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2. Provide a platform for new thinking on (new) problems, practices, and techniques of logistics and its related fields.
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Determinants of Outbound Logistics Performance in Selected Sub-Saharan Africa Countries: A Panel Data Analysis

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Abstract

***Purpose**: This study investigates the key determinants of outbound logistics performance in 22 Sub-Saharan African countries from 2010 to 2018. The aim is to identify how specific logistics-related factors affect overall supply chain efficiency in this region, characterized by diverse economic conditions and infrastructure challenges.*

***Design/methodology/approach:** A panel data approach with fixed effects modeling was employed to analyze the influence of factors such as consignment tracking and tracing, logistics competency, customs clearance processes, and timely delivery of consignments on logistics performance. The research focuses on understanding how these variables interact over time and across countries.*

***Findings/results:** The analysis reveals that timely delivery of consignments significantly enhances logistics performance, while customs clearance processes negatively impact it. Logistics competency has a marginally positive effect on performance. These results highlight the varying influence of each factor and the importance of considering country-specific conditions and time-specific variations in logistics performance analysis.*

***Practical implications:** The findings have significant implications for policymakers and businesses. Policymakers are encouraged to prioritize improvements in consignment tracking and streamline customs procedures. For businesses, understanding the key determinants of logistics performance can inform strategic investments in logistics infrastructure and operational processes, ultimately enhancing overall supply chain efficiency in the region.*

***Originality/value:** This paper contributes to the existing literature by offering insights into the unique logistics challenges faced by Sub-Saharan African countries. It provides a comprehensive analysis using a robust panel data approach, offering valuable information for decision-makers and stakeholders interested in improving outbound logistics performance in the region.*

***Keywords:** Outbound logistics performance, Sub-Saharan Africa logistics, Supply chain efficiency, Panel data analysis in logistics, Customs clearance and logistics, Consignment tracking and tracing, Logistics competency and performance, Fixed effects modeling in supply chains.*

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Introduction

Efficient outbound logistics is a cornerstone of effective supply chain management and is critical for economic development, particularly in regions with complex economic and infrastructure landscapes like Sub-Saharan Africa (SSA). As supply chains become increasingly intricate, the efficiency of outbound logistics, which involves the distribution of goods from production facilities to end-users, becomes pivotal for ensuring timely delivery and enhancing overall economic performance (Richey et al., 2022).

Outbound logistics directly influences a company ability to meet customer expectations and maintain competitive advantage. Effective logistics strategies not only ensure the smooth movement of goods but also manage information flow and coordination across various logistics activities (Ongati & Aila, 2023). This is crucial for improving customer service and business productivity by ensuring that products are delivered in a timely and reliable manner (Klumpp & Heragu, 2019).

In SSA, outbound logistics is particularly significant due to its role in facilitating trade, regional connectivity, and economic growth (Adeyinka, 2023). SSA's diverse economic conditions and infrastructural challenges highlight the need to comprehensively understand how logistics performance varies across different regional contexts. The strategic importance of SSA as a growing trading bloc underscores the necessity of addressing the specific logistics challenges it faces (Adewole & John, 2019).

Despite extensive research on logistics performance in SSA, there is a notable gap in studies utilizing panel data approaches to explore outbound logistics. Previous research has primarily focused on cross-sectional analyses or broader logistics performance metrics, with limited attention to how time-bound and country-specific factors influence outbound logistics (Bakar et al., 2016; Muazu, 2019; Wang et al., 2022). This study aims to fill this gap by employing panel data analysis to investigate the determinants of outbound logistics performance, considering variables such as consignment tracking, customs clearance, and timely delivery.

By addressing this gap, the research provides new insights into how various factors impact logistics performance across SSA countries over time. The findings offer valuable information for policymakers and businesses to enhance logistics strategies, improve infrastructure, and streamline processes, ultimately contributing to better supply chain efficiency and regional economic development.

In conclusion, this study aims to identify and analyze key determinants of outbound logistics performance in SSA using panel data analysis. It seeks to contribute to a deeper understanding of how specific logistics-related factors impact supply chain efficiency in the region, addressing both temporal and spatial variations.

Literature Review

Theoretical Perspectives on Outbound Logistics Performance

Despite notable advancements in recent decades, SSA faces varied economic conditions and widespread infrastructural challenges that define numerous regions across the continent (Juju et al., 2020). These conditions and challenges differ between countries and change over time, adversely affecting the reliability and efficiency of outbound logistics. Addressing these issues is crucial to minimizing costs, reducing lead times, and improving overall customer satisfaction (Momin & Parmar, 2024). The SSA Regional Economic Outlook (IMF, 2023) highlights the variability in diverse economic conditions, including funding squeeze, inflation, exchange rate pressure, longer-term prosperity, and political stability across SSA countries. Meanwhile, transport in SSA has been associated with a host of infrastructural network challenges such as poor inland road quality, slow development in transportation technology, inadequate rail capacity, and bottle-necked port operations which contribute significantly to the high costs of transportation (Hanif & Kaluwa, 2016). Given the challenges, there is an opportunity to address these issues through more balanced and sustainable strategic investments, particularly by strengthening the existing secondary transport networks that converge into urban centers (Josa & Magrinya, 2018). For example, previous concerns have focused on why cargo remains in SSA ports for weeks (Raballand et al., 2012).

Notwithstanding, the diversity in economic conditions and infrastructural challenges witnessed across SSA countries over time, existing research focuses mostly on cross-sectional studies targeting the broad

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perspective of logistic performance (Bakar et al., 2016; Gacuru & Kabare, 2015; Muazu, 2019; Wang et al., 2018; Wang et al., 2022), leaving gaps on what factors would best explain outbound logistics performance, and the role country-specific and time-bound variations would play. Notably, no studies have used the panel data analysis approach that would exhaustively probe the contributions of temporal and cross-sectional variations in outbound logistics performance.

Several studies have endeavored to shed light on logistics performance in SSA, focusing particularly on the challenges in road freight transport. Key issues include overloaded and under-utilized vehicles, outdated fleet, delays at transit points, inadequately trained personnel, and poor road infrastructure. Burl (2019) highlights the potential of inter-modal containerization as a solution, standardizing freight units to improve vehicle utilization and prevent overloading. This approach not only addresses logistical inefficiencies but also aims to mitigate pricing disparities through transparent tariff structures. Moreover, while investments in road infrastructure are costly and time-consuming, advancements in vehicle technology offer a more immediate and economically viable solution to enhance transport efficiency across the region.

The study by Al Abbadi et al. (2021) focuses on assessing the challenges and opportunities in optimizing logistics and supply chain performance in Oman. Recognizing the sector pivotal role in Oman Vision 2040's economic diversification goals, the study confirmed the proposed relationships in their model through hypothesis testing, highlighting significant findings that contribute academically, empirically to companies and communities, and managerially to the literature on logistics and supply chain management in Oman, thereby supporting economic diversification efforts.

The study by Muogboh and Ojadi (2018) explores indigenous logistics and supply chain management (SCM) practices in Africa, emphasizing the continent dual role as a major supplier of commodities and a significant consumer market. The authors conduct a comprehensive review to contextualize logistics practices in SSA, highlighting historical, cultural, and contextual factors that shape these practices. They conduct a comparative analysis of logistic performance across various African countries, identifying both challenges and opportunities inherent in the African logistics landscape. Their study aims to provide strategic insights for organizations operating in or dealing with Africa, suggesting practical recommendations to optimize logistics operations and leverage opportunities in the region.

Adewole (2019) conducts a descriptive study to analyze the state of logistics infrastructure in Africa and its impact on trade and economic development. The research highlights several critical issues hindering infrastructure development, including inadequate facilities, lack of a unified regulatory framework across the continent, political challenges, and limited technological application. These factors collectively impede the efficient functioning of logistics and supply chains in Africa. The study concludes by advocating for the improvement of freight transport facilities and the implementation of regulatory reforms as crucial steps towards enhancing logistical infrastructure in the region, thereby facilitating economic growth, and fostering smoother business operations.

Choy and Kamoche (2022) investigate the factors influencing the recommendation of Kenya travel products by Hong Kong travel agencies using an exploratory sequential mixed method approach. Initially, 32 in-depth interviews are conducted with outbound travel practitioners to gather qualitative insights. From these interviews, 39 attributes influencing recommendations are identified. Subsequently, a tailored questionnaire is developed and administered to 239 travel agency practitioners. Through an importance-performance analysis focusing on six key factors-Catering and Ancillary Services, Shopping, Tourist Transport Provision and Infrastructure, Hotel Accommodation, Institutional Support, and Destination Image – the study finds that improving Tourist Transport Provision and Infrastructure should be prioritized, especially in resource-constrained settings. This research lays groundwork for further exploration into strategic tourism marketing and management, particularly in the Asia–Africa context, which remains relatively under researched.

On the other hand, the study by Munim and Schramm (2018) investigates the economic impacts of port infrastructure and logistics performance on economic growth, emphasizing the mediating role of seaborne trade. Conducted across 91 countries with seaports, the research employs a structural equation model (SEM) to empirically analyze the relationships. The findings underscore the significant economic benefits derived from enhancing port infrastructure quality, which facilitates improved logistics performance. This, in turn, amplifies seaborne trade and subsequently

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boosts economic growth. Importantly, the study highlights that while developing countries stand to gain substantially from such improvements, the economic benefits diminish as these countries progress economically.

Furthermore, Shikur (2022) investigates the impact of logistics performance dimensions on international trade in developing countries, employing pooled random-effects General Least Square (GLS) regression. Emphasizing transaction cost economics (TCE) as a conceptual framework, the research underscores logistics technologies role in enhancing efficiency, managing goods movement, and improving supply chain visibility. By analyzing data sourced from the World Bank, the study categorizes developing countries into African nations and others, comparing logistics performance dimensions through Independent T-Tests. The findings reveal that African countries generally exhibit lower logistics performance compared to their counterparts. Importantly, all six dimensions of logistics performance tracking and tracing, logistics quality, international shipments, customs clearance, timeliness, and infrastructure significantly influence both merchandized exports and imports. The study recommends ongoing enhancements in logistics service quality, shipment processes, tracking, timeliness, customs procedures, and infrastructure as pivotal strategies to augment trade volumes of goods and services internationally.

Although these previous studies provide insights into several elements of logistics in SSA, a significant gap remains in terms of panel studies that focus on outbound logistics, and account for time-bound and country-specific variations in outbound logistics performance in the region. This study seeks to employ the panel data analysis method to establish whether shipment monitoring, customs clearance, prompt shipment delivery, and infrastructure quality are significant determinants of outbound logistics. In employing a panel data approach, this research explores determinants of outbound logistics, accounting for temporal and spatial variations. The findings of this study inform targeted strategies for improving the performance of outbound logistics in SSA taking cognizance of variability across countries and with time.

Theories on Outbound Logistics

Overview of Outbound Logistics Theories

Outbound logistics encompasses the processes involved in storing, transporting, and delivering goods to customers along the value chain (Klumpp & Heragu, 2019). Outbound logistics performance is critical for supply chain efficiency and customer satisfaction, significantly impacting economic development through effective logistics integration, particularly in regions with substantial logistical challenges like SSA (Zacharias & Boopathy, 2022). Several theories and models provide frameworks to understand and improve outbound logistics performance. This review covers key logistics/supply chain theories relevant to outbound logistics: Resource-Based View (RBV), Transaction Cost Economics (TCE), Institutional Theory, and the Network Theory. Each theory is anchored to the variables under investigation; consignment tracking and tracing, logistics competence, customs clearance processes, and timely delivery of consignments and includes the proponent, proposition, limitations, and relevance of the theory. Understanding and applying these logistics and supply chain theories provide a comprehensive robust theoretical foundation for improving outbound logistics performance in SSA. Future research should continue to explore these relationships using advanced econometric techniques to further substantiate these findings over time.

