2 %	8	8.3 %	3.07	1.059
The software and digital tools used by the company often face usability challenges.	5	5.2 %	14	14.6 %	34	35.4 %	37	38.5 %	6	6.3 %	3.26	0.965

Source: Survey data, May 2025

To explore how digital technologies influence construction transport efficiency, respondents were asked to rate six items under the construct Digital Tools and technologies. Table 4.3 below presents the frequency distribution with percentage, mean scores, and standard deviations for each item. The mean scores of Digital tool and technology attribute range from 3.02, for the adequate investment in upgrading digital tools for managing material transport operations to 3.33, for the attribute GPS tracking systems are used effectively to control and trace trucks during transport operations.

Use of GPS tracking systems to monitor trucks achieved a mean score of 3.33 (SD = 1.270). Which falls in the uncertainty or moderate range. While the response of a portion of respondents with 35.4% agree and 19.8% strongly agree shows its application, a substantial number or 27.1% disagreement showed underutilization of GPS tracking across projects. The use of transport and logistics management software item yielded a mean of 3.17 (SD = 1.158) also imitating neutral to moderate agreement. The results represented that while the software is somewhat in use, it is not taken as a standard practice. Digital data storage and analysis tools (e.g., scanners) had a mean score of 3.16, showing a similar trend. A significant percentage of participant’s response, 30.2% disagree and 25% neutral indicate limited utilizations of digital tools in construction transport.

Similarly, the next two items, investment in upgrading digital tools for managing material transport operations and the integration of digital tools into workflow also received lower mean values of 3.02 and 3.07 respectively. These suggests the sectors limited digital integration in the daily operation and low budget prioritization for digital tool upgrading because the mean score fall between 2.60 to 3.39 which shows the moderate range with nearly 62.5% and 62.6% of respondents neutral or disagreeing, respectively. Interestingly, the item on the company usability challenges with digital tools had a mean of 3.26 with 38.5% agreeing. This indicates that contractor

organizations struggle with user friendliness or a lack of digital technical knowledge, which might affect widespread adoption.

Generally, the collective findings expose that the use of digital tools in transport operations is moderately practiced with mean scores for all items falling between 3.02 and 3.33 as shown in the table 4.3 above. These results suggest that while digital technologies like GPS tracking and software tools are present in some projects, their application is not yet uniform or fully optimized. Furthermore, relatively high levels of disagreement and neutrality, combined with reported usability challenges, indicate limited technological maturity and varying levels of digital integration among contractors under the Mega Projects Office.

4.2.3 Descriptive Statistics on Logistics Service

Table 4. 4 Descriptive Analysis for Logistics Service

Items	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree		Mean	Std. Deviation
	N	%	N	%	N	%	N	%	N	%		
There is minimal loss or damage to materials during transportation.	1	1.0 %	11	11.5 %	15	15.6 %	62	64.6 %	7	7.3 %	3.66	0.819
Loading and unloading operations are carried out in a timely and efficient manner.	4	4.2 %	21	21.9 %	19	19.8 %	44	45.8 %	8	8.3 %	3.32	1.041
Just-in-Time (JIT) delivery is practiced, ensuring materials arrive exactly when needed on site.	5	5.2 %	28	29.2 %	18	18.8 %	36	37.5 %	9	9.4 %	3.17	1.111
Frequently used materials are often well stocked at project site.	3	3.1 %	11	11.5 %	12	12.5 %	52	54.2 %	18	18.8 %	3.74	0.997
Waste management and collection services at the construction site are insufficient.	6	6.3 %	18	18.8 %	18	18.8 %	48	50.0 %	6	6.3 %	3.31	1.049
Smaller deliveries are effectively consolidated into single loads to improve transport efficiency.	1	1.0 %	17	17.7 %	17	17.7 %	55	57.3 %	6	6.3 %	3.50	0.894
There is flexible logistics service for urgent or unexpected deliveries.	1	1.0 %	15	15.6 %	14	14.6 %	58	60.4 %	8	8.3 %	3.59	0.889

The project logistics service responds promptly and effectively when transport issues arise.	0	0.0 %	16	16.7 %	16	16.7 %	55	57.3 %	9	9.4 %	3.59	0.878
There is reliable logistics service that support transport operations.	0	0.0 %	20	20.8 %	22	22.9 %	48	50.0 %	6	6.3 %	3.42	0.890

Source: Survey data, May 2025

There are nine attributes in Logistics services that were assumed to influence construction transport efficiency. The mean scores have been computed for all nine attributes of Logistics services. The result is offered in Table 4.4. The mean scores of logistics services attributes range from 3.17, for item Just-in-Time (JIT) delivery is practiced, ensuring materials arrive exactly when needed on site to 3.74, for the attribute Frequently used materials are often well stocked at project site. For the first item, minimal loss or damage to materials during transportation has a mean score of 3.66 (SD = 0.819) with 64.6% agreeing and 7.3% strongly agreeing, indicating a high level of agreement, suggesting that material handling during transport is generally secure and effective.

For timely and efficient way of loading and unloading operations, the attribute scored 3.32 (SD = 1.041) with moderate 45.8% agreement and 8.3% strong agreement, showing the need for improvement in this operation. Insufficient waste collection services also received relatively lower mean values of 3.31 (SD=1.049) with 50.0% agreeing and 6.3% strongly agreeing. These results fall in the moderate range 2.60 to 3.39, suggesting some inefficiencies or inconsistencies in on-site logistics operation. As stated above the lowest score for logistics service is Just-in-Time (JIT) delivery is practiced, ensuring materials arrive exactly when needed on site, with 3.17 (SD = 1.111), 37.5% agreement and 9.4% strong agreement, indicating neutral to slightly positive / moderate perceptions, with relatively high variability with 5.2% strongly disagree, 29.2% disagreeing and 18.8% neutral to agree. This may imply that JIT delivery is not consistently practiced or is difficult to implement due to site or supplier constraints. Similarly, Waste management and collection services at the construction site are insufficient.

Consolidation of small deliveries into single loads scored a mean of 3.50 with 57.3% agreeing and 6.3% strongly agreeing, reflecting moderate to high agreement. This suggests that practices to improve transport efficiency through load consolidation are fairly implemented.

Flexible logistics service for urgent/unexpected deliveries and responsive logistics service to transport issues received mean scores of 3.59 with 60.4% and 57.3% agreeing and 8.3% and 9.4% strongly agreeing respectively, reflecting consistently positive perceptions of service adaptability and responsiveness in dynamic construction environments. For the last item in this dimension, there is reliable logistics service that support transport operations, it had a mean of 3.42, placing it in the “agree” range but slightly lower. While reliable logistics service is acknowledged, it is not as much consistent as its flexibility in this study.

Overall, logistics service items have a mean score of 3.48 as in the table 4.7 below, which is high range between 3.40 and 4.19. This shows that logistics services specifically in terms of material availability, flexibility and responsiveness are perceived positively by respondents and substantially contribute to construction transport efficiency. However, certain operational logistics aspects such as loading/unloading efficiency, waste management, and JIT delivery remain areas that require improvement.

