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School of Mechanical and Industrial Engineering (SMIE)

Vehicles Characteristics and Their Implication on Fleet Management Performance: A Case of East Africa Bottling S.C (EABSC)

A Master's Thesis Progress Report Submitted to School of Graduate Studies of Addis Ababa University in Partial Fulfillment of the Requirements of Degree of Masters of Science in Mechanical and Industrial Engineering (Industrial Engineering Stream)

By: Tesfamichael Assefa

Advisor: Dr. Kassu Jilacha

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Addis Ababa, Ethiopia

Submitted by

Tesfamichael Assefa	____________________	____________________
Student	**Signature**	**Date**

Approved by

1. Dr. Kassu Jilcha	____________________	____________________
Advisor	**Signature**	**Date**
2. Dr. Ameha Mulugeta	____________________	____________________
Examiner (Internal)	**Signature**	**Date**
3. Dr. Ermiyas Tesfaye	____________________	____________________
Examiner (External)	**Signature**	**Date**
4. ____________________	____________________	____________________
Dean, SMIE	**Signature**	**Date**
5. ____________________	____________________	____________________
Director post graduate program	**Signature**	**Date**

Declaration

I, Tesfamichael Assefa, hereby declare that this thesis titled "Vehicles Characteristics and Their Implication on Fleet Management Performance: A Case of East Africa Bottling S.C (EABSC)" is the result of my own work and that it has not been submitted for any other degree or professional qualification.

I have acknowledged all the main sources of help and all the main ideas expressed are my own. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.

Tesfamichael Assefa

Date: February 05, 2025

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Abstract

Effective fleet management is essential for organizations to enhance operational efficiency, achieve cost savings, and promote sustainability in transportation and logistics. Notably, logistics costs can account for 10% to 30% of a manufacturing firm's overall expenses, with transportation comprising about 50% of total distribution costs. This study focuses on the impact of various vehicle characteristics on fleet management performance at East Africa Bottling S.C. (EABSC), examining factors such as fleet aging, vehicle mass, fleet size, standardization, commonality, and wheelbase. Utilizing a mixed-methods approach, the research combines primary data from questionnaires with secondary data from academic and industry sources, employing quantitative analyses like regression and correlation to explore the relationships between vehicle characteristics and fleet performance. The study also develops a Capacitated Vehicle Routing Problem (CVRP) optimization framework that incorporates these vehicle characteristics to enhance fleet optimization accuracy. Findings indicate that fleet aging, fleet size, fleet standardization, and fleet commonality significantly affect overall fleet performance. On the other hand, vehicle mass affects the fleet performance moderately. Vehicle height and vehicle wheel base has low significant on the performance. The optimization results suggest that integrating vehicle characteristics into the CVRP model can improve the fleet composition to meet a delivery demand of 80 million cases while adhering to a cost target of 150 million from 164 million. Recommendations include implementing effective maintenance practices, optimizing fleet usage, and aligning fleet strategies with organizational goals. This research contributes to existing knowledge by clarifying how vehicle characteristics influence fleet management performance and emphasizing their importance in transportation and logistics system design.

Keywords: Vehicles Characteristics, Fleet Management Performance, Capacitated Vehicle Routing Problem.

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List of Acronyms

FM ………………………………………Fleet Management

FMP ………………………………………Fleet Management performance

FMS ……………………………………… Fleet management system

(EABSC) ………………………………… East Africa Bottling Share Company

KPI: ………………………………… Key performance indicator

PLC: …………………………………Private Limited Company

EPSA ………………………………… Ethiopian Pharmaceutical Supply Agency

SCM: ………………………………… supply chain management

TDC: ………………………………… total discounted cost,

DW: ………………………………… Durbin-Watson

GPS: ………………………………… Global Positioning Systems

CVRP: ………………………………..Capacitated Vehicle Routing Problem

Chapter One

1. Introduction and Background

1.1. Introduction

In today's highly competitive market, businesses must adopt robust systems and principles that drive success and profitability. This can be achieved by ensuring low operating costs while simultaneously maximizing customer satisfaction. Effective logistics management plays a crucial role in this equation, as highlighted by research conducted by Lapinskaitė & Kuckailytė (2014) and Ho Thi et al. (2020), which identifies key cost factors within the supply chain.

The studies emphasize that transportation and inventory management are the primary contributors to overall supply chain costs. These elements significantly impact the final selling price of products, making it essential for companies to focus on these areas to maintain competitive pricing. According to Khan (2014) and Ho Thi et al. (2020), logistics competency accounts for 10% to 30% of the total costs incurred by manufacturing firms. This includes expenses related to the movement of goods from one location to another, underscoring the importance of efficient logistics strategies. Further research by Ghazali et al. (2012), reveals that total distribution costs can represent 9% to 14% of total sales. Notably, transportation costs make up about 50% of these distribution expenses, highlighting the need for focused efforts to manage and reduce these costs.