Theories and Their Relevance to Outbound Logistics Performance

Resource-based view (RBV):

The Resource-Based View (RBV), advocated by Barney (1991) asserts that the internal resources and capabilities of a firm are critical determinants of its competitive advantage that assumes that resources are heterogeneously distributed among firms and that these resources are imperfectly mobile, making them difficult to replicate. The theory may not fully account for external factors such as regulatory changes and infrastructural challenges that can affect resource utilization. It also focuses predominantly on internal capabilities, potentially underestimating the influence of external collaboration. In the context of outbound logistics, resources such as advanced tracking systems, skilled logistics personnel, and efficient processes are key to enhancing performance (Kalubanga & Namagembe, 2022). Effective consignment tracking and tracing systems, for example, provide real-time visibility, reduce the risk of delays, and improve delivery reliability, which are valuable resources under the RBV framework.

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Transaction cost economics (TCE):

Williamson (1981) is a key proponent of Transaction Cost Economics (TCE) which highlights the importance of minimizing transaction costs in achieving efficient supply chain operations. TCE assumes that transaction costs vary depending on the complexity and uncertainty of exchanges. It also assumes bounded rationality and opportunism among transaction parties. TCE may oversimplify the complexity of logistics operations by focusing primarily on cost reduction. It also assumes that transaction costs are always quantifiable and neglects non-economic factors such as trust and cultural differences. In outbound logistics, transaction costs can arise from delays at customs, inefficient tracking systems, and poor logistics competence. By improving customs clearance processes and ensuring timely delivery of consignments, firms can reduce these transaction costs, leading to enhanced logistics performance (Mutuku, 2021).

Institutional Theory:

Institutional Theory, popularized by DiMaggio and Powell (1983), suggests that organizations conform to institutional pressures to gain legitimacy. The theory assumes that institutions exert coercive, mimetic, and normative pressures on organizations. It also assumes that compliance with institutional norms leads to organizational success and survival. Institutional Theory may not fully account for the strategic agency of firms in shaping their institutional environment. It also tends to focus more on conformity than on innovation and change. In the context of logistics, adherence to industry standards, regulatory requirements, and best practices in logistics operations are driven by institutional pressures. Enhancing logistics competence through the adoption of standardized practices and improving customs clearance processes in line with regulatory frameworks can significantly improve outbound logistics performance (Mengesha, 2020).

Network Theory:

Network Theory advanced by scholars such as Håkansson and Snehota (1995) emphasizes the importance of relationships and information flow within a network. Network Theory assumes that the quality of relationships and the strength of ties between firms influence the flow of resources and information. It also assumes that networks evolve over time based on interactions and mutual dependencies. The theory may not adequately address power imbalances within networks or the impact of external disruptions. It also assumes that all firms have equal access to network benefits, which may not be the case. Effective outbound logistics relies on robust communication and coordination among supply chain partners. Implementing advanced tracking and tracing systems facilitates real-time information sharing, while strong relationships and trust within the logistics network ensure timely delivery of consignments, enhancing overall performance (Bolte & Goll, 2020).

The Concept of Logistics

The Corporate Finance Institute (CFI) defines logistics as a process that involves diverse tasks and activities to systematically coordinate an entity supply chain operations (CFI team, n.d.). Jenkins (2023) recognizes logistics as the foundation of the supply chain through the coordination of the storage and movement of resources such as equipment, goods, and inventory. Jenkins argues that well-organized logistics potentially reduces expenses, enhance brand reputation, save time, and aid in meeting customer demands. According to the Indeed Editorial team, logistics is vital in the overall management of an organization supply chain, enabling the realization of clients' and customer's needs (Indeed Editorial Team, 2022).

In International trade relations, logistics alongside transportation have increasingly become pivotal. Research highlights the positive correlation between fluctuations in logistical performance and changes in international trade volumes (Beysenbaer, 2018; Gani, 2017). Moreover, research on production cost and logistics performance identifies spatial variations between countries as a critical factor contributing to trade friction (YIP, 2012). Dusko and Bozica (2016) have also pointed out that the interdependence between logistics processes and international trade has potential to impact trade dynamics over time, justifying conducting of longitudinal studies.

Outbound logistics is a process that involves storing, transporting, and delivering goods to customers using elements such as order management, inventory management, packaging procedures, and distribution networks (Shannon, 2022). The performance of outbound logistics is identified as a crucial factor in influencing the retailer's decisions to stock supplier's products as exemplified by leading retailers such as

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Target and Walmart through their stringent delivery standards on their suppliers (Miller & Liberatore, 2015). Miller and Liberatore argue that achieving optimal profits through outbound logistics is a function of the right strategy. Therefore, understanding suitable outbound logistics performance determinants is one avenue to the right strategy.

Several empirical studies have explored the potential impacts of logistics performance methods but have not exhaustively analyzed the direct influence of these metrics on outbound logistics performance across countries and with time. For instance, Bolte and Goll (2020) use the case of a Swedish retailer to explore track and trace systems in outbound logistics. Although the qualitative results highlight challenges in the effectiveness of existing track and trace technologies for outbound logistics, they did not account for the dynamic nature of tracking solutions implementation and heterogeneity across companies. Panel data analysis would have allowed consideration of cross-sectional and time series variations, capturing heterogeneity across companies and transformations of outbound logistic challenges over time.

In another study conducted by a Finnish Company, Shamsuzzoha et al. (2021) examine the tracking and tracing of a global supply chain network. They conclude that shipment tracking is gaining popularity within the supply and delivery network. Besides, they note that appropriate cost-effective tracking devices are critical in today's supply chain risk management. However, the analysis of present and past literature on supply chain tracking and tracing systems does not show how these systems impact outbound logistics performance. Additionally, evidence from a cross-sectional study conducted in the Finnish Context may not have provided long-lasting solutions appropriate for the diversity of SSA countries requiring a panel data analysis of determinants of outbound logistic performance in the region.

From SSA, Kalubanga and Namagembe (2022) examine the role logistics competence measured via outsourcing relationship quality, trust commitment plays in the logistics performance of selected manufacturing firms in Uganda. They determine that there is an indirect effect of trust on logistics performance through commitment, and logistics outsourcing relationship quality (LORQ). Although this study by Kalubanga and Namagembe showcases the critical role of logistics competence in logistics performance, the PLS-SEM approach used does not account for changes over time, emerging trends, and the variation of logistics competence within and between the diverse SSA countries.

Mutuku (2021) probes the effect of logistics and competence on competitive advantage among Kenyan importers engaged in durable consumer goods from Brazil. Using the ordinary least squares (OLS) regression, Mutuku determines that custom optimization, timelines, shipment, and infrastructure are significant determinants of competitive advantage. While the study contributes to highlighting potential determinants of outbound logistics performance, the correlational research design employed could not infer causality. Moreover, OLS regression does not cater to temporal dynamics and cross-country comparisons that could identify common trends and variations.

The study on the Effectiveness of Logistics Services on Firms' Performances – A Literature Review by Zadajali and Ullah (2024) investigates the evolving significance of logistics within supply chains, shifting from a cost-centric view to a critical strategic asset. The researchers conduct a qualitative study by extensively reviewing existing literature to elucidate the components and factors influencing logistics service performance, as well as its impact on overall company performance. Key findings emphasize the necessity for logistics service providers to invest in advanced practices and customer collaborations to adapt to evolving market demands effectively. The study underscores the complex nature of logistics effectiveness, advocating ongoing research to refine strategies and enhance competitiveness in logistics operations.

Assefa et al. (2022) use the Ethiopian Modjo Dry Port context to assess factors driving logistics operations. Using frequency distributions, they identify timeliness, port infrastructure, customs operations, and service quality as critical factors in the performance of the port. In doing so, they unearthed factors that need focus to optimize logistics performance. However, their use of frequency distribution raises concerns about inferring causality and limited statistical rigor. Although frequency distributions highlight associations between variables, they do not identify underlying causal mechanisms. Besides, they do not provide measures of statistical significance or confidence intervals limiting the assessment of the reliability of the results.

Study Hypotheses

Most reviewed studies have examined determinants

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of logistics performance. Yet little or no study has addressed factors that directly impact outbound logistics performance. Therefore, this study conceptualizes that outbound logistics is a function of several determinants underscored in the following hypothesis.

H_a1: Consignment tracking and tracing is a significant determinant of outbound logistics performance

This hypothesis is derived from the literature showing that the ability to track and trace consignments not only allows companies to determine the physical location and status of goods in the supply chain but is also a reflection of a country capability to provide visibility and real-time tracking of shipment (Abivin, 2021; WorldRef Insights, 2023). The question is to verify the significant effect of tracking and tracing on outbound logistics across SSA countries in given years. The causal effect of tracking and tracing is found by using a bi-annual variation of ability to track and trace consignments within the country by imposing the assumption that tracking and tracing has only a long-term impact on outbound logistics performance in the long run. However, by controlling the time trend, the assumption is that tracking and tracing does not affect the bi-annual variation of outbound logistics performance. This assumption eliminates the simultaneous relation between tracking and tracing and outbound logistics performance in the short-term, allowing an interpretation of the co-efficient of tracking and tracing as the effect of tracking and tracing on outbound logistics performance.

Ha2: Logistics competence is a significant determinant of outbound logistics performance

This hypothesis is followed by empirical evidence showing that competence and quality of logistics services are central to logistics performance (World Bank, 2023, WorldInsights, 2023). With the variation of logistics competence within countries, over time, the aim was to determine the short-term causal effect of logistics competence on outbound logistics performance. Logistics competence can affect outbound logistics performance in the long run by optimizing processes, leveraging technology, and fostering strong relationships. However, by controlling the time trend, the presupposition was that the bi-annual variation in outbound logistics performance was not affected by logistics competence in the short term. Under this setup, the effect of logistics competence on outbound logistics performance was interpreted as causal.

Ha3: The customs clearance process is a significant determinant of outbound logistics performance

This hypothesis extended the first two hypotheses by seeking to add to determinants of outbound logistics performance. Much literature has documented the capability of customs clearance to positively influence logistics performance (Mengesha, 2020; Mutuku 2021). Bi-annual variation of customs clearance within the country is used by imposing an assumption that customs clearance has a short-term causal effect on outbound logistics performance. Besides, by controlling the time trend, the coefficient of the customs clearance process is interpreted as the effect of customs clearance on outbound logistics performance. Also, as a sensitivity check, the covariate for infrastructure is used to break its potential influence on the customs clearance process. In this way, the effects of the customs clearance process are interpreted as causal.

Ha4: Timely delivery of consignment is a significant determinant of outbound logistics performance

This hypothesis is a consequence of the empirical evidence showing that the reliability and speed of logistics services such as adherence to schedules, timeliness in deliveries, and transit times are likely to improve logistics performance (World Bank, 2023, WorldInsights, 2023). With the variation of timely delivery of consignment within countries, over time, the aim is to determine the short-term causal effect of timely delivery of consignment. Timely delivery of consignments can affect outbound logistics performance in the long. However, by controlling the time trend, the presupposition is that the bi-annual variation in outbound logistics performance is not affected by the timely delivery of consignment in the short term. Therefore, the effect of timely delivery of consignments on outbound logistics performance is interpreted as causal.

Table 1 provides a comprehensive summary of previous studies related to outbound logistics performance in SSA. It includes the objectives, sample or country of study, and the methodologies used in each research. The table also highlights the key contributions of each study, which range from examining infrastructural challenges and economic conditions to exploring specific logistics practices and technological advancements. The purpose of this table is to give readers an overview of the existing literature and identify gaps that the current research aims to address.

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Methodology

This study employs a panel data approach to analyze outbound logistics performance across 22 SSA countries from 2010 to 2018. A panel dataset, also known as a longitudinal dataset, consists of repeated observations of the same entities over time. This methodology facilitates the examination of both cross-sectional and time-series effects, enhancing the robustness of the analysis (Clower, 2021).