4.2.4 Descriptive Statistics of Transport Management Practices

Table 4. 5 Descriptive Analysis for Transport Management Practices

Items	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree		Mean	Std. Deviation
	N	%	N	%	N	%	N	%	N	%		
A clear and effective vehicle maintenance policy is in place and followed (e.g., regular servicing to avoid breakdowns).	5	5.2 %	19	19.8 %	17	17.7 %	42	43.8 %	13	13.5 %	3.41	1.111
Fuel management practices are efficiently implemented and monitored.	3	3.1 %	15	15.6 %	15	15.6 %	45	46.9 %	18	18.8 %	3.63	1.059
Driver management practices are well-organized (e.g., trained, reliable drivers assigned properly).	3	3.1 %	16	16.7 %	16	16.7 %	44	45.8 %	17	17.7 %	3.58	1.063
Vehicle scheduling for transporting materials and waste is conducted in a timely and systematic manner.	5	5.2 %	17	17.7 %	22	22.9 %	41	42.7 %	11	11.5 %	3.38	1.069

There is a lack of effective policies for maximizing vehicle load or space capacity utilization.	5	5.2 %	16	16.7 %	26	27.1 %	42	43.8 %	7	7.3 %	3.31	1.009
Route planning and optimization practices for vehicle movements are inadequate.	2	2.1 %	18	18.8 %	29	30.2 %	44	45.8 %	3	3.1 %	3.29	0.882
Delivery schedules are well-structured and effectively executed.	3	3.1 %	26	27.1 %	23	24.0 %	34	35.4 %	10	10.4 %	3.23	1.061
Transport schedules are adjusted dynamically in response to real-time site or road conditions.	3	3.1 %	23	24.0 %	22	22.9 %	40	41.7 %	8	8.3 %	3.28	1.023
There is effective contingency plans to respond to unexpected material transportation issues. (i.e. Existing alternative remedial solution for deviated transport processes from plan).	3	3.1 %	23	24.0 %	27	28.1 %	40	41.7 %	3	3.1 %	3.18	0.940

Source: Survey data, May 2025

The respondents’ perceptions regarding transport management practices using descriptive statistics output are depicted in the above table 4.5. Among the items used to assess transport management practices which particularly focuses on vehicle maintenance, fuel management, driver management, vehicle scheduling, route planning and contingency planning. The mean scores of transport management practices attributes range from 3.18 for There is effective contingency plans to respond to unexpected material transportation issues, ensuring alternative remedial solution for deviated transport processes from plan to 3.63 for the attribute Fuel management practices are efficiently implemented and monitored. Pulling out the attributes, the item, a clear and effective vehicle maintenance policy is in place mean scores resulted 3.41. While 43.8% agreed and 13.5% strongly agreed, a notable 19.8% and 5.2% disagreed or strongly disagreed respectively. In contrast, the item, fuel management practices are implemented and monitored, respondents response shows a higher level of agreement with a mean score equals 3.63 with 46.9% agreeing and 18.8% strongly agreeing. This implies the implementation and monitoring of fuel tracking and cost control systems across projects.

The perceptions of respondents on driver management practices were relatively positive with a mean score of 3.58 and with 45.8% and 17.7% indicating agreement and strong agreement respectively. This reveals the good practices in driver management practices. However, systematic vehicle scheduling for transporting materials and waste was rated slightly lower with mean score 3.38 and with 42.7% showing agreement and 11.5% with strong agreement suggesting that lining up vehicle dispatches with construction needs improvements.

On the attribute regarding there is a lack of effective policies for maximizing vehicle load or space capacity utilization respondents expressed moderate concern as indicated by a mean score of 3.31 with 43.8% agreeing and 7.3% strongly agreeing. This suggests that underutilization of transport resources may be caused by insufficient strategic efforts to optimize load efficiency. Similarly, Route planning and optimization practices for vehicle movements mean score equal 3.29 with 48.9% respondents show agreement in total, 45.8% agreed and 3.1% strongly agreed. These findings highlight a potential weakness in this area that could influence the efficiency of time and fuel.

For item, delivery schedules are well-structured and effectively executed, respondents gave a moderate rating mean score equal 3.23 with only 35.4% agreeing and 10.4% strongly agreeing. Likewise, Transport schedules are adjusted dynamically in response to real-time site or road conditions item was rated at a mean of 3.28 which is moderate with 41.7% agreement and 8.3% strong agreement. These findings suggest that delivery scheduling systems and real-time optimization features are moderately performed with the need of attention to improvements.

The lowest rated item was contingency planning for unexpected transport disruptions (Mean = 3.18, SD = 0.940). Although 41.7% agreed that contingency plans were in place, the low overall mean and the high neutral response rate 28.1% imply a lack of clarity or confidence in the adequacy of these emergency protocols. This exposes the passive response to unexpected issues and a critical gap in risk management related to transportation inefficiencies or breakdowns.

Overall, transport management practices items have a mean score of 3.36, as in Table 4.7 below, which is moderate, with a range between 2.60 and 3.39. The item with the greatest contribution is fuel management practices are efficiently implemented and monitored.

4.2.5 Descriptive Statistics of Construction Transport Efficiency of Mega Projects

Table 4. 6 Descriptive Analysis for Construction Transport Efficiency of Mega Projects

Items	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree		Mean	Std. Deviation
	N	%	N	%	N	%	N	%	N	%		
Materials are delivered to project site in a timely manner.	3	3.1 %	19	19.8 %	24	25.0 %	41	42.7 %	9	9.4 %	3.35	1.005
The transport of material and waste operation in your project site experience minimal interruptions.	3	3.1 %	17	17.7 %	30	31.3 %	40	41.7 %	6	6.3 %	3.30	0.942
There is optimal utilization of transport resources (e.g., vehicles, drivers) in the project.	1	1.0 %	20	20.8 %	19	19.8 %	50	52.1 %	6	6.3 %	3.42	0.925
Transport related problems rarely cause delays in construction activities.	1	1.0 %	19	19.8 %	9	9.4 %	58	60.4 %	9	9.4 %	3.57	0.949
Transport operations to and from project site align with construction schedule.	0	0.0 %	18	18.8 %	19	19.8 %	53	55.2 %	6	6.3 %	3.49	0.871
There is reduced vehicle turnaround time (the time between loading at source and unloading at site/terminal).	0	0.0 %	14	14.6 %	34	35.4 %	40	41.7 %	8	8.3 %	3.44	0.844
The cost of material and waste transport operations in the project is reasonable.	1	1.0 %	24	25.0 %	22	22.9 %	41	42.7 %	8	8.3 %	3.32	0.979
Vehicle space/capacity is adequately utilized in each material transportation to and from project.	1	1.0 %	15	15.6 %	21	21.9 %	50	52.1 %	9	9.4 %	3.53	0.906
The number of vehicle movements (start/stop) is reduced in the transport operation in your project site.	0	0.0 %	18	18.8 %	22	22.9 %	50	52.1 %	6	6.3 %	3.46	0.870
The project has optimum total vehicle kilometer (total kilometer travelled by vehicle).	1	1.0 %	14	14.6 %	20	20.8 %	47	49.0 %	1	14.6 %	3.61	0.944