Given the significant financial implications of logistics and transportation, optimizing these areas has become a critical challenge for transport and distribution managers. The dual goals of minimizing costs while enhancing customer satisfaction create a complex landscape that requires innovative solutions (Akoudad & Jawab, 2018). To address these challenges, companies are increasingly turning to various fleet management models. These models are designed to streamline operations, improve delivery efficiency, and ultimately reduce expenses associated with transportation. By leveraging technology and data analytics, businesses can better manage their fleets, optimize routes, and enhance service levels, leading to improved customer satisfaction (Bolanos et al., 2022).

In summary, the competitive landscape necessitates that companies focus on logistics as a key area for improvement. By understanding the cost structures and implementing effective fleet management strategies, organizations can achieve a balance between cost efficiency and customer satisfaction, paving the way for sustained success

1.2. Background

A variety of fleet management activities, including maintenance, fuel management, vehicle replacement (Milenkovic et al., 2020), safety and driver management (Sun et al., 2021), and vehicle routing (Makarov a et al., 2020 and Adam, 2020), can be included in vehicle fleet management. Regarding the services provided, the Vehicle Fleet Management function has had its fair share of client complaints (Baffour- awuah, 2018; Nguyen, 2021). In order to promptly address the demands of their clients, Giglio et al. (2018) recommend that businesses include car maintenance into their business strategy in a comprehensive manner. In a similar vein, Özener et al. (2020) and Gitahi and Ogollah (2014) claim that vehicle spare parts management favorably improves the how a company attends to the demands of its clients. In line with this, Hu et al. (2018) noted that having replacement parts on hand helps to mitigate the effects of vehicle downtime and is crucial to obtaining the required level of equipment availability at the lowest possible cost.

Fuel management is one of the most crucial aspects of vehicle fleet management, according to Gitahi and Ogollah (2014). They stressed that additional fleet management procedures cannot be installed or put into effect without adequate fuel management. According to Pedraza -Martinez and Van Wassen hove (2012), in order to guarantee high-quality service delivery, fuel management methods should be used with the goal of lowering the cost of gasoline for running a company's fleet. They added that fuel management techniques improve not only consumption reduction but make cost analysis possible.

Fahim (2018) emphasized the significance of driver management and stated that a company must make sure it hires and keeps the knowledgeable, devoted, and highly motivated employees it needs. Recruitment, education, and recognition of drivers are all part of driver management (Begashaw, 2018; Ampiah, 2018; Aflabo et al., 2020). According to Osborne and Hammond (2017), driving training programs enable drivers to immediately improve the knowledge, skills, abilities, attitudes, and professionalism they need to satisfy client expectations and better respond to their requirements. According to Ludbrook, Meehan, and Mason (2016), effective planning keeps the company from losing money by ensuring that only the appropriate cars are purchased in the appropriate quantities and at the appropriate times. However, Ludbrook, and Mason (2016) pointed out that a car replacement policy that makes an effort to foresee the demands of the client in the future also wins over consumers and increases customer satisfaction. Additionally, Sahling and Kayseri (2016) noted that the corporation can predict the future and, as a result, acquire cars that will satisfy customers thanks to a vehicle procurement strategy. The ideas above emphasize that inadequate planning is unacceptable as it impacts the vehicle model specifications that deal with the proper matching of the vehicle's responsibilities to control fuel consumption.

On the other hand, fleet management has been affected by different factors. In research conducted by Torrão et al. (2010) and Eboli et al. (2020), the road condition, the external environment, the driver behavior, and vehicle characteristics are the broad classifications of fleet management factors.

Hence, companies need to put in place a robust system in today's cutthroat market to guarantee low operating costs and high customer satisfaction. Costly logistics components include inventory and transportation, particularly when delivering a product. Businesses have been developing and putting into practice a variety of fleet management models in an effort to reduce transportation expenses and boost customer satisfaction. These consist of vehicle replacement, safety and driver management, maintenance, and fuel management. For businesses to meet customer demands quickly and guarantee the provision of high-quality services, car maintenance is essential. To improve consumption reduction and reduce the cost of gasoline, fuel management techniques should be applied. Hiring and retaining informed, devoted, and driven staff members is the responsibility of driver management; recruitment, training, and recognition are essential components of this process. Also, Companies must plan well in order to prevent financial loss and guarantee that the right cars are purchased in the right quantities and at the right times. Insufficient planning can have a detrimental effect on fuel economy and vehicle model specifications.

1.3. Statement of the problem

Even if different technological or managerial ways developed to enhance the performance and efficiency of vehicle fleet management; still companies or firms have been struggling with the occurrence of high vehicle maintenance cost, high tied up cost, high fuel management cost, low fuel efficiency, low fleet efficiency, low operational performance, high crash rate, high crash severity rate in the fleet management because of different reasons (Yükseltürk et al., 2021: Castillo et al., 2023: Pedraza-Martinez & Van Wassenhove, 2012 : Kraa & Agbenyo, 2020: Atay et al. 2022: Min Zhou et al., 2016: Amirah et al., 2013: Vivaldini et al., 2012). One of the main reasons for those problems are the existence of different vehicle characteristics in the vehicle fleet management systems (Brunheroto et al., 2022: Pedraza-Martinez & Van Wassenhove, 2012 : Min Zhou et al., 2016: Bolanos et al., 2022). Then, fleet managements have been failed to achieve the ultimate successes of make the vehicles on the road with the minimum cost possible and efficient performances (Backman et al., 2016: Bolanos et al., 2022). The listed fleet characteristics have high impact on vehicle fleet management related with cost, performances, safety and compliance (Narcizo et al., 2020). Various studies have discussed vehicle (fleet) characteristics and the implications that such features have on the fleet management but there are no detail studies conducted especially on manufacturing environment to show the impact on fleet management practices considering different vehicle characteristics. Also, in Ethiopia different researches have addressed the influence of several elements on fleet management, but most of the studies have not discussed vehicle characteristics and their implications.