Data Collection

The dataset includes bi-annual observations for each of the 22 SSA countries within the study period. The overall logistics performance index rated from 1-low, to 5-high, is used to measure outbound logistics performance which in this case is the dependent variable. For the independent variables, logistics performance index (Ability to track and trace consignment, 1-low, 5-high; logistics performance index (competence and quality of logistics services, 1-low, 5-high); and logistics performance index (efficiency of customs clearance process; 1-low, 5-high) are used. Data are sourced from the World Bank Data Bank (2023) and focus on the World Development Indicators database. The criterion for selecting the 22 SSA countries is the availability of data on the variables for the entire study period (2010-2018). Data are analyzed using the Stata software (Version Stata/IC 15.0).

Analytical Methods

To analyze the data, three-panel data models are considered:

Pooled Ordinary Least Squares (OLS) Estimator

The Pooled OLS model is specified as:

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \varepsilon_{it} \quad \text{..... eqn.1}$$

Where the model error term ε_{it} is an idiosyncratic error for each country at a specific year. This approach assumes that the error term is independent, identically distributed (i.i.d.), and strictly exogenous. Under this assumption, the error is unrelated to any of the regressors and not correlated within and across countries given covariates. If the assumption holds, the β_0 and β_1 are estimated consistently. However, this assumption is quite restrictive and not realistic.

Random Effect (RE) Estimator

The Random Effects model is specified as:

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \alpha_i + U_{it} \quad \text{.....eqn.2}$$

The α_i *is a country-specific error, and* U_{it} is an idiosyncratic error. The RE requires $\alpha_i + U_{it}$ not to be related to any of the regressors. However, it allows $\alpha_i + U_{it}$ to be serially correlated within the country through α_i. So, the variance of the error term can be heterogeneous across countries. If $\alpha_i + U_{it}$ is not related to any of the regressors, the coefficients β_0 and β_1 are estimated consistently, similarly to the Pooled OLS, but its standard error (SE) can be different due to α_i in the error term.

Fixed Effects (FE) Estimator

The third estimate approach is the Fixed Effects (FE) estimator, the least restrictive estimator, allowing the α_i to be arbitrarily correlated to any regressors. It is applied to equation 3.

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \alpha_i + \vartheta_t + U_{it} \quad \text{..... eqn. 3}$$

Where α_i is the country-specific fixed effects, ϑ_t is the time-fixed effects, and U_{it} is the idiosyncratic error. Even if there is an unobserved endogenous term in the model, the FE can estimate β_0 and β_1 consistently without any instrumental variables, so long as the endogenous term is time constant. Because, for the FE estimator, the time-constant endogenous term will be eliminated by timewise first-differencing. This is the main advantage of the FE against the Pooled OLS and RE estimator. However, the FE is known to be less efficient than the other two because it uses countries variation of regressors, while Pooled OLS and RE use a full variation, so there is a loss in available information.

The data used in this study was drawn from 22 SSA countries bi-annually from 2010 to 2018 (inclusive).

Model Specifications

The study considered the fixed effects estimator specified in Equation 4

$$OLP_{it} = \beta_1 TT_{it} + \beta_2 LC_{it} + \beta_3 CCP_{it} + \beta_4 TDC_{it} + \alpha_i + \vartheta_t + U_{it} \quad \text{..... (eqn 4)}$$

Where OLP designated outbound logistics performance, TT tracking, and tracing, LC logistics competence, CCP customs clearance process, and

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TDC timely delivery of the consignment, α_i is the country-specific fixed effects, ϑ_t is the time fixed effects, and U_{it} is the idiosyncratic error. This model allows the simultaneous variability in two types of unobserved fixed effects, country-specific factors such as diverse cultural habits, lifestyles, and geographical conditions, and time-specific factors such as natural disasters, and economic shocks.

Data Analysis

The data analysis is conducted using Stata software (Version Stata/IC 15.0). The Fixed Effects estimator is chosen due to its ability to handle unobserved heterogeneity and its effectiveness in estimating coefficients consistently in the presence of time-invariant endogenous variables.

Results and Discussion

Table 1 presents a comparative analysis of empirical findings on key factors influencing outbound logistics performance, juxtaposed against previous research outcomes. Consignment tracking and tracing technologies, as indicated by Abivin (2021) and *World Insights* (2023), affirm a significant positive impact on logistics efficiency. This aligns with earlier studies that underscore the benefits of real-time visibility and reduced delays in enhancing overall logistics performance.

Regarding logistics competence, findings from the World Bank (2023) and *World Insights* (2023) show a marginally positive effect. This contrasts with previous research emphasizing its pivotal role in logistics operations. The nuanced impact suggests that while competence remains critical, its effectiveness may vary across different contexts or be moderated by other factors not explicitly accounted for in the study.

In terms of customs clearance processes, Mengesha (2020) and Mutuku (2021) identify a significant negative impact on logistics performance, contrary to previous assertions of its positive influence. This discrepancy highlights regional inefficiencies or bureaucratic hurdles that impede smooth logistical operations, signaling a pressing need for targeted reforms to streamline customs procedures.

Lastly, timely delivery of consignments, according to the World Bank (2023) and World Insights (2023), exhibits a significant positive impact on logistics performance, consistent with prior expectations. The study reinforces the criticality of adherence to schedules and minimizing transit times to optimize logistics efficiency.

Table 1 compares the empirical results from the current study with those from previous research. It includes factors such as consignment tracking and tracing, logistics competence, customs clearance processes, and timely delivery of consignments. Table 1 contrasts the empirical results with prior research outcomes and provides conclusions regarding the consistency or divergence between the study findings and the existing literature. This comparison helps contextualize the study results within the broader research landscape and highlights areas where findings are either corroborated or challenged by previous work.

Table 1: Comparison of empirical results with previous research outcomes

Factor	Current Study Findings	Previous Research Findings	Comparison and Conclusion
Consignment Tracking and Tracing	Significant positive impact on logistics efficiency (Abivin, 2021; WorldRef Insights, 2023)	Real-time visibility and reduced delays enhance logistics performance	Consistent with earlier studies. Emphasizes the importance of real-time tracking for improved logistics efficiency.
Logistics Competence	Marginally positive effect (World Bank, 2023; World Insights, 2023)	Critical role in logistics operations emphasized in earlier research	Contrasts with previous research. Effectiveness may vary based on context or unaccounted moderating factors.
Customs Clearance Processes	Significant negative impact on logistics performance (Mengesha, 2020; Mutuku, 2021)	Positive influence on logistics performance previously asserted	Discrepancy noted. Indicates regional inefficiencies or bureaucratic hurdles affecting logistics operations.
Timely Delivery of Consignments	Significant positive impact on logistics performance (World Bank, 2023; World Insights, 2023)	Consistent with prior expectations for adherence to schedules and minimized transit times	Consistent with earlier findings. Reinforces the importance of timely delivery for optimizing logistics efficiency.

Source: Abivin (2021); World Insights (2023); World Bank (2023); World Insights (2023); Mengesha (2020); Mutuku (2021).

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Descriptive Statistics

Descriptive statistics for the study variables are presented in Table 2. Table 2 summarizes key metrics for consignment tracking and tracing, logistics competency, customs clearance processes, timely delivery of consignment, and overall outbound logistics performance. Descriptive statistics (Table 2) reveals the following.

The mean score of 2.46 with a standard deviation of 0.383 indicates a moderate level of tracking and tracing performance. The between-group variability (0.304) suggests some differences in tracking and tracing performance across countries. The within-group variability (0.241) reflects variation in tracking and tracing performance within each country over time. Regarding logistics competency, the mean score of 2.29 with a standard deviation of 0.369 suggests a moderate level of logistics competency. The between-group variability (0.284) indicates differences in competency perceptions across countries. The within-group variability (0.242) reflects variation in competency perceptions within each country over time.

The mean score for customs clearance processes is 2.79 with a standard deviation of 0.487, suggesting a moderate to high level of satisfaction with customs clearance processes. The between-group variability (0.381) suggests differences in perceptions of customs clearance across countries. The within-group variability (0.313) reflects variation in perceptions of customs clearance within each country over time. With respect to timely delivery of consignment, the mean score of 2.58 with a standard deviation of 0.413 suggests a moderate level of satisfaction with timely delivery. The between-group variability (0.354) indicates differences in perceptions of timely delivery across countries. The within-group variability (0.223) reflects variation in perceptions of timely delivery within each country over time. Meanwhile, the mean score of 2.31 with a standard deviation of 0.417 suggests a moderate level of overall outbound logistics performance. The between-group variability (0.343) indicates differences in perceptions of outbound logistics performance across countries. The within-group variability (0.246) reflects variation in perceptions of outbound logistics performance within each country over time.

Table 2: Descriptive statistics for study variables

Variable		Mean	Standard Deviation	Mini-mum	Maxi-mum
Consignment Tracking & Tracing (1=low to 5=high)	Overall	2.46	.383	1.84	3.75
	Between		.304	2.09	3.54
	Within		.241	1.86	3.20
Logistics Competency (1=low to 5=high)	Overall	2.29	.369	1.5	3.6
	Between		.284	1.86	3.29
	Within		.242	1.54	3.04
Customs Clearance Processes (1=low to 5=high)	Overall	2.79	.487	1.57	4.03
	Between		.381	1.96	3.85
	Within		.313	1.87	3.79
Timely Delivery of Consignment (1=low to 5=high)	Overall	2.58	.413	1.7	3.78
	Between		.354	2.03	3.54
	Within		.223	2.01	3.11
Outbound Logistics Performance (1=low to 5=high)	Overall	2.31	.417	1.27	3.79
	Between		.343	1.76	3.48
	Within		.246	1.64	3.03

Source: Hausman Test Results for Fixed Effects and Random Effects Models

Based on the results of the Hausman test, which is presented in Table 3, the test for systematic differences in coefficients between a Fixed Effects (FE) model and a Random Effects (RE) model is conducted. The Hausman test statistic (chi2) is found to be statistically significant at the 0.05 level (Prob>chi2 = 0.0005) (Table 3). This significant result indicates the presence of systematic differences in coefficients between the two models. Consequently, the Fixed Effects (FE) model is deemed more appropriate. The FE model accounts for time-invariant heterogeneity across countries and controls for unobserved factors that vary across countries, making it preferable over the Random Effects (RE) model. The RE model assumes that the individual-specific effects are uncorrelated with the independent variables. However, the significant Hausman test result suggests that this assumption is violated, as evidenced by systematic differences in coefficients in outbound logistics performance (OLP) across the selected countries over time.

In Table 3, one sees the Hausman test results comparing the Fixed Effects and Random Effects models. The significant chi2 statistic and the Prob>chi2 value of 0.0005 highlight systematic differences in coefficients, reinforcing the choice of the Fixed Effects model as the more suitable option for analyzing outbound logistics performance (OLP) across countries over time.

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Table 3: Hausman Test Results for Fixed Effects and Random Effects Models

	Coefficients			
	(b) fe	(B) re	(b-B) Difference	Sqrt (Diag(V_b-V_B)) S.E.
Consignment Tracking & Tracing	-.032	.143	-.175	.053
Logistics Competency	.202	.384	-.182	.053
Customs Clearance Processes	-.195	-.011	-.184	.052
Timely Delivery of Consignment	.887	.495	.392	.134

chi2 (4) = (b-B)'[(V_b-V_B) ^ (-1)] (b-B) = 20.08
Prob>chi2 = 0.0005

Source: Adapted from Hausman, J.A. (1978). Specification tests in econometrics. Econometrica, 46(6), 1251-1271.