Source: Survey data, May 2025

Construction Transport Efficiency, was measured using ten items. These items captured the perceptions of respondents regarding the timeliness, reliability, cost-effectiveness, and resource utilization of transport operations within construction projects administered by the Mega Projects Office. The mean scores of Construction transport efficiency attributes range from 3.30, for transport of material and waste operation in your project site experience minimal interruptions, to 3.61, for the attribute project has optimum total vehicle kilometer (total kilometer travelled by vehicle). Concerning the statement Materials are delivered to the project site in a timely manner the attribute yielded a mean score of 3.35 (SD = 1.005), indicating a moderately favorable perception, with 42.7% and 9.4%, total 52.1% of respondents agreeing and strongly agreeing. However, the presence of total of 22.9% disagreement and 25% neutrality suggests inconsistencies in on-time delivery across projects. The respondent were in agreement with the item, the transport of material and waste experiences minimal interruptions which scored 3.30 (SD = 0.942). This reflects moderate efficiency with 41.7% agreeing and 6.3% strongly agreeing and potential disruption with total of 20.8% disagreement plus 31.3% neutral to agree response indicating the uncertainty or variability in experiences among projects. A mean score of 3.42 (SD = 0.925) with 52.1% agreeing and 6.3% strongly agreeing was recorded for Optimal utilization of transport resources attribute, This suggests that contractors perceive adequate use of trucks, drivers, and related logistics, though a combined 40.6% were neutral or disagreed indicating that not all projects achieve optimal usage. Regarding Transport related problems rarely cause delays in construction activities item recorded a relatively high mean of 3.57 (SD = 0.949) with 60.4% agreeing and 9.4% strongly agreeing. It shows that respondents generally believe transport related issues are not major sources of delay, with over 69% agreeing or strongly agreeing.

Transport operations align with the construction schedule received a mean of 3.49 (SD = 0.871) with agreement of 55.2% and strong agreement of 6.3%, further reinforcing the trend of moderate to strong alignment between construction transport logistics and project timelines. With item, There is reduced vehicle turnaround time yielded a mean score of 3.44 (SD = 0.844) with 41.7% agreeing and 8.3% strongly agreeing, this reflects that vehicle usage efficiency (load-unload cycles) is fairly good, yet over 35% were neutral, which may indicate opportunities for improvement through better coordination or resource planning. In contrast, when it comes to the cost of material and waste transport, it yielded a lower mean score of 3.32 (SD = 0.979) with 42.7% agreement and 8.3% strong agreement. A quarter of respondents (25%) disagreed, indicating that

cost efficiency is a concern in some projects. Regarding, Vehicle space/capacity is adequately utilized in each material transportation to and from project item scored a mean of 3.53 (SD = 0.906) 52.1% agreement and 9.4% strong agreement, showing that respondents generally agree that truck space is utilized moderate to high, reducing the number of unnecessary trips and supporting cost and time efficiency. Similarly, for the number of vehicle movements (start/stop) is reduced in the transport operation item, a mean score of 3.46 (SD = 0.870) with 52.1% agreeing and 6.3% strong agreement, professional respondents moderately agreed which is falling in the range between 3.40 to 4.20 showing that start-stop frequencies are minimized, contributing to fuel efficiency and smoother logistics flow, though a combined 41.7% were neutral or disagreed indicating the variation increased number of trips for some projects. However, concerning the attribute the project has optimum total vehicle kilometer yielded a mean score of 3.61 (SD = 0.944) with 49.0% agreeing and 14.6% strongly agreeing, indicating that transport operations are generally optimized in terms of distance traveled to and from projects.

Overall, Construction transport efficiency items have a mean score of 3.45, as shown in Table 4.7 below, which is moderate to good and falls within the range of 3.40 to 4.19. This overall suggests that while many aspects of transport performance are functioning well, there are areas where improvement is needed for timeliness of delivery (M = 3.35), transport interruptions (M = 3.30), and cost efficiency (M = 3.32) in Addis Ababa construction projects.

Table 4. 7 Descriptive Analysis

Variables	N	Minimum	Maximum	Mean	Std. Deviation
Construction transport efficiency	96	2	5	3.45	0.580
Information Sharing	96	2	5	3.58	0.741
Digital Tools and technology	96	1	5	3.17	0.800
Logistics Service	96	2	5	3.48	0.533
Transport management Practice	96	1	5	3.36	0.666

Source: Survey data, May 2025

4.3 Factors Affecting Construction Transport Efficiency

To assess the perceived relevance of the key independent variables; Information Sharing, Digital Tools and Technology, Logistics Service and Transport Management Practices attributes, a Relative Importance Index (RII) study was carried out. This method is commonly used in construction related research to rank components based on their perceived contribution, with responses collected using a five-point Likert scale. The thirty two items RII value were calculated for the four key dimensions and ranked accordingly. The RII values are classified using the standard thresholds very low (0.0-0.2), low (0.2-0.4), average (0.4-0.6), high (0.6-0.8) and very high (0.8-1.0) (Tarek et al., 2022). In this study, the relative importance index for all items are greater than 0.6 which is labeled as high importance indicating the importance of each items in determining construction transportation efficiency.

Table 4. 8 Rank of Construction Transport Efficiency Dimensions.

Items	Items	Mean	Std. Deviation	RII	Rank
Information sharing	Accurate transport related information is consistently shared with all involved parties (e.g., suppliers, transporters, contractors).	3.69	1.098	0.738	4
	All involved parties (e.g., suppliers, transporters, contractors) have adequate access to transport related information.	3.71	0.994	0.742	3
	All transport related updates are shared quickly with all parties.	3.55	1.035	0.710	11
	There is sufficient communication between transporters and contractors regarding transport operations.	3.63	1.039	0.725	6
	Regular transport evaluation report are provided to all relevant bodies.	3.42	0.991	0.683	14
	Contractors maintain an adequate level of internal information sharing regarding transport activities.	3.77	0.814	0.754	1

	Real-time info is shared during transport (e.g., live vehicle location tracking)	3.40	1.081	0.679	17
	Delivery times are communicated clearly (e.g., supplier informs contractor of exact arrival time).	3.47	1.015	0.694	13
Digital tools and technology	GPS tracking systems are used effectively to control and trace trucks during transport operations.	3.33	1.270	0.667	19
	Transport and logistics management software is utilized for scheduling and monitoring material deliveries.	3.17	1.158	0.633	28
	Data from transport operations is digitally stored, recorded, and analyzed using tools such as digital scanners.	3.16	1.009	0.631	30
	There is adequate investment in upgrading digital tools for managing material transport operations.	3.02	1.015	0.604	32
	Digital tools are well-integrated into the existing construction and transport workflow.	3.07	1.059	0.615	31
	The software and digital tools used by the company often face usability challenges.	3.26	0.965	0.652	25
Logistics Service	There is minimal loss or damage to materials during transportation.	3.66	0.819	0.731	5
	Loading and unloading operations are carried out in a timely and efficient manner.	3.32	1.041	0.665	20
	Just-in-Time (JIT) delivery is practiced, ensuring materials arrive exactly when needed on site.	3.17	1.111	0.633	29
	Frequently used materials are often well stocked at project site.	3.74	0.997	0.748	2
	Waste management and collection services at the construction site are insufficient.	3.31	1.049	0.663	21