In relation with the above study gaps, the impact of those fleet characteristics have been showing in this study case company. In the company, there are around 36 different models of vehicles without considering trailers and motorcycles which indicates there are no specific standards for the vehicles. This leads to the company have spare parts in the store that value more than 80 million birr, which is a huge tide up cost, and affect the variable cost highly and make the procurement process challenging which leads to high down time for maintenance and eliminate the hedging power of the company. Besides, there are different types of tires, inner tubes and batteries in the store that have millions tide up cost, which affect the operation. In addition, low technical skill of employees on some vehicle models, low training materials availability and low special tools availability for those vehicle models affect the employee's performance and create unnecessary stress on the employees and downtime. The researcher had an interview with the company fleet staff and found they do not get any specific training related with most vehicle models.

Secondly, most of the fleet populations have zero salvation value but still work in the company's operation system even if the vehicles have aged which have high down time and maintenance cost due to this the fleet availability for delivery have lower from the standard 90%. Also, most of the vehicles have been purchased without considering the company's operational condition and there value to the operation which leads to excessive fleet size. Lead to an impact on fuel management that have different fuel benchmarks for different models that create difficulty to manage fuel consumption. Also, the company have been using three types of fuels diesel, petrol and liquefied petroleum gas (LPG), which creates an additional cost of spending to build storage and fuel purchase cost.

Hence, showing the above facts, those fleet characteristics affect the fleet management practices of the company. Therefore, in this research the detail implication of fleet characteristics have analyzed relation with fleet performance and the necessary recommendations raised for the corrective measures.

1.4. Research Question

The researcher employed the following research questions in line with the study objectives to attain its goals:

1. What are the key vehicle characteristics that affect fleet management performance at East Africa Bottling S.C (EABSC)?
2. How do vehicle characteristics impact fleet management performance at EABSC's?
3. What are the best practices to reduce the impact of vehicle characteristics and to enhance fleet management performance at EABSC?

1.5. Objectives

1.5.1. General Objective

The general objective of this study is to assess the impact of vehicle characteristics on the performance of fleet management at East Africa Bottling S.C. (EABSC).

1.5.2. Specific Objective

The specific objectives of the study are:

1. To identify the key vehicle characteristics that affect the fleet management performance of EABSC's.

2. To examine how vehicle characteristics influence the fleet management performance.
3. To optimizing the fleet for better performance at EABSC.
4. To provide recommendations and best practices for optimizing vehicle characteristics to improve fleet management performance at EABSC.

1.6. Significance of the study

The research have significant on showing in depth the impact of fleet characteristics on the fleet management. In relation with the investigation, the case company management team can understand the impacts of those fleet characteristics and able to put some directions to reduce the impacts of those factors on the company performance and profitability.

Secondly, the research have a significant for other companies fleet managers and officers to give an insight and good understanding about fleet management and how fleet characteristics can impact fleet practices. This understanding able to give the managers a good starting point to analyze their fleet management system and create a best techniques to improve performance and profitability.

Finally, the research paves the way for academics to investigate how fleet characteristics should be lowered in order to increase the economics and performance of fleet management. The study's findings give information for scholars and academicians interested in learning more about the notion of fleet management. It also lays the groundwork for future study on the subject. Future scholars will be able to apply the research findings to a variety of fields thanks to the findings of this study.

1.7. Scope and Limitation of the study

1.7.1. Scope

The scope of this research is limited to the vehicle population that is owned and operated by the case company, East Africa Bottling S.C. (EABSC). This includes only the vehicles that are listed as part of the company's asset inventory, excluding trailers, motorcycles, rental vehicles, and forklifts. The study will not examine any vehicles or fleet management practices related to these excluded vehicle types, as they fall outside the primary focus of investigating the characteristics and implications of EABSC's owned vehicle fleet. By focusing solely on the company's directly controlled vehicle assets, the research aims to provide a detailed and actionable assessment of how fleet characteristics impact the management and operations of EABSC's core transportation resources.

In addition, this research study is limited in scope to examining the static characteristics of the vehicles in EABSC's owned fleet. The dynamic and kinematic properties of the vehicles are excluded from the analysis due to constraints on available time and resources. The exclusion of dynamic and kinematic characteristics, which involve more complex performance data and modeling, is necessary to ensure the feasibility and timeliness of the research within the given constraints. The static characteristics refer to the fixed, inherent attributes of the vehicles, such as standardization, commonality, size and age. By focusing the research on these tangible, measurable vehicle characteristics, the study aims to provide insights that can be more readily applied to enhance EABSC's fleet operations and decision-