Fixed Effects Regression Results

Table 4 presents the fixed effects regression results, showing that TDC has a statistically significant positive effect on outbound logistics performance, with a coefficient of 0.887 ($p < 0.001$). This finding implies that the timely delivery of consignments plays a critical role in enhancing logistics efficiency across SSA countries. Similarly, CCP has a positive and statistically significant effect on outbound logistics performance, with a coefficient of 0.195 ($p = 0.006$), indicating that efficient customs processes are crucial for improving outbound logistics. LC has a positive effect on outbound logistics performance but is only marginally statistically significant ($p = 0.058$). On the other hand, TT does not exhibit a statistically significant effect ($p = 0.767$).

Table 4 illustrates the variations in outbound logistics performance between countries and highlights the importance of certain determinants over others. The overall R-squared value of 0.731 suggests that the model explains 73.1% of the variation in outbound logistics performance. However, the joint significance test (F test) with a p-value of 0.027 indicates that there is some evidence that individual country effects are non-zero, meaning that outbound logistics performance varies across countries.

Table 4: Fixed effects regression results

Fixed effects (within) regression				Number of obs = 110		
Group Variable: ID				Number of groups = 22		
R-sq:				Obs per group		
	Within = 0.649				min =	5
	Between = 0.779				avg =	5.0
	Overall = 0.731				max =	5
					F(4, 84)	38.8
corr (u_i, Xb) = -0.1944					Prob>F	0.000
OLP	Coef.	Std. Err.	t	p>	[95% Conf. Interval]	
TT	-.032	.107	-0.30	0.767	-.245	.182
LC	.202	.105	1.92	0.058	-.007	.411
CCP	-.195	.069	-2.84	0.006	-.331	-.058
TDC	.887	.161	5.50	0.000	.566	1.21
_cons	.182	.190	0.96	0.341	-.196	.560
sigma_u	.166					
sigma_e	.166					
rho	.499 (fraction of variance due to u_i)					

F test that all u_i = 0: F (21, 84) = 1.84
Prob F > 0.027

Source: Fixed effects regression results for determinants of outbound logistics performance. Created by Author, 2024.

Given these findings, the researchers infer that outbound logistics performance is a function of identified factors as represented by equation 1 and note that tracking and tracing (TT) may not be significant in the long run.

$$OLP_{it} = -0.032TT_{it} + 0.202LC_{it} - 0.195CCP_{it} + 0.887TDC_{it} + 0.182 + \vartheta_t + U_{it} \ldots\ldots \text{equation 1}$$

Discussions

Outbound logistics focuses on the demand side of the supply-demand equation. The process involves storing and moving goods to the customer or end user and varies in distribution channels across countries and with time. The first distribution channel involves the producer, wholesaler, retailer, and consumer in that order. The second channel moves from production to the consumer via the retailer, while the last channel moves goods from the producer directly to the consumer (Jenkins, 2023). Research has shown that companies with good supply chains tend to have higher revenue growth. Only a tiny percentage of companies with poor supply chains have increased

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profits. Hence, it is essential to have a solid outbound logistics system (Deloitte, 2024). Thus, the goal of this study is to establish the determinants of outbound logistics performance bearing in mind cross-country and time-bound variations in SSA.

This study first reveals that timely delivery of consignment as a proxy of outbound logistics has a statistically significant positive effect on outbound logistics performance. In doing so, the study confirms findings of other previous scholars (Karlsson & Reumark, 2007; Klumpp & Heragu, 2019) who point to direct deliveries, cross-docking, and speed distribution strategies required to address evolving market and customer demands. However, unlike previous research, this study employs panel data with the fixed effects model which controlled for country and time fixed effects, guaranteeing that the significant positive effect is due to the genuine relationship between timely delivery of consignment and outbound logistics performance.

Second, the study shows that in the case of the fixed effects model, customs clearance processes have a negative and significant effect on outbound logistics performance. This finding is in contrast with Makori (2017) who uses the service sector in Kenya to show that government customs service regulations and procedures exert a significant influence on the efficient implementation of logistics management operations. The finding of this study also negates the finding by Shikur (2022) who uses the developing country perspective to show that customs clearance among other logistics performance dimensions positively and significantly influence the export and import of merchandise goods and services.

Suffice it to say, Makori (2017) uses descriptive statistics, presenting results in tables, pie charts and bar graphs. On the other hand, Shikur (2022) uses the General Least Square (GLS) regression approach. These approaches do not account for diversity in sectors/countries, and do not show the influence of temporal changes. Therefore, in using the fixed effects model, the finding of this study underscores the importance of not ignoring the country and time fixed effects when finding the genuine relationship between customs clearance processes and outbound logistics performance.

Third, the results for the effect of logistics competency on outbound logistics performance suggests that an increase in logistics competency is associated with a positive effect on outbound logistics performance, although it was marginally statistically significant. This implies that entities with higher levels of logistics competency tend to have slightly better outbound logistics performance, but the effect is not strong enough to reach conventional levels of statistical significance. This finding supports the finding by Shikur (2022) who indicates that logistics quality, international, and infrastructure all facets of logistics competency positively and significantly impact outbound and inbound logistics.

However, while Shikur reports robust coefficients, this study using the fixed effects model reports marginally significant coefficients. This contrast could perhaps be explained by the fact that the fixed effects model controlled for country and time fixed effects, guaranteeing that the marginally significant positive effect is due to the genuine relationship between logistics competency and outbound logistics performance.

This study finally reveals that consignment tracking and tracing as a measure of outbound logistics has a negative but non-significant effect on outbound logistics performance. In doing so, the study contradicts findings of other studies (Bolte & Goll, (2020; Shamsuzzoha et al., 2021; Shikur, 2022) that point to direct effect of tracking and tracing on logistics performance. Considering that unlike previous research, this study employs panel data with the fixed effects model, which is controlled for country and time fixed effects, the researchers can argue that the significant positive effect reported by other scholars exists only in the short term. This essentially suggests a lack of Granger causality between consignment tracking and tracing and outbound logistics performance.

Theoretical Implications

A Panel Data Analysis contributes significantly to theoretical and practical understandings of logistics performance in the region. By integrating various theoretical perspectives, the study elucidates crucial factors influencing outbound logistics across diverse SSA countries. The Resource-Based View (RBV) underscores the importance of internal resources like advanced tracking systems and skilled personnel in enhancing logistics efficiency. Transaction Cost Economics (TCE) emphasizes minimizing costs associated with delays and inefficiencies at customs and in logistics processes. Institutional Theory highlights the role of regulatory compliance and industry norms in shaping logistics operations, while Network Theory

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underscores the significance of strong partnerships and information sharing within supply chains.

The study findings indicate that timely delivery of consignments and efficient customs clearance processes significantly enhance outbound logistics performance in SSA. These factors are critical amidst the region infrastructural challenges and economic variability. The use of panel data analysis reveals substantial variations in logistics performance both within and between countries over time, supporting tailored strategies for improving logistics efficiency. Practically, the research suggests investments in improving logistics competence, enhancing customs procedures, and adopting advanced tracking technologies to mitigate delays and improve reliability in consignment delivery. Such enhancements not only reduce transaction costs but also enhance customer satisfaction and overall supply chain efficiency in the region.

Managerial Implications

Effective management strategies should focus on enhancing consignment tracking and tracing capabilities, improving logistics competence through training and technology adoption, streamlining customs clearance processes, and ensuring timely delivery of consignments. Managers can leverage these insights to optimize operational efficiencies and reduce costs, thereby improving overall outbound logistics performance.

Policy Implications

Policy makers should prioritize investments in infrastructure development, particularly in road and port facilities, to alleviate bottlenecks and reduce transportation costs. Regulatory reforms should aim to standardize customs procedures and enhance transparency, facilitating smoother logistics operations across SSA. Additionally, policies supporting technological advancements and skill development in the logistics sector can enhance regional competitiveness and attract investment in logistics infrastructure.

Conclusion

In conclusion, this study identifies several key determinants of outbound logistics performance in SSA using a panel data approach with fixed effects modeling. Timely delivery of consignments emerges as a significant driver of improved logistics performance, underscoring the importance of adherence to schedules and reducing transit times. Conversely, customs clearance processes exhibit a negative impact, highlighting inefficiencies that hinder logistics efficiency across the region. Logistics competency shows a marginal positive effect, suggesting room for improvement in skill development and technological adoption within logistics operations.

Limitations

Despite its contributions, this study has some limitations that merit consideration. First, the data cover a span from 2010 to 2018, which may not capture recent developments or changes in logistics infrastructure and practices. Second, the study focuses on a select number of SSA countries, limiting generalizability across the entire region. Third, while fixed effects modeling controls for time-invariant heterogeneity, it may not fully account for dynamic changes within countries over time. Fourth, the study reliance on secondary data sources could introduce biases or inaccuracies inherent in the data collection processes of these sources.

Recommendations for Future Research

Future research could address these limitations by incorporating more recent data to capture current trends and developments in logistics performance. Employing more extensive geographical coverage within SSA could enhance the generalizability of findings. Additionally, exploring more advanced econometric techniques such as Granger causality and cointegration tests could provide deeper insights into the causal relationships among the identified determinants and outbound logistics performance. Lastly, qualitative studies could complement quantitative findings by offering nuanced understandings of institutional factors and local contexts influencing logistics operations in SSA. By addressing these recommendations, future studies can further refine one's understanding of outbound logistics dynamics in SSA and provide actionable insights for policymakers, managers, and stakeholders aiming to improve logistics efficiency and economic development in the region.

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Is the Inland Waterways System Primed for Mitigating Road Transport in Egypt?

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Abstract

***Purpose**: This paper aims to investigate the possibility of using hybrid transportation modes depending on inland waterways transport to reduce the dependency on road transport in Egypt focusing on environmental, economic, and social measures.*

***Design/ methodology/ approach:** The research is considered inductive qualitative research that employs a focus group tool to collect interactive and in-depth insights from experts in the field of transportation within different sectors in Egypt.*

***Findings:** The study reveals that, while Egypt's inland waterways have significant potential to reduce reliance on road transport, significant challenges require being addressed, such as infrastructure improvements, fleet modernization, labor training, and government incentives, all of which have been recognized as significant opportunities for development this mode in Egypt.*

***Research implications/ limitations:** One of the major research limitations encountered in this study was a lack of comprehensive and up-to-date data on inland waterway transport in Egypt. The data accessible from diverse sources, such as government bulletins, reports, and scholarly publications, are often inconsistent.*

***Practical implications/ limitations:** Many practical limitations were involved during the study, including the socioeconomic elements that form perceptions regarding inland waterways transport, which may have influenced participants' perspectives.*

***Originality:** This study fills a significant gap throughout the existed literature by investigating the integration of inland waterways transport with road transport in Egypt. It is a stakeholder-centered approach focused on Egyptian experts' comments about both modes. This study provides practical insights that could improve and promote sustainable transportation in Egypt.*

***Keywords:** Focus Group; Inland Transportation; Inland Waterways; Road Congestion; Road Transport; Transportation; Transport Utilization.*

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Introduction

Transportation is regarded as a milestone in socioeconomic interaction, which is now vital for human activity (Shen et al., 2022). However, developing countries face several transportation issues, including lack of reliable and safe transportation, road congestion, and accidents. Transportation is responsible for high air and noise pollution and generates significant Greenhouse Gas (GHG) emissions (Ahmed and Abd El Monem, 2020). In recent years, the negative impacts on the environment, economy, and society have grown significantly, and all evidence confirms that the situation may deteriorate even more, posing an obvious threat to the quality of urban life (Faheem et al., 2024).