	Smaller deliveries are effectively consolidated into single loads to improve transport efficiency.	3.50	0.894	0.700	12
	There is flexible logistics service for urgent or unexpected deliveries.	3.59	0.889	0.719	8
	The project logistics service responds promptly and effectively when transport issues arise.	3.59	0.878	0.719	9
	There is reliable logistics service that support transport operations.	3.42	0.890	0.683	15
Transport management practices	A clear and effective vehicle maintenance policy is in place and followed (e.g., regular servicing to avoid breakdowns).	3.41	1.111	0.681	16
	Fuel management practices are efficiently implemented and monitored.	3.63	1.059	0.725	7
	Driver management practices are well-organized (e.g., trained, reliable drivers assigned properly).	3.58	1.063	0.717	10
	Vehicle scheduling for transporting materials and waste is conducted in a timely and systematic manner.	3.38	1.069	0.675	18
	There is a lack of effective policies for maximizing vehicle load or space capacity utilization.	3.31	1.009	0.663	22
	Route planning and optimization practices for vehicle movements are inadequate.	3.29	0.882	0.658	23
	Delivery schedules are well-structured and effectively executed.	3.23	1.061	0.646	26
	Transport schedules are adjusted dynamically in response to real-time site or road conditions.	3.28	1.023	0.656	24

	There is effective contingency plans to respond to unexpected material transportation issues. (i.e. existing alternative remedial solution for deviated transport processes from plan).	3.18	0.940	0.635	27
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Source: Survey data, May 2025

As depicted in the above table 4.8, the items received the highest RII scores which is very important for a construction transport efficiency as per the current study findings were: (1) item in information sharing dimension, contractors maintain an adequate level of internal information sharing regarding transport activities (RII = 0.754). (2) Logistic service attribute, frequently used materials are often well-stocked at the project site (RII = 0.748). (3) Information sharing attribute which is all involved parties have adequate access to transport related information (RII = 0.742).

There are also several items with reasonably high levels of significance with RII values ranging from 0.710 to 0.738. These includes accurate sharing of transport related information (RII = 0.738), minimal loss or damage to materials during transport (RII = 0.731), sufficient communication between transporters and contractors (RII = 0.725) and efficient fuel management practices. In addition, the availability of flexible logistics services for urgent deliveries (RII = 0.719), the logistics team's quick response to transportation concerns (RII = 0.719) and effective driver management practices (RII = 0.717) were the subsequent significant factors. These findings re highlight the importance of communication efficiency, operational responsiveness and resource management in improving transportation efficacy in construction projects. The items within this range highlights the contribution of communication, resource management and responsiveness of operation in improving construction projects transport efficiency.

Although every single item were rated essential, there were also a group of items scored toward the bottom of the high importance category, with RII scores close to 0.6 to 0.7. These included real-time sharing of transportation information (RII = 0.679), systematic vehicle scheduling (RII = 0.675), and the use of GPS tracking devices (RII = 0.667). Furthermore, logistical difficulties like timely loading or unloading, waste management, route planning and just-in-time delivery practices received lower RII scores in the high importance band ranging 0.665 to 0.633. Notably, digital related factors such as digital tool integration, upgrade digital tools, and the

usage of logistics software for delivery monitoring consistently rated at the bottom of the list, with RII values ranging from 0.604 to 0.633.

As depicted in the following Table 4.9 the composite analysis of the four independent factors shows that information sharing has the greatest perceived influence on construction transport efficiency with a mean score of 3.58 (SD = 0.741), ranking first among all variables. This proposes that the critical elements for efficient transport were adequate communication and timely information exchange among stakeholder. Logistics service comes in second with a mean of 3.48 (SD = 0.533) indicating that the delivery of frequently used material, material handling and quick logistics support are all essential for improving transport efficiency. In the current study transportation management practices are ranked third (mean = 3.36, SD = 0.666) indicating modest efficacy in vehicle scheduling, driver management, fuel management and contingency planning. Meanwhile, digital tools and technology had the lowest mean of 3.17 (SD = 0.800), demonstrating that digital integration is still a relatively underdeveloped field. This low score indicates that modern technology like as GPS tracking, logistics software, and real-time data systems are not widely used or effective. Overall, the findings indicate that communication and logistical execution are currently stronger pillars, whereas technology adoption and strategic transport management require additional investment and development to improve construction transportation efficiency.

Table 4. 9 Rank of Overall Construction Transport Efficiency Dimensions.

Variables	N	Minimum	Maximum	Mean	Std. Deviation	Rank
Information Sharing	96	2	5	3.58	0.741	1
Digital Tools and technology	96	1	5	3.17	0.800	4
Logistics Service	96	2	5	3.48	0.533	2
Transport management Practice	96	1	5	3.36	0.666	3

Source: Survey data, May 2025

4.4 Correlation

The most widely used correlation coefficient is Pearson's, which is commonly just called the correlation. When determining correlations between two interval or ratio-scaled variables, Pearson's correlation is a suitable method. But it can also be applied when one variable is binary, for instance, and the other is interval or ratio-scale.

The only possible values for Pearson correlation coefficients (r) are -1 and $+1$. The front sign shows whether the two variables are positively or negatively correlated, meaning that as one increases the other declines. The strength of the link is shown by the size of the absolute value (without including the sign). When there is a perfect correlation of 1 or -1 , it means that one variable's value can be precisely ascertained by knowing the value of the other. This association would display a straight line in a scatter plot. Conversely, if there is no correlation between the two variables, the correlation value is 0 . Predicting the value of the second variable is not aided by knowing the value of the first one.

Correlations		Constructi on transport efficiency	Informatio n Sharing	Digital Tools and technolog y	Logisti cs Service	Transport managemen t Practice
Constructio n transport efficiency	Pearson Correlation	--				
	N	96				
Information Sharing	Pearson Correlation	.507**	--			
	Sig. (2- tailed)	0.000				
	N	96	96			
Digital Tools and technology	Pearson Correlation	.447**	.510**	--		
	Sig. (2- tailed)	0.000	0.000			
	N	96	96	96		
Logistics Service	Pearson Correlation	.640**	.448**	.497**	--	
	Sig. (2- tailed)	0.000	0.000	0.000		
	N	96	96	96	96	

Transport management Practice	Pearson Correlation	.628**	.469**	.481**	.715**	--
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	
	N	96	96	96	96	96

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

The correlation analysis reveals important relationships between construction transport efficiency and several critical variables: information sharing, digital tools and technology, Logistics Service, and Transport management practice. The Pearson correlation coefficient between construction transport efficiency and information sharing is 0.510, indicating moderate positive relationship. This suggests that as Mega projects office projects enhances information sharing among stakeholders such as maintain an adequate level of internal information sharing, the efficiency of construction transport also improves significantly. Therefore, information sharing improve construction transport efficiency.

The correlation between construction transport efficiency and digital tools and technology equals 0.447. This shows that there is moderate relationship between digital tools and technology and construction transport efficiency. The Pearson correlation coefficient between construction transport efficiency and logistics service equals 0.640. These finding aligns with previous research indicating that logistics service plays an important role in enhancing construction transport efficiency within the construction sector followed by transport management practices with Pearson correlation coefficient value equals 0.628 indicating same strong relationship.

4.5 The Relationship between Construction Transport Efficiency and Key Factors

Regression analysis are used in inferential data analysis, and SPSS is the statistical program of choice. The outcomes are discussed below based on this.