Road transport is the most used for daily activities, whether in terms of the social or economic status of a country. Road transport enables the performance of the initial and final legs for all other modes of transportation, as these modes cannot provide full door-to-door service (Reis and Macário, 2019). However, one of the most essential aspects of road transport is the contradiction with the principles of sustainability, harming the global environment (Afrin and Yodo, 2020, Shah et al., 2021), bringing significant strain on both the government and the social sectors with serious economic and environmental consequences (Hassanin, 2020, Faheem et al., 2024),

Considering the negative impacts of road transport, from an economic perspective, congestion raises travel expenses, lowers local economic growth, lengthens journey times, and increases fuel consumption. From an environmental perspective, it increases noise pollution and air pollution emissions such as particulate matter in the atmosphere, GHG emissions, carbon dioxide (CO_2), nitrogen oxides (NO_x), and sulphur oxides (SO) (Faheem et al., 2024). All of these factors increase energy usage and accidents, which have raised major concerns in the global community (Heidari et al., 2023).

As a result, the expansion of the transportation system should be carefully organized for global sustainability (Shah et al., 2021), with a focus on responsible resource management for future generations. In this context, sustainability is defined as the ability to reduce negative impacts through socially inclusive working conditions, economic performance, and ecologically friendly transportation services. Inland Waterway Transportation (IWT) contributes significantly to the transformation of the transportation sector by offering large transport capacities, lower costs, energy efficiency, and, as a result, fewer GHG emissions than other modes of transportation, particularly road transport (Specht et al., 2022).

In such a context, this study proposes enhancing the utilization of IWT in the combination transportation system, reducing the share of road transport. Regarding the Egyptian case, the absolute rapid growth of the population is reflected in traffic increases, resulting in traffic jams and increasingly frequent and serious accidents (Hassanin et al., 2021, Faheem et al., 2024). Consequently, new approaches to optimizing and managing traffic congestion and its repercussions are required (Hassanin et al., 2021). Hence, in Egypt, IWT provides numerous environmental, economic, and social advantages and numerous studies have recently been done to improve the infrastructure of the Nile River to increase the total volume of shipped cargo via inland waterways that connect most Egyptian cities (Moustafa et al., 2022).

This study examines the possibility of raising the share of IWT in the transportation sector to mitigate the negative impact of road transport with consideration of the environmental, economic, and social perspectives because they represent the most critical dimensions of sustainability (Kristensen and Mosgaard, 2020). The framework of this paper is as follows: the second section goes over the background information related to the main aspects of the study, and the third section discusses the road transport sector in Egypt and its implications. The fourth section concentrates on the need for alternative transport options based on IWT, then section five represents the study methodology. In section six, a presentation of the results and discussions, then section seven specifies the conclusion and recommendations, and finally, the limitations and future scopes are emphasized in section eight.

Background Information

The style and form of a city road network help shape its morphological identity (Shen et al., 2022). Nevertheless, Road transport, in particular, is seen as vital in all freight and transportation legs, with significant environmental consequences on the one side and social and economic impacts on the other side.

Environmental Consequences of Road Transport

Currently, the global transportation sector is responsible

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for around 24% of energy emissions worldwide; by 2050, it is predicted that this percentage will rise to 60% (Thomas and Serrenho, 2024). As a result, in the modern era, there is a growing understanding of the negative consequences of the transportation industry on global warming and climate change (Samaras and Vouitsis, 2013). Compared to all other modes, road transport energy consumption, CO_2 emissions, and other pollutants are increasing at a greater rate. For instance, the main source of GHG emissions from road transport is fossil fuel-powered vehicles. They account for 19% of energy consumption, approximately 50% of particulate matter, 25% of CO_2, and 30% of NO_x emissions (Wojewódzka-Król and Rolbiecki, 2019). Thus, the environmental consequences of road transport directly affect environmental sustainability, and addressing these issues through sustainable practices is crucial for achieving long-term ecological balance and growth in environmentally sustainable development (Ekram et al., 2023).

Social and Economic Effects of Road Transport

The challenges of road transport caught substantial attention from scholars in recent times, primarily because of the swift growth of urban areas and transportation infrastructure. Lately, sophisticated traffic management and control strategies have proven to be successful in reducing traffic congestion and improving the overall effectiveness of urban transportation (Faheem et al., 2024). As a result, it is possible to ensure that there is agreement among urban transportation experts that social sustainability is an important factor in evaluating sustainable transportation. Furthermore, historical study on social sustainability as a concept differs from the other two sustainability dimensions, namely environmental and economic aspects (Grande-Ayala et al., 2024).

On the other hand, some research suggests that since a developed transportation network stimulates economic growth in a nation, there is a critical relationship between productivity and transportation (Vencataya et al., 2018). The economic consequences of transportation challenges, especially road transport, such as congestion, high fuel costs, and infrastructure degradation, can hinder productivity and growth (Weisbrod and Fitzroy, 2011). To address these challenges, fostering economic sustainability through investments in efficient and sustainable transportation systems is essential as economic growth and sustainable development rely significantly on the condition of the transportation sector (Nawazish Ali et al., 2024).

Hence, in light of the negative effects that road transport has on the environment as well as on the economic and social domains, Thomas and Serrenho (2024) propose a way to mitigate these effects through the modal shift, whereas, less emissions-intensive modes of transportation are employed instead of more emissions-intensive modes. For example, Egypt's primary mode of transportation is the road and it is receiving more attention than IWT, although, the latter can move commodities more effectively and with less of an impact on the environment. Egypt's goal of attaining sustainable development and encouraging environmentally friendly transportation is sharply at odds with these tendencies (Sulaiman et al., 2023).

IWT Effectiveness

The European Union's transport strategy aims to reduce traffic congestion, promote traffic safety, employ ecologically friendly means of transportation, and use alternative fuels (Erceg, 2019, Wojewódzka-Król and Rolbiecki, 2019). Thus, developing IWT is vital for guaranteeing the long-term viability of these aims (Wehrle et al., 2024). Thus, IWT plays an important role in the logistics and supply chains of various European countries, with a core network connecting the Netherlands, Belgium, Luxembourg, France, Germany, and Austria. The principal waterways include enormous rivers like the Rhine and Danube that connect major cities, but many smaller towns and industrial sites are also easily accessible by numerous tributaries and canals (Erceg, 2019).

European inland waterways transport around 500 million tons of freight each year, with Germany, the Netherlands, Belgium, and France leading the way (Kotowska et al., 2018). Germany is the major player, accounting for 44%, while the Netherlands comes in second with roughly 39% (Sys et al., 2020). Following are examples of the most successful European countries where IWT is particularly well developed, with its significant implications for ports and trade flows:

Germany

Germany has one of the most extensive inland waterway networks in Europe, IWT in Germany transports roughly 230 million tons of freight yearly along a 7300-km infrastructure network (Wehrle et al., 2024), with rivers including the Rhine, Elbe, and Danube. The containers are mostly transported along the Rhine route and to/from Hamburg's seaport, which serves as the connection to the Elbe River corridor and connected canals. Furthermore, the Hamburg port is located 130 km inland from the open sea on the Elbe

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River, with the middle section of the river and the Elbe Lateral Canal connecting it to German business areas such as Hanover, Braunschweig, Salzgitter, Wolfsburg, and the Ruhr district (Kotowska et al., 2018).

Also, the Port of Duisburg is located on the Rhine, which is considered the largest inland port in Europe. It serves as a hub for both domestic and international freight, connecting Germany to the Netherlands, Belgium, and beyond via the Rhine–Main–Danube Canal (Pascha, 2021). Freight flows are heavily focused on bulk commodities like coal, chemicals, and agricultural products, as well as containers. This indicates that there is a growing interest in improving all business solutions over the long term. The basic idea is to address problems with infrastructure, traffic, and goods flows by integrating ecological and economic considerations (Kapkaeva et al., 2021)

Netherlands

In addition to being connected to inland ports in the Netherlands, Germany, Belgium, France, Switzerland, and Austria through the Rhine–Main–Danube canal, the Port of Rotterdam is situated in the estuary of the Rhine and Meuse rivers. In addition, a vast system of canals and the Rhine, Meuse, and Scheldt rivers are particularly significant (Engström and Anna, 2019). The expansion of container shipping in the ports of Rotterdam and Antwerp is also linked to the robust growth. Furthermore, in Belgium and the Netherlands, the majority of containers are shipped by inland canal routes, mostly to and from the seaports in Rotterdam and Antwerp (Kotowska et al., 2018, Sys et al., 2020).

Belgium

With a share of about 8%, Belgium ranks third in Europe for inland navigation. Belgium has extensive inland waterway networks, with major rivers such as the Scheldt, Meuse, and the Sambre, as well as a vast system of canals (Sys et al., 2020). The main port of Belgium is the Port of Antwerp, which lies on the Northern Sea and is regarded as one of the largest ports in Europe. Because of its advantageous location in the Scheldt-Meuse-Rhine delta, it has access to more than 75 inland ports throughout Europe as well as 1500 km of the European network of inland waterways. Over 915 interior barges are handled each week, with 190 of those being regular links with Belgian inland ports (Kotowska et al., 2018).

Road Transport Problems in Egypt

Egypt's population is estimated to be approximately 107 million in November 2024 by the Egyptian Central Agency for Public Mobilization and Statistics (CAPMAS). By 2027, more than 24 million people would have lodged available. This rapid increase is directly correlated with the mounting strain on the infrastructure systems now in place, primarily the road networks. It is anticipated that daily average vehicle speeds in the town will be less than 10 km/h, which will have a substantial detrimental impact on both the economy and the standard of living (Soliman et al., 2016).

Regarding the Egyptian economy, Fig. 1 displays the recent expansion of trade size in Egypt by illustrating the rise in demand for more trade as a result of population growth. Furthermore, road transport is still the preferred means of transportation for domestic trade within the country (Elshahawany et al., 2022). This is corroborated by the World Economic Forum, which found that there is an imbalance in Egypt's various forms of transportation, with roads carrying 95% of the country's freight, railways moving 4%, and the IWT carrying less than 1%. Road transport in Egypt thus has a significant share and contribution that adversely influences the environmental, economic, and social dimensions, which is reflected through the three main indicators, i.e., air pollution, traffic congestion, and road accidents (Vencataya et al., 2018).

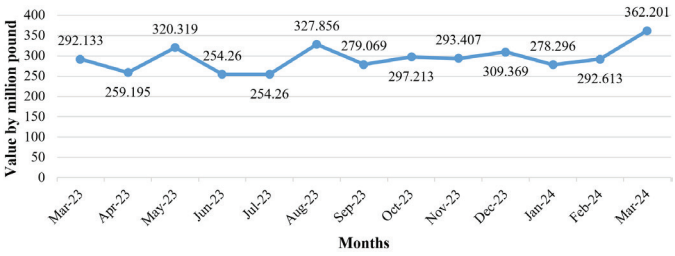

Figure 1. Trade size in Egypt

Source: Egyptian Ministry of Transport (2024)

Air pollution

As illustrated in Fig. 2, generally, the transportation sector consumes gas and petroleum products in second place after the electricity sector, accordingly, it becomes the second generator of CO_2 emissions. Since there has been a greater need for road transport for moving commodities between Egyptian cities rather than IWT or railways, this is a concerning development that has resulted in excessive emissions from the road transport sector (Sulaiman et al., 2023). Approximately 13% of all licensed vehicles in Egypt are transport vehicles (lorries) moving on the country road network. These vehicles include gas, diesel, and gasoline-powered vehicles (Ramadan et al., 2022).

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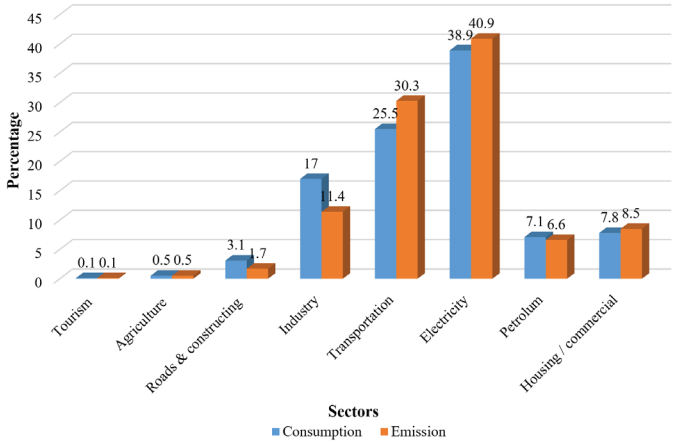

Figure 2. Sectoral consumption of petroleum products, gas, and resulting CO2 (2021/2022)
Source: Egyptian Ministry of Petroleum and Mineral Resources (2024)

Traffic Congestion

The problem of traffic congestion, particularly in Egypt, has a negative impact on the well-being of the country population and its economic stability. In this context, Fig. 3 displays CAPMAS statistics showing that the total number of licensed vehicles ascended from 6.6 million in 2012 to 9.9 million in 2022, with 1.3 million licensed transport vehicles and trailers included in the same year, as shown in Fig. 4. The primary source of urban traffic congestion is expected to be an overall increase in the total number of vehicles on the road (Faheem et al., 2024).

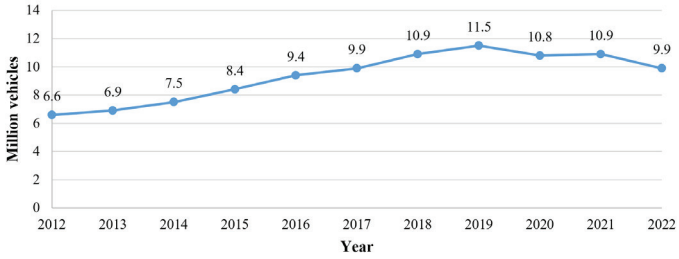

Figure 3. The total number of licensed vehicles in 2022

Source: CAPMAS Statistical Yearbook (2023)

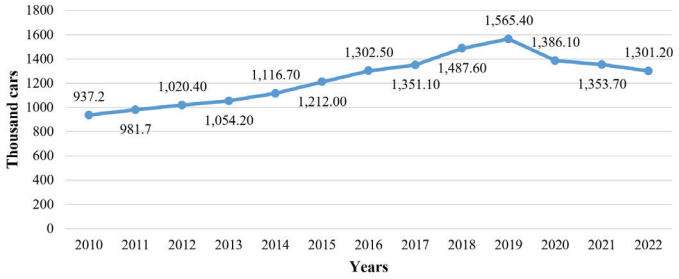

Figure 4. Licensed transport vehicle and trailer

Source: CAPMAS Statistical Yearbook (2023)

Road Accidents

Considering Egyptian road accidents, an increase in accidents and fatalities is correlated with both population growth and the number of registered vehicles in metropolitan areas (Onyeneke et al., 2018), as well as Egypt's Vision 2030 which prioritizes road network expansion. Nevertheless, there is not a specific road safety program; hence, the number of traffic fatalities and incidents is rising rather than declining as seen by the following data from CAPMAS 2023:

- The number of road accident injuries reached 55991 in 2022, compared to 51511 in 2021, an increase of 8.7%.
- The rate of injury per 100 thousand vehicles was 563.2 in 2022, compared to 472.2 in 2021, an increase of 19.3%.
- 7762 persons lost their lives in traffic accidents in 2022 as opposed to 7326 in 2021, a 6 % increase.

A Necessity for Sustainable Transport

The idea of sustainable transport development states that using more environmentally friendly solutions and improving the integration of different transport modes are necessary (Wojewódzka-Król and Rolbiecki, 2019), modifying the transportation system, which contributes significantly to both emissions and traffic, is one of the primary solutions. This will be accomplished by moving cargo transportation from the road to more environmentally friendly sectors, a process known as the "mode shift" (Niedzielski et al., 2021). IWT uses less energy and emits less dangerous substances, and many cities that are close to waterways can use this mode for both freight and passenger traffic (Wojewódzka-Król and Rolbiecki, 2019). Moreover, IWT logistics expenses account for 7% of the total cost of road transport (El-deasty et al., 2024). Since IWT is thought to be seven times more sustainable than other modes of transportation, it is the most environmentally friendly mode of transportation in logistics (Vilarinho et al., 2019).

Concerning Egypt's case, the Nile River has long been significant because it is the primary route used by the ancient Egyptians for transportation (Farag, 2024). The world's longest river stretches from its sources at Lake Victoria in Northeast Africa to the Mediterranean Sea (Bunbury et al., 2023). The Nile River in Egypt is roughly 1530 km long, mainly intended to be a two-

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way channel (El-deasty et al., 2024). Furthermore, Egypt's internal waterways contain roughly 47 river ports; but as of right now, the Nile River accounts for about 0.6% of Egypt's freight traffic (World Bank Group, 2018).

Consequently, the Egyptian Ministry of Transport top aim at the moment is to greatly increase freight traffic across the Nile River (Moustafa et al., 2022), developing the Nile River navigation path along four major axes (El-deasty et al., 2024), which are as follows:

- 205 kilometers along the Alexandria-Cairo axis. It begins at the Foum El-Riyah El-Beheiry lock, west of the Rosetta Branch, and continues west to the Bolin Lock. From there, it shifts left and meets the Noubaria Canal, which goes north to the Great Maleh, and Small Maleh locks in the Alexandria Seaport.
- The Damietta-Cairo axis stretches 241 kilometers from the start of the Damietta Branch of the Nile River to the Damietta Seaport.
- The Cairo-Aswan axis spans 980 kilometers from the Delta Barrage to Aswan and Wadi Halfa.
- The Aswan-Wadi Halfa axis spans 350 kilometers.

The Egyptian Ministry of Transport has prepared a comprehensive plan to develop the river transport sector and implemented some mechanisms to ensure a strong start to maximize transport across the Nile River. As a result, the government works on proposing some draft legislation and plans that restructure this sector, including its facilities. Some of these are presented by the State Information Service, including:

- **The development of a comprehensive network of river ports along the Nile River:** This initiative will facilitate the efficient receiving and shipping of diverse goods and containers to various river terminals distributed across multiple governorates. Each port will be strategically located to optimize accessibility and connectivity, with many focusing on specific categories of cargo, such as agricultural products, construction materials, or consumer goods.
- **The navigational infrastructure enhancements:** Coordination with the Egyptian Ministry of Irrigation to ensure the effective maintenance and continuous improvement of navigational locks. This initiative includes the construction of new locks that meet modern engineering standards, significantly increasing system capacity and reducing wait times for vessels. These enhancements include:
  - **Cairo/Alexandria Navigational Waterway:** Including the Noubaria Canal, which spans 120 km from the Noubaria lock to the Maleh lock. This project includes a 100 km lock designed to facilitate safe navigation. The navigation link to the Noubaria Canal is also being expanded to accommodate two new 200 m berths. Concurrently, efforts are underway to enhance the km 100 lock and to protect its banks, alongside dredging the Noubaria Canal from km 0 to km 100. Additionally, the efficiency of the km 61 Al-Khatahtbeh lock is being improved.
  - **Cairo to Aswan Navigational Waterway**: Work is being conducted to establish a continuous navigational route between Cairo and Aswan by removing obstacles along the stretch from km 8 to km 885.
  - **Cairo/Damietta Navigation Channel**: Efforts have been made to clear bottlenecks between km 953 and km 1195 (spanning Al-Qanater al-Khairiyah, Mit Ghamr, and Damietta Port) to ensure smooth navigation.
  - **Cairo/Ismailia Navigation Waterway**: The construction of this waterway is complete, with obstructions to navigation in the Ismailia Canal cleared between km 0 and km 50 (from Al-Mazalat to Belbeis).
- **The development of River Information Services (RIS):** Implementing an advanced information infrastructure system for the Nile River. The RIS aims to enhance navigational safety through electronic mapping services that identify the river safest routes. Additionally, RIS facilitates real-time information exchange with the River Transport Authority (RTA) regarding river units within the navigational course, thereby improving safety for all vessels.
- **Encouraging private sector participation:** By contributing and investing in IWT, leveraging private expertise and resources, ultimately enhancing the efficiency and effectiveness of river transport in Egypt.

Furthermore, to achieve the necessary balance between environmental, economic, and social requirements, the Egyptian Ministry of Transport has adopted a philosophy that goes beyond the movement of people and goods. To this end, a flexible and advanced comprehensive policy has been followed, which includes the expansion of transportation options to connect Egypt with its surrounding countries and regions. Subsequently, considering all elements mentioned before, this study recommends increasing the utilization of IWT in the transportation system, preparing to gain from the Nile River employment as a vital component in transportation strategies.

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Methodology

The purpose of this study is to investigate important logistics management choices that increase the use of IWT while decreasing dependency on road transport. The study follows the inductive qualitative research method using a focus group approach for this investigation to collect interactive and in-depth insights from a panel of industry experts, who have been invited to evaluate the feasibility of increasing reliance on IWT as a substitute for road transport. This method makes it possible to gather qualitative data that might clarify the possible benefits and drawbacks of making such a shift. Key decision-making factors, such as environmental sustainability, cost-effectiveness, time effectiveness, and safety concerns will form the foundation of this examination.

A focus group is commonly defined as a gathering of six to twelve people when a moderator or interviewer asks questions regarding a specific subject. Although the data collected using this method contain aspects of both group interviews and "natural" discussions of pertinent topics. Finding out respondents' impressions, interpretations, and opinions is the objective of arranging focus groups. It is anticipated that the unstructured and spontaneous comments will represent the members' true thoughts, feelings, and opinions regarding the issue at the discussion. To prevent a single individual from becoming the group dominant figure, to support each other equally, and to make sure that everyone is aware of the contributions made by others, the participants should have comparable backgrounds and work experiences (Chacko, 2018).

Focus Group Procedures

Using a less structured focus group methodology to acquire a thorough understanding of the perspectives of shifting from road transport toward IWT. The arguments for each of the two modes are examined closely during discussions. Focus groups, which generate qualitative data through concentrated talks among a small group of members, offer a useful platform for investigating the subject.

Planning

Conceptualizing the study, creating the questions, and figuring out the logistics are all part of the planning step for focus groups (Chacko, 2018). This study mainly focuses on environmental, economic, and social perspectives as sustainability domains, allowing for a holistic assessment of the negative effects of road transport on IWT. Hence, during this phase, the researchers prepare a manuscript for the main concept and key aim of the study to be introduced to all the participants during the introduction part of each session, to help the participants understand the main objectives of the study. Then, as specified in Table 1, the researchers generate pertinent questions that addressed the aim of the study. Each main question has a set of follow-up questions to ensure the topic is saturated. In addition, consider some general questions that are specified for gaining more data related to the topic with more concentration on the case of Egypt.

Table 1: The focus group questions

Perspective	No.	The main questions of the moderator guide	Code
Environmental Perspective	1	How do you evaluate the impact of IWT on the environment in comparison to road transport?	E1
	2	Which special environmental advantages do you see with more dependence on IWT?	E2
	3	Are there any possible adverse effects on the environment that come with IWT that need to be taken into account?	E3
	4	How much weight does sustainability have when selecting the modes of transportation?	E4
Economic Perspective	5	In your experience, how do the costs of IWT measure compared with road transport?	C1
	6	What are the cost-effectiveness aspects that encourage using IWT instead of road transport?	C2
	7	How do unforeseen costs (e.g., repair, delays) differ between IWT and road transport?	C3
Social Perspective	8	How safe do you think the IWT's safety records are in comparison to those of road transport?	S1
	9	Have you personally encountered or seen any safety-related issues in either mode that have affected your decision?	S2

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Perspective	No.	The main questions of the moderator guide	Code
General	10	What particular improvements are required for IWT to gain greater popularity in the logistics services in Egypt?	G1
	11	In order to build a more effective supply chain, how can IWT be successfully linked with other means of transportation in Egypt?	G2

Source: The authors

Regarding the logistical organization of the groups, every group is made up of experts who, albeit displaying variation in other pertinent aspects, share certain common qualities. Additionally, to put the research into context, it is done online via an online platform to facilitate participation, with sessions planned for Fridays and Saturdays on June 7th, 8th, 14th, 15th, 21st, and 22nd. Every session lasts between 90 and 100 minutes, and small groups are chosen to provide a setting in which each member can actively contribute to the conversation, whereas smaller groups provide more room for discussion and comprehensive investigation of the many issues.