4.5.1 Assumption Testing for Regression Analysis

This study employed multiple regression analysis to evaluate the extent to which variables explained the variability in the outcome (construction transport efficiency). The following presumptions must be investigated before analyzing the extent to which the aforementioned predictors explained the variability.

4.5.1.1 Auto Correlation (Durbin Watson Test)

The first diagnostic test used in this investigation was the autocorrelation test. The assumption is that errors are not connected with one another. According to Brooks (2008), if errors are not uncorrelated, they are referred to as 'autocorrelated' or 'serially correlated'.

Table 4. 10 Durbin-Watson Statistics

Model Summary		
Model	Std. Error of the Estimate	Durbin-Watson
1	0.416	2.040

Source: Survey data, May 2025

The Durbin-Watson statistic measures autocorrelation in regression residuals. The scale spans from 0 to 4, with a score 2 suggesting no significant autocorrelation. The result of 2.040 indicates very low autocorrelation in the model. The regression model's mistakes appear to be independent, with no concerns about autocorrelation. The Durbin-Watson statistic supports this view.

4.5.1.2 Multicollinearity

In multiple regression equations, multi collinearity occurs when an independent variable has a strong correlation with one or more additional independent variables. This is a concern since it reduces the statistical significance of an independent variable. The following table displays the results of the multicollinearity test of the dependent variables in this study.

Two values are provided: tolerance and VIF. Tolerance is a measure of how much of the variability of the given independent variable is not explained by the other independent variables in the model, and it is determined for each variable using the formula $1-R^2$. If this value is very little (less than .10), it suggests that the multiple correlation with other variables is strong, implying the likelihood of multicollinearity. The other value provided is the VIF (variance inflation factor), which is simply the inverse of the Tolerance value. VIF values more than 10 might be problematic here, showing multicollinearity. The study used generally used cut-off values to determine the presence of multicollinearity (a tolerance value less than .10 or a VIF value greater than 10). Accordingly as per the result provided in the following table below there is no multicollinearity.

Table 4. 11 Multi-collinearity test of the Independent Variable

Model		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	Information Sharing	0.668	1.497
	Digital Tools and technology	0.639	1.566
	Logistics Service	0.454	2.201
	Transport management Practice	0.454	2.204

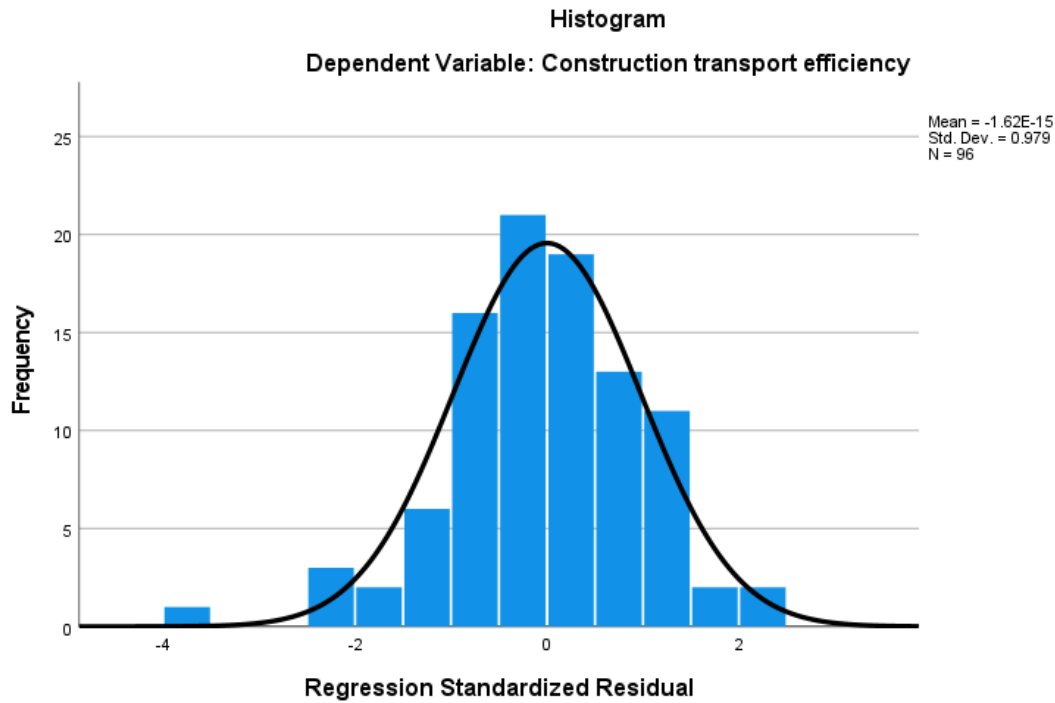
Source: Survey data, May 2025

4.5.1.3 Normality test

Multiple regression requires that the independent variables be regularly distributed. Errors have a normal distribution and can be approximated by plotting residual values (Keith, 2006).

Frequency distribution has many different forms and sizes. It's vital to provide a general description of common distribution types. In an ideal world, data would be dispersed symmetrically around the center of all scores. Drawing a vertical line through the center of the distribution should produce the same results on both sides. The normal distribution has a bell shaped curve. According to Field (2006), this distribution shape indicates that the majority of scores are clustered at the center. Figure 4 displays a normal distribution graph, indicating that the normality condition was met.

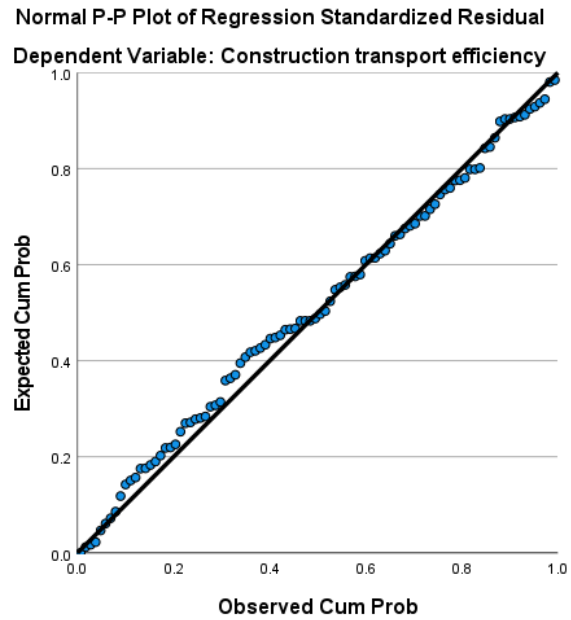
Figure 4 Regression assumption for normality



4.5.1.4 Linearity Test

To test the linearity of the relationship between dependent and independent variables, use the P-P plot for the model. The distribution of residuals is more typical as the dots approach the diagonal line. The graph in Figure 5 below shows a linear relationship between the dependent and independent variables.