Participants Pooling

The subject matter-related criteria are used to choose participants. However, because prominent people can influence others in the session, it is advisable to hold many group sessions. Furthermore, gathering data from multiple group conversations allows the researcher to compare and contrast results among groups (Krueger, 2014). In this study, six focus groups are formed, each with six transportation and logistics experts from different sectors such as freight forwarding, multimodal transport, shipping, trucking, and customs clearance companies. The participants' bio information is summarized in Table 2, and the complete categorization is explained in Appendix Table A1. Arabic is used as the language of communication to avoid any potential misunderstandings caused by the usage of English.

Table 2: Bio question data Analysis for 36 participants

Bio Information	No. of Participants	
Gender		
Male	34	
Female	2	
Age		
22-30	1	
31-35	3	
36-40	7	
41-45	10	
46-50	5	
51-55	10	
Educational level		
Bachelor	28	
Master's Degree	5	
PhD Holder	3	
Job type		
Trainee	1	
Full-time	35	
Occupation	**Code**	
Freight Forwarder Company Owner	1	FFO
Road Transport Company Owner	2	RTO
Multimodal Transport Operator	2	MTO
Operator	6	O
RTA Responsible	2	RTA
Shipping Customer Service	7	SCS
Documentation	4	DOC
Custom Clearance	5	CC
Freight Forwarder Sales	7	FFS

Source: The authors

The participants' identities have been obscured, so they are asked to briefly introduce themselves only by providing their age, years of experience, job position, and duties. It is highlighted that the research is carried out for academic purposes. Following the introduction, the moderator discusses the focus group guidelines and conditions, such as confidentiality, respect for each other's viewpoints, and session time frame. Then, each group discusses the different benefits and drawbacks of IWT compared to road transport, notably from the perspectives of the environment, economy, and society. Following a moderation framework, open-ended questions are posed to begin the debate, followed by focused follow-up queries and general questions, as demonstrated in Table 1.

Content Analysis

To reduce redundancy and inefficiency, both human-based and automated content analyses are performed. The automated method can significantly reduce the time associated with evaluating broad text data (Haddad and Nasib, 2023). Accordingly, the analysis process is divided into three main stages: preparation, organization, and reporting, as follows:

- Initially, transcripts are thoroughly checked to

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guarantee the correctness and interpretation of the data. Furthermore, every transcription has been translated from Arabic to English for purposes of analysis.

- The text is organized with brief notes and titles in the margins, with emphasis on appropriate phrases and keywords. Coding is carried out by hand as well as with NVIVO software to take benefit of both methods.
- NVIVO is used to code into acceptable categories for study ("environmental", "economical", "social", and "general"). After the text is categorized into code categories, the codes are manually input on NVIVO, and the findings for each participant in the focus groups are summarized and assigned to the appropriate code. Finally, the discovered categories and subcategories are integrated, examined, and interpreted, as outlined in Table 3.

Results and Discussions

Participants in a series of focus group meetings give vital information regarding the operating reality, infrastructure problems, and views of IWT. This section seeks to summarize the findings from these discussions, emphasizing the important themes and patterns that arose. The discussion focuses on how IWT might help to improve overall transportation efficiency in Egypt. It also looks at the barriers raised by focus group participants. Table 3 summarizes the analysis of these arguments.

Environmental Perspective

Environmental implications

Participants unanimously rate IWT as having a considerably lower environmental impact than road transport. Many participants indicate confidence that IWT contributes to lower GHG emissions, which can mitigate air pollution. They also highlight some environmental hazards related to road transport, such as high air pollution and considerable noise pollution. However, the majority of them have expressed worries regarding IWT infrastructures and potential ecological consequences, such as disruptions to aquatic ecosystems. It implies that, while IWT provides environmental benefits, it is critical to address these concerns to secure the mode long-term development, implying that these factors must be carefully considered in future developments.

The environmental advantages of IWT

Participants pointe out many important environmental benefits connected with greater reliance on IWT, with several emphasizing that IWT often generates less GHG per ton of cargo than road transport. This is due to the higher fuel efficiency of larger barges. Participants also underline that transferring freight from roads to waterways might dramatically reduce air pollutants such as particulate matter and NO_x, hence improving urban air quality. Four participants (P31, P32, P34, and P35) provide extensive information about road transport, specifically diesel trucks, which are prominent in Egypt and contribute heavily to NO_x and particulate matter.

However, two participants (P25 and P30) comment that even barges use diesel as a primary fuel source, and three specialists (P26, P27, and P29) respond that the fuel efficiency of barges compared to trucks varies greatly depending on specific parameters such as cargo type, distance, and vessel or truck design. A popular estimate is that one barge can normally transport the equivalent of 15 to 20 trucks. In terms of fuel usage, this means that the barge frequently needs substantially less fuel to convey the same amount of cargo over the same distance.

The possible adverse effects of IWT on the environment

Many participants highlight that, while IWT is generally more efficient, there are major hazards involved with barge accidents or fuel leaks, which can cause significant water pollution and have a negative impact on the Nile water quality and aquatic life. To expand the percentage of transportation via the Nile River, the government must undertake stringent monitoring and enforce regulations that penalize illicit conduct. Given the limited number of private organizations working in Egypt's IWT sector, such approaches could be especially effective in guaranteeing compliance and conserving this vital resource.

The importance of sustainability

Regarding sustainability, several participants attempt to demonstrate that sustainability does not exist in actual or economic activities, particularly in developing countries. From the customer's perspective, all that matters is that the products arrive as soon as possible and at the lowest possible price. (P29) confirm that in the transportation business, the only effective elements in decision-making are cost and speed. Another participant (P09) responds that sustainability is an issue for both the environment and the economy, choosing more sustainable modes of transportation can result in long-term cost benefits because they typically use less fuel and put less burden on infrastructure.

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Economic Perspective

Cost structure

During this phase, the first question occupied the most duration of the focus group of all sessions, and nearly all 36 participants contribute to the discussion, with each response based on his/her professional experience. The debate focuses on the many sorts of costs that emerged in both modes, which are divided into two categories: capital costs and operational costs.

Capital costs:

Some participants state that the investment expenses for IWT are relatively significant including transportation means, river port expansion, and navigational waterway preparation. When referring to road transport with low capital expenses is reflected by the cost of acquiring the fleet, which is considered significantly extremely low when compared to IWT. While others refer to the cost of building roads, road transport ought to consider its average share as capital expenditures.

Operational costs:

- All participants agree that IWT has cheaper fuel costs per ton/km compared to road transport, whether it is heavy fuel oil, diesel (for barges), or diesel (for trucks). In the case of IWT, economies of scale are significant in reducing costs. Barges can transport massive volumes of goods at once, while sharing the fuel costs across these volumes.
- According to (P05), IWT incurs additional costs beyond those of road transport. For example, labor costs such as IWT may have greater initial costs in terms of professional manpower for navigation and barge operation; nevertheless, other participants note that even if they are higher, the principle of economy of scale also addresses this issue. Some others (P26, P27, and P29) state that for substantial amounts of commodities transported over long distances, as previously discussed, one barge can be equivalent to 15-20 trucks. Thus, one or two labor wages will eventually be less than that of 15-20 truck drivers.
- The debate includes a comparison of IWT maintenance costs against road transport. IWT maintenance costs are quite cheap because barges require less regular maintenance than vehicles. Other participants, however, inform that barges might face challenges such as hull maintenance and engine repairs, which can be costly if not addressed regularly. Finally, most of them agree that, while IWT incurs maintenance expenses, it is less expensive than road transport in terms of cost, frequency, and quantity of units conveyed.
- In some sessions, the arguments include additional operational costs related to IWT, such as port and terminal fees, handling costs, port facility charges, and navigation and pilotage fees (where applicable). All participants agree that these costs are relatively low in road transport, which primarily are represented by handling costs and other surcharges related to the shipments that are already paid by the service buyers themselves. However, (P03, P09, P12, P34, and P35) confirmed that IWT has lower operational costs than road transport, even with these additional charges.

In general, (P22 and P23) identified the absence of information about the cost structure, which is considered a fundamental issue in the IWT that needs to be addressed. The majority of participants are aware of the structure of the costs related to road transport, which may be simply computed. As a result, it may provide clients with a final rate for transporting certain goods from point to point by road; nonetheless, if the same quantity has to be transported for the same distance via IWT, the cost cannot be estimated easily. Only two participants (P14 and P26) in all sessions have quit information and confirm that it is easy to know it whether by asking in the RTA or sending a quote to any public or private companies working on the IWT. They add that it differs from one season to another according to the water level. In addition, there are some other conditions, for example, the movement of tourist boats from Luxor to Aswan.

Cost-effectiveness

(P10 and P20) state that the economies of scale idea is the most important aspect that might encourage the use of IWT. Barges can transport huge amounts of goods in a single trip. This capacity enables operators to divide their fixed costs across a larger cargo base, lowering the cost per ton. (P01) notes that ??? what can be described as cargo volume and states that this factor is important in reducing fuel costs for IWT.

Other participants emphasize the importance of maintenance costs as a cost-effective factor in IWT. Road transport frequently has greater maintenance costs owing to the regular use of vehicles and the infrastructure. While IWT barges do require maintenance, costs may be reduced because they are not subject to the same road conditions. (P19) notes that while addressing maintenance costs, it must

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include depreciation costs as one cost-effective element in IWT, which typically has lower yearly depreciation costs than road transport because of longer asset lifespans and higher value retention. Other participants remark how trucks often have shorter lifespans (about 5-15 years), resulting in greater annual depreciation costs. Barges usually have longer lifespans (often 20-30 years), leading to lower annual depreciation costs when divided over their lifetime.

Unforeseen costs

Regarding unexpected costs, (P05) identifies several cost-related factors that may give advantages to road transport, as reflected by transit time for time-sensitive cargo; hence, road transport may be preferable despite higher costs. In addition, (P07, P22, P25, P36) during different sessions mentioned tariffs, taxes, and environmental laws as having an impact on the overall cost for both modes. Furthermore, the majority of participants indicate that road conditions and congestion can raise truck rates and transit times, making IWT desirable because it frequently uses established waterways that can bypass crowded urban areas, minimizing delays and fuel waste.

Social Perspective

Safety Records

Mainly, all participants believe that IWT has a better safety record than road transport, particularly in terms of accidents and fatalities. Participants (P04, P14, P34, and P35) state that road transport is associated with a significantly greater rate of accidents, injuries, and fatalities. Furthermore, factors such as driver error, speeding, and poor weather, particularly for dangerous goods, frequently result in spills and fires. In contrast, participants (P08, P15, P18, P21, P26, and P33) state that IWT has fewer incidents than transportation by road. Barges typically go through less busy areas; therefore, the chance of collisions is lower than on congested roadways.

Safety and Decision-making

In response to this question, most of the participants describe a variety of personal experiences with safety difficulties in both IWT and road transport, with a general opinion that road transport seems riskier due to frequent accidents and unpredictability. Participant (P32) has witnessed multiple accidents, primarily on highways especially at night, caused by the erratic behavior of other drivers paired with catastrophic road conditions. Additionally, (P02, P03, P14, and P31) add that in their logistics work, road transport involves a lot of delays due to road accidents.

While (P08 and P26) report that water transportation is generally safer. Delays may occur in IWT, but based on their experiences, they believe the safety margins are diverse, and the system is more controllable and trustworthy. However, there are significant issues about how IWT handles emergencies. As a result, it appears that many participants have had unfavorable experiences with road transport, either seeing or being involved in accidents. IWT, on the other hand, appears to raise fewer safety concerns.