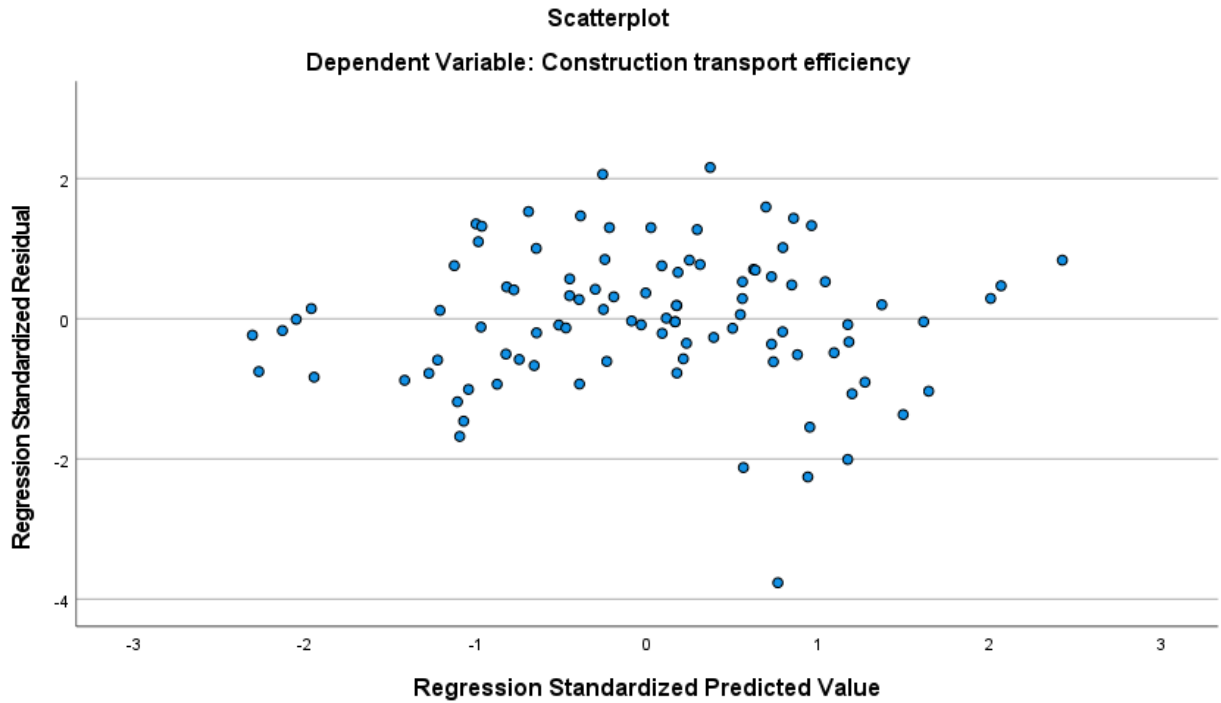
Figure 5 P-P Plot of Regression Standardized Residual



4.5.1.5 Homoscedasticity

According to Osborne and Waters (2002), the assumption of homoscedasticity means that errors have similar variance across all levels of independent variables. This indicates an equitable distribution of residual terms and homogeneity of error terms across the data. To assess for homoscedasticity, examine a plot of standardized residuals versus regression standardized predicted value (Osborne & Waters, 2002). If mistake words are scattered randomly without a specific pattern, the problem is not destructive to analysis. Figure 6 displays an equally distributed scatter plot of standardized residuals, indicating no violation of homoscedasticity in this study.

Figure 6 Scatter plot of standardized residuals



4.5.2 Multiple Regression Analysis

4.5.2.1 Multiple Regression Model summary

Table 4. 12 Regression model summary

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.713 ^a	0.508	0.486	0.416

Source: Survey data, May 2025

Table 4.12 shows that R² is a metric that measures how well predictors explain variability in outcomes, such as construction transport efficiency. Table 4.12 also shows that the major criteria given account for 50.8% of the variation in construction transport efficiency. Other variables not examined in this study account for the remaining 49.2% of the variance. This means that the regression model which includes information sharing, digital tools and technology, logistics services and transport management practices explains 50.8 percent of the variance in the perceived transport efficiency.

**4.5.2.2 ANOVA table summary of critical factors with the dependent variable
(construction transport efficiency)**

Table 4. 13 ANOVA table summary

ANOVA^a						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	16.232	4	4.058	23.478	.000 ^b
	Residual	15.728	91	0.173		
	Total	31.960	95			
a. Dependent Variable: Construction transport efficiency						
b. Predictors: (Constant), Transport management Practice, Information Sharing, Digital Tools and technology, Logistics Service						

Source: Survey data, May 2025

The sig. value in Table 4.13 of the aforementioned ANOVA results is 0.000. The model can explain the deviations, indicating their high significance. The significant relationship is supported by data at $p < 0.05$.

Table 4. 14 Coefficients of multiple regressions

Coefficients^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.717	0.296		2.421	0.017
	Information Sharing	0.163	0.070	0.208	2.309	0.023
	Digital Tools and technology	0.034	0.067	0.047	0.508	0.613
	Logistics Service	0.357	0.119	0.328	3.007	0.003
	Transport management Practice	0.238	0.095	0.274	2.506	0.014
a. Dependent Variable: Construction transport efficiency						

Source: Survey data, May 2025

The coefficients table 4.14 provides regression analysis on the link between major determinants and construction transport efficiency with the contribution of each independent variable in the construction project context.

$$Y = 0.717 + 0.163X_1 + 0.034X_2 + 0.357X_3 + 0.238X_4 + e$$

Information sharing has a statistically significant positive influence on construction transport efficiency ($B = 0.163$, $p = .023$), with a standardized Beta value of 0.208, showing that enhanced communication and information exchange among stakeholders improves transport performances. Logistics Service has the largest influence among each predictor with a highly significant coefficient ($B = 0.357$, $p = .003$) and standardized beta of 0.328. This emphasizes logistics service attributes importance such as prompt, responsive and reliable services in improving material transportation efficiency. Transport Management Practice also has a significant and favorable impact on transportation efficiency ($B = 0.238$, $p = .014$) and standardized beta of 0.274 implying that scheduling, maintenance and contingency planning make a meaningful contribution. However, digital tools and technology did not have a statistically significant effect ($B = 0.034$, $p = .613$) and standardized beta of 0.04 indicating that despite their perceived importance current implementation or integration of digital technologies in transportation operations is insufficient or ineffective in terms of efficiency.

Therefore, the study regression results show that the key determinants of construction transport efficiency are information sharing, logistics service and transportation management practices. The findings also highlight the need of improving transport performance in the construction industry through strengthening human and organizational coordination.

4.6 Discussion of Key Findings

This section evaluates the quantitative findings obtained from the study in relation to the conceptual framework and existing literature. The discussion focused on the four independent variables such as information sharing, digital tools and technology, logistics services and transport management practices and their impact on construction transport efficiency which is the dependent variable measured using regression analysis, mean scores and relative importance index (RII).

The study prove the importance of information sharing as a significant predictor of construction transport efficiency. It had the highest overall mean (3.58) among the four dimensions. It also generated many top ranking items in the relative importance index (RII) analysis. These include: “Contractors maintain an adequate level of internal information sharing” (RII = 0.754, Rank 1). The results of the regression analysis also showed a significant positive

impact on transport efficiency ($\beta = 0.208$, $p = 0.023$) supporting the idea that good information flow in streamlining activities and preventing delays. These findings are in line with the views of Otjacques et al. (2005) and Golyani and Yan Hon (2010), who underlined the importance of structured, real-time and accessible communication in the construction supply chain. Naz (2022) and Naz & Fredriksson (2023) also pointed out that poor communication and asymmetrical flow of information are the main reasons of inefficiency in construction transport and conflict between stakeholders.

Despite the recognized importance of digital tools in boosting the efficiency of construction projects, this dimension received the lowest mean (3.17) and produced the smallest relative importance index values among all factors. Investment in upgrading digital tools (RII = 0.604, Rank 32) and integration of digital tools into existing workflows (RII = 0.615, Rank 31) ranked close to the lowest values. In the regression model digital tools had an insignificant effect on construction transport efficiency ($\beta = 0.047$, $p = 0.613$). This result confirms the digital maturity gap in the construction logistics in Addis Ababa Ethiopia projects. Gebrehiwot and Demeke (2019) state that the majority of the local companies remain reliant on manual systems and face problems in adoptions of digital logistics systems. Mossie (2024) also stated that integration of construction management with information and communication technology (ICT) systems such as digital documentation management, barcoding, mobile technology and applications can increase the efficiency of construction projects by improving the accuracy and real-time visibility of construction activities. According to Eriksson (2019) and Ko et al. (2016) construction transport efficiency could also be improved by using GPS tracking, real-time scheduling software and digital data integration. The present study findings revealed that these technologies are either underutilized or poorly integrated in Mega construction projects. Therefore, in spite of the tremendous potential benefits of digital tools in boosting the efficiency of construction projects, the impacts of such tools among the current study construction projects remains insignificant due to lack of technical capacity and strategic investment.

Logistics service factor appeared as the second most significant factor (mean = 3.48) with a high RII values for key elements such as “frequent material stockpiling at the project site” (RII=0.748, Rank2) and “little material loss during transportation” (RII=0.731, Rank5). Results from regression analysis also confirmed a significant relationship ($\beta=0.328$, $p=0.003$), thereby

verifying the significance of quality logistics services in enhancing transportation efficiency. The current study findings on logistics service factors indicates association to the study stating the direct correlation between reliability and responsiveness of logistics support services (e.g., inventory availability, loss prevention and consolidated deliveries) with improved delivery times and reduced site disruption (Fredriksson et al., 2021 and Janné & Fredriksson, 2020). Furthermore, the study confirmed suggestion made by Ekeskär and Rudberg's (2020) regarding the importance of planning, transparency and consolidation in construction transport. Again the findings validate these ideas in the context of the Addis Ababa projects.

Transport management practices had a medium score with a mean value of 3.36 but had a significant association with transportation efficiency within the regression model ($\beta = 0.274$, $p = 0.014$). Factors like “Fuel management practices” and "Driver management practices" were ranked 7 with (RII = 0.725) and 10 with (RII = 0.717) respectively. Which are top among the other factors indicating that contractor professionals who participated in the study regard operational management and allocation of resources especially fuel as critical. The of Resource-Based View (RBV) theory holds that equipment, human capital and planning are internal assets from which companies can gain competitive advantage (Wernerfelt, 1984; Teece et al., 1997). This is consistent with the study findings. Furthermore, the medium to large influence of transport management practices is consistent with Naz's (2022) findings, which reported how unstructured scheduling, poor route planning and the lack of contingency plans are common reason for material delays and cost overruns. While most contractors seems to have basic procedures established there is a room for further refinement, mainly in the areas of dynamic scheduling and contingency planning.

In conclusion, the empirical findings significantly validate the conceptual model of the study. Among the four dimensions, information sharing is the most important and consistently significant aspect. Next to that Logistics Services have a direct operational impact and are ranked highly both conceptually and statistically. The third rated dimension, transport management practices have a favorable impact, but they require more strategic planning. Among all the factor influencing construction transport Digital tools and technology score was very low and statistically insignificant, while theoretically advantageous, have yet to be completely utilized in practice.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the study's key findings, makes theoretical and practical implications, and offers suggestions for those involved in the construction industry. The chapter also discusses opportunities for further research, the research constraints, and contributions to knowledge.

5.1 Summary of the Study

The purpose of this study was to investigate the main factors affecting construction transport efficiency in projects managed by the Mega Projects Office in Addis Ababa. Construction transport efficiency was the dependent variable in this study, which was guided by four main independent variables: information sharing, digital tools and technology, logistics services, and transport management practices. Using a quantitative survey based approach data were collected from potential respondents who considered to have sufficient about the study area of knowledge across contractor organization.

Multiple linear regression, the relative importance index (RII), and descriptive statistics were used to analyze the results. The findings showed that the most significant factors was information sharing, which was followed by logistical services, transportation management practices and digital tools and technologies. The overall predictive value of the chosen variables was demonstrated by regression model which accounted for 50.8% of the variation in transport efficiency.

Information Sharing had the highest influence on transport efficiency; high mean score and significant regression results supported respondents' emphasis on the importance of internal communication and timely access to transport related information among all stakeholders.

Transport efficiency was also significantly impacted by logistics services next to information sharing. Important logistics component that received high ratings includes material stocking, minimal damage for the duration of transportation and responsive delivery.

Regarding transport management practice, particularly in fuel and driver management, the variable made a favorable contribution in transport efficiency. On the other hand, areas like route optimization and contingency planning were comparatively weaker and implemented less frequently.

Although conceptually intriguing, digital tools and technology did not significantly affect transport efficiency in this study. Majority of digital tool related items were scored lowest by RII analysis, indicating minimal investment, poor integration, and usability problems.

5.2 Conclusions

The results show that human coordination, effective logistics services and organized transport management practices although their known potential, there is digital solutions underutilization. Sufficient communication, resource coordination and responsive logistics are vital inner abilities that have a significant impact on construction transportation efficiency and this findings are theoretically align with the lean construction and resource based view frameworks. According to the current study, in the context of Mega projects in Addis Ababa, Ethiopia, the most important practices includes information sharing, logistics planning and fuel, vehicle and driver management however digital technologies are less important except implemented and supported strategically.

5.3 Recommendations

The recommendations that can be drawn to improve transport efficiency based on the study objectives are as follows for contractors and project stakeholders and policy makers: Contractors needs to firstly establish accurate and consistent internal information sharing among procurement, supply and transportation departments. Secondly, Improve logistics planning by streamlining site level inventory control, consolidating smaller deliveries, and coordinating waste transport to reduce congestion and inefficiency. Thirdly, devise effective vehicle maintenance schedules, driver assignment procedures and fuel tracking systems which are included in formal transportation management systems. Fourthly, develop contingency plan based on past experience lesson to be proactive during unexpected situations like breakdowns, traffic delays and construction sequence changes. Last but not least, invest in digital technologies and train how to use to enhance usability.

Based on the finding of the study, the recommendation for project Stakeholders and Policy Makers are the following: (1) Encourage standardization of logistics protocols and reporting practices across contractors working under government led projects. (2) Support digital transformation through subsidies or incentives that promote the adoption of transport management software and communication platforms. (3) Build logistics capacity through targeted training programs, particularly in lean logistics principles and digital systems operation and (4) Integrate transport key performance index (KPIs) into project performance monitoring, ensuring accountability for cost, time, and resource utilization in transport operations.

5.4 Contribution

This study contributes to construction logistics and transport literature in a developing country, including Addis Ababa, Ethiopia in the following ways: (1) it provides empirical evidence about the construction transport efficiency of Addis Ababa, Ethiopia as a ground for further study. (2) It identifies information sharing as the most critical success factor, which adds to existing knowledge on lean construction practice followed by Logistics service and transport management practices that enhance efficiency of construction transport. (3) It highlights disconnect between the perceived value of digital tools and their practical impact, which is underexplored in prior studies.