Table 3: NVIVO list of frequently discussion directions

Perspectives	Parameters	Mode	Discussions	Directions	Effects
Environmental	Ecological Outcomes	IWT	Fuel consumption efficiency for barges	Lower GHG emissions	Positive
				Mitigate air pollution	Positive
				Improving urban air quality	Positive
			Dredging and enhancement operations	Disrupt local aquatic habitats, affecting fish populations and overall biodiversity.	Negative
			Fuel leaks from barges		
			Expand the percentage of transportation via the Nile River	Negative impact on the Nile's water quality	Negative
		Road	Low fuel consumption efficiency for diesel trucks	High air pollution	Negative
				Contribute heavily to NOx and particulate matter	Negative
			Increase the number of trucks	Considerable noise pollution	Negative
	Sustainability	IWT	Fuel efficiency and cost savings in the long term	Sustainable transport mode	Positive
		Road	Customer needs	Speed	Negative
				Lowest price	Negative

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Economic	Capital Cost	IWT	Docking cost (barges building)	Considerable investment cost	Negative
			River ports construction		
			Preparing the navigational waterways		
		Road	Purchasing modernized fleet	High capital cost	Negative
			The average share of road constructing		
	Operational Cost	IWT	cheaper fuel costs per ton/km	cheaper operational cost	Positive
			Lowest labour cost		
			Minimal maintenance cost		
			Absent of information about the cost structure	Ambiguous	
		Road	Higher fuel cost per ton/km	Cost-effectiveness of fuel	Negative
	Cost-effectiveness	IWT	Economies of scale	High cargo volume	Positive
				Reducing total transportation cost	
			The long-life span for transportation means (20 - 30 years)	Low depreciation cost	
		Road	The economy of scale concept is not applicable	Low cargo volume	Negative
				Increasing total transportation cost	
			The average life span for transportation means (5 - 15 years)	High depreciation cost	
Social	Safety	IWT	Low accidents rates	Better safety records	Positive
			Almost no injuries or fatalities		
			No training for emergencies	Handling emergencies inefficiently	Negative
		Road	Drivers' errors	High accidents rate	Negative
			Speeding		
			Poor weather		

Source: The authors

The results of this study are consistent with the positive outcomes associated with IWT development as highlighted in the literature. Hence, this study indicates that IWT in Egypt offers substantial opportunities to address key environmental, economic, and social challenges, notably through reductions in congestion, CO_2 emissions, and air pollution, alongside enhanced safety and lower costs. These outcomes align closely with the experiences of countries like Germany, the Netherlands, and Belgium, where IWT has been successfully integrated into their transport systems, contributing to the reduction of total transportation costs and offering a sustainable alternative to road and rail transport. The high cargo volume and cost-effectiveness of IWT in these regions serve as clear examples of its potential, reinforcing the relevance of this study findings for Egypt's transportation future. Thus, the results of this research not only highlight the significant benefits of IWT in the Egyptian context but also underscore the alignment with European best practices, demonstrating the viability of IWT as a sustainable transport solution.

Conclusion and Recommendations

This paper has highlighted the significant disadvantages of road transport in Egypt, particularly its adverse impacts on the environment, economy, and social well-being. The excessive reliance on road transport contributes to severe environmental degradation, including increased CO_2 emissions and air pollution, as well as higher levels of congestion, which exacerbate inefficiencies in the transportation system. Economically, road transport incurs substantial operational costs and contributes to the growing financial burden of infrastructure maintenance. Socially, the negative externalities of road transport, including safety risks and reduced quality of life due to traffic-related problems, further strain Egypt's transport ecosystem.

In contrast, the study has demonstrated the considerable potential of IWT as a viable alternative to road transport. IWT offers several key advantages, including sustainability through reduced emissions,

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cost-efficiency via lower operational and infrastructure expenses, and improved safety. Furthermore, the findings indicate that IWT could significantly alleviate congestion, reduce transportation costs, and enhance the overall efficiency of cargo transport in Egypt. The possibility of integrating IWT into Egypt's transportation sector as an alternative mode to road transport has been confirmed through data collected from focus. The experts affirmed that IWT presents a more sustainable, cost-effective, and safer solution, with clear advantages over the current over-reliance on road transport.

The study also suggests that the implementation of IWT in Egypt could be a transformative step towards a more sustainable and efficient transport system. Drawing on the successful experiences of countries in Europe, such as Germany, the Netherlands, and Belgium. However, realizing this potential requires strategic planning, investment in infrastructure, and policy reforms to facilitate the development of comprehensive IWT networks. In conclusion, the findings of this study provide compelling evidence that the IWT can play a pivotal role in addressing the pressing challenges faced by Egypt's transport sector, offering a sustainable, cost-effective, and environmentally friendly alternative to road transport.

Finally, the moderator encourages a broad argument about the situation in Egypt by raising two additional questions, G1 and G2, which help to develop additional viewpoints and to conclude the Egyptian situation, primarily, the improvements required to enhance IWT utilization in logistics services in Egypt. Furthermore, regarding the involvement of IWT in the supply chain and the entire transportation sector in a multimodal transportation system to maximize the benefits. Moreover, the insights gained from the focus group conversations not only emphasize the need for a shift in transportation paradigms but also serve as a solid platform for future research and policy development targeted at improving Egypt's logistics sector.

Most of the participants believe that one of the key challenges is the infrastructure, such as the need for improved cargo ports and terminals along the Nile River, because most docks and facilities are obsolete, slowing down operations, particularly loading and unloading systems. Participants also highlight how important it is to maintain rivers. Some stretches of the Nile River are difficult to navigate due to sediment buildup or debris.

Some recommendations have been generated for improving IWT operations, increasing intermodal connectivity, and encouraging broader acceptance of waterways as a critical component of Egypt's transportation network. Whereas IWT in Egypt offers substantial implications to address key environmental, economic, and social challenges The authors summarize the various participants' points of view in each session. Accordingly, the prevalent recommendations that summarize over all sessions are as follows:

- **Accessibility and better integration with other transport modes:** A smoother system is required for transferring commodities from waterways to trucks or railways instead of Athar Al-Nabi port. If there were more intermodal hubs where commodities could be promptly transferred, IWT would be more efficient. Additionally, the notion of logistics centers that connect the various modes of transportation might help to smoothly connect IWT with highways and railways.
- **Reliability and real-time monitoring:** shipments on waterways can be delayed due to weather or navigational problems. Consequently, with improved tracking technologies or communication systems for barge operators, companies could have greater trust in delivery schedules. This improvement would significantly increase companies' reliance on IWT.
- **Promotion, awareness, and marketing campaigns:** many companies are not completely aware of the potential of IWT. Hence, there is a need for government or private sector initiatives that demonstrate how inland waterways can lower costs and environmental impacts, perhaps attracting more logistics companies to use this mode.
- **Upgrading the fleet:** newer barges are required to lower pollutants and improve fuel efficiency, which is becoming increasingly crucial for businesses. If Egypt can promote IWT as a green solution by investing in eco-friendly barges driven by green fuel, it may be able to attract more logistics companies looking to improve their environmental impact. Also, in terms of capacity, some of the barges are not large enough to satisfy rising demand, so with larger and more modern barges, IWT could handle much more tonnage, making it more competitive with road and rail transport.
- **More investment in training plans:** barge operators, port personnel, and logistics managers all need to complete specific training programs. The more skilled the staff, the fewer errors and delays. Additionally, those who are better trained will be able to deal with emergencies or unanticipated circumstances more effectively.

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Study Limitations and Future Scopes

While this study provides valuable insights into the potential of IWT in Egypt, several limitations must be acknowledged. Firstly, this study is primarily descriptive, offering a qualitative exploration of the potential benefits of IWT based on existing literature and expert opinions. However, it lacks empirical, practical data that could provide more definitive conclusions regarding the viability of IWT as a large-scale solution in Egypt's transportation system.

One key limitation is the reliance on expert opinions collected through focus groups, which, while insightful, do not provide quantitative validation of the environmental, economic, or social claims appointed in the study. For instance, to confirm the feasibility of implementing IWT in the Nile River, a more detailed practical study is needed to assess the river depth, navigability, and capacity for handling significant cargo traffic. This could include on-the-ground surveys and technical assessments to gather more precise data.

Additionally, this study does not include quantitative analysis, which would be essential for verifying the potential environmental and economic impacts of IWT in comparison to other transport modes. A comprehensive cost-benefit analysis, incorporating real-world data on transport costs, emissions reductions, and safety improvements, would provide a more robust and statistically grounded understanding of the advantages and challenges of IWT in Egypt.

Hence, several avenues remain open for further exploration, which could include the following areas:

- **Economic Impact Analysis**: focusing on conducting a comprehensive economic analysis comparing the infrastructure costs of both road transport and IWT. This could include a detailed assessment of the investment required to develop and maintain IWT infrastructure, compared to the current and projected costs of road transport, including maintenance.
- **Environmental Modelling**: building on the environmental benefits highlighted in this study, future research should aim to create a model that quantifies the actual reductions in CO_2 emissions and other environmental consequences that would result from the adoption of IWT.
- **Regional Feasibility Studies Beyond the Nile River:** While this study primarily focuses on the Nile River utilization; thus, further research should explore the feasibility of IWT in the Nile River, including the possibility of multimodal transport solutions that minimize reliance on road transport.
- **Technological Integration:** Another important area for future investigation would be the role of emerging technologies in enhancing IWT efficiency, such as automation, digital navigation systems, and eco-friendly propulsion technologies.

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Appendix

Table A1: Detailed information regarding the focus group participants

Sessions	Participant code	Gender	Age	Educational level	Job type	Occupation
1	P01	F	22-30	Bachelor	Trainee	DOC
	P02	M	51-55	Bachelor	Full time	O
	P03	M	51-55	Bachelor	Full time	O
	P04	M	41-45	Bachelor	Full time	MTO
	P05	M	36-40	Master's Degree	Full time	RTO
	P06	M	31-35	Bachelor	Full time	DOC
2	P07	M	41-45	Bachelor	Full time	DOC
	P08	M	41-45	Bachelor	Full time	RTA
	P09	M	46-50	PhD Holder	Full time	O
	P10	M	36-40	Bachelor	Full time	CC
	P11	M	41-45	Bachelor	Full time	SCS
	P12	M	51-55	Bachelor	Full time	FFS
3	P13	M	36-40	Bachelor	Full time	CC
	P14	M	51-55	PhD Holder	Full time	FFO
	P15	M	46-50	Bachelor	Full time	SCS
	P16	M	41-45	Bachelor	Full time	FFS
	P17	M	36-40	Bachelor	Full time	CC
	P18	M	41-45	Bachelor	Full time	SCS
4	P19	M	51-55	Bachelor	Full time	O
	P20	M	51-55	Master's Degree	Full time	O
	P21	M	41-45	Bachelor	Full time	SCS
	P22	M	41-45	Bachelor	Full time	FFS
	P23	M	51-55	Bachelor	Full time	MTO
	P24	M	46-50	Bachelor	Full time	SCS
5	P25	F	36-40	Bachelor	Full time	CC
	P26	M	51-55	Bachelor	Full time	RTA
	P27	M	41-45	Bachelor	Full time	SCS
	P28	M	31-35	Master's Degree	Full time	DOC
	P29	M	31-35	Bachelor	Full time	RTO
	P30	M	51-55	Bachelor	Full time	FFS
6	P31	M	36-40	Bachelor	Full time	O
	P32	M	41-45	PhD Holder	Full time	FFS
	P33	M	46-50	Bachelor	Full time	SCS
	P34	M	51-55	Bachelor	Full time	FFS
	P35	M	46-50	Master's Degree	Full time	FFS
	P36	M	36-40	Master's Degree	Full time	CC

Source: The authors

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