5.5 Limitations and Future Research Areas

While the study yielded valuable insights, it is subject to the following limitations, it was confined to contractors under the Mega Projects Office in Addis Ababa, which may limit generalizability to smaller contractors projects and the use of self-reported perceptions may introduce bias or subjectivity, especially regarding performance related responses.

To add to the findings of this study, for instance, future studies may be designed to: (1) Analyze sectoral variation in transport efficiency by conducting a comparison study between public and private construction companies. (2) Assessing operational data and technology or specific transportation effects, and (3) a framework for transport efficiency that integrates technology and human centered approaches and tailored to the emerging economies.

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Appendix 1

Introduction

This questionnaire is designed to gather data for a research study entitled " Factors Affecting Construction Transport Efficiency in a Developing Country Context: The Case of Mega Projects Office" The study is being conducted by Befikir Ashenafi as part of the requirements for the Master's Degree in Management (Transport Management) at Addis Ababa University. The research is being supervised by Yohannes Workaferahu (PhD).

The primary aim of this study is to identify and analyze the major factors influencing transport efficiency of construction projects, with particular focus on projects administered by Mega Projects Office. The study specifically investigates the impact of four key factors: Information Sharing, Digital Tools & Technologies, Logistics Service, and Transport Management Practices on Construction Transport Efficiency (CTE).

Your participation is highly valuable and will contribute significantly to the success of this research. The data collected will be used strictly for academic purposes and will be treated with full confidentiality. There are no right or wrong answers your honest and thoughtful responses are what matter most.

We kindly ask you to complete the questionnaire based on your experience and current practices. The survey uses a 5-point Likert scale ranging from Strongly Disagree (1) to Strongly Agree (5).

Thank you in advance for your cooperation and time.

Section 1. Demographic Information

1. Gender: Male Female

2. Highest Educational Level

Diploma

Degree

Masters

Post graduate/PHD

Other: _____

3. What is your department in the construction company?

Construction Department

Equipment/Machinery administration and maintenance Department

Property administration and Supply Department

Procurement Department

Other: _____

4. How many years of experience do you have in construction?

Less than 5 years

6–10 years

11–15 years

16–20 years

More than 20 years

5. Years of Experience with the Current Company

Less than 2 years

2–5 years

6–10 years

11–15 years

16–20 years

More than 20 years

6. What is the size of your construction company?

Small organizations (1–50 employees)

Medium organizations (51–250 employees)

Large organizations (more than 250 employees)

7. To what extent is the project you participate successful in managing its logistics and transportation in general?

Fully successful partially successful less successful Not successful

8. Does your company measure the performance of transport in projects to and from construction site?

Yes No

9. Does your company use Construction logistics solution for its projects?

Yes No Don't know

10. If Yes, please select all that apply the Construction logistics solution used for projects

Checkpoint

Consolidation terminal

Logistics coordinator on site

Don't know

Other: _____

Section 2: Factors Affecting Construction Transport Efficiency

Section 2: The following questions assess the factors affecting construction transport efficiency, based on your experience in the projects you participated. Please provide extent of agreement by putting tick (√) mark the following

1 = Strongly Disagree

2 = Disagree

3 = Neutral

4 = Agree

5= Strongly Agree

Section A: Information Sharing

No	Statement	1	2	3	4	5
A1	Accurate transport related information is consistently shared with all involved parties (e.g., suppliers, transporters, contractors).					
A2	All involved parties (e.g., suppliers, transporters, contractors) have adequate access to transport related information.					
A3	All transport related updates are shared quickly with all parties.					
A4	There is sufficient communication between transporters and contractors regarding transport operations.					
A5	Regular transport evaluation report are provided to all relevant bodies.					
A6	Contractors maintain an adequate level of internal information sharing regarding transport activities.					
A7	Real-time info is shared during transport (e.g., live vehicle location tracking).					
A8	Delivery times are communicated clearly (e.g., supplier informs contractor of exact arrival time).					

Section B: Digital Tools and Technologies

No	Statement	1	2	3	4	5
B1	GPS tracking systems are used effectively to control and trace trucks during transport operations.					
B2	Transport and logistics management software is utilized for scheduling and monitoring material deliveries.					
B3	Data from transport operations is digitally stored, recorded, and analyzed using tools such as digital scanners.					
B4	There is adequate investment in upgrading digital tools for managing material transport operations.					
B5	Digital tools are well-integrated into the existing construction and transport workflow.					
B6	The software and digital tools used by the company often face usability challenges.					

Section C: Logistics Service

No	Statement	1	2	3	4	5
C1	There is minimal loss or damage to materials during transportation.					
C2	Loading and unloading operations are carried out in a timely and efficient manner.					
C3	Just-in-Time (JIT) delivery is practiced, ensuring materials arrive exactly when needed on site.					
C4	Frequently used materials are often well stocked at project site.					
C5	Waste management and collection services at the construction site are insufficient.					
C6	Smaller deliveries are effectively consolidated into single loads to improve transport efficiency.					
C7	There is flexible logistics service for urgent or unexpected deliveries.					
C8	The project logistics service responds promptly and effectively when transport issues arise.					
C9	There is reliable logistics service that support transport operations.					

Section D: Transport Management Practices

No	Statement	1	2	3	4	5
D1	A clear and effective vehicle maintenance policy is in place and followed (e.g., regular servicing to avoid breakdowns).					
D2	Fuel management practices are efficiently implemented and monitored.					
D3	Driver management practices are well-organized (e.g., trained, reliable drivers assigned properly).					
D4	Vehicle scheduling for transporting materials and waste is conducted in a timely and systematic manner.					
D5	There is a lack of effective policies for maximizing vehicle load or space capacity utilization.					
D6	Route planning and optimization practices for vehicle movements are inadequate.					
D7	Delivery schedules are well-structured and effectively executed.					
D8	Transport schedules are adjusted dynamically in response to real-time site or road conditions.					
D9	There is effective contingency plans to respond to unexpected material transportation issues. (i.e. Existing alternative remedial solution for deviated transport processes from plan).					

Section 3: Construction Transport Efficiency (Dependent Variable)

The following questions assess construction transport efficiency of the project. Please provide your level of agreement by putting tick (✓) mark for the following based on your experience in the projects you are participating/participated and current practices.

1 = Strongly Disagree

2 = Disagree

3 = Neutral

4 = Agree

5 = Strongly Agree

No	Statement	1	2	3	4	5
G1	Materials are delivered to project site in a timely manner.					
G2	The transport of material and waste operation in your project site experience minimal interruptions.					
G3	There is optimal utilization of transport resources (e.g., vehicles, drivers) in the project.					
G4	Transport related problems rarely cause delays in construction activities.					
G5	Transport operations to and from project site align with construction schedule.					
G6	There is reduced vehicle turnaround time (the time between loading at source and unloading at site/terminal).					
G7	The cost of material and waste transport operations in the project is reasonable.					
G8	Vehicle space/capacity is adequately utilized in each material transportation to and from project.					
G9	The number of vehicle movements (start/stop) is reduced in the transport operation in your project site.					
G10	The project has optimum total vehicle kilometer (total kilometer travelled by vehicle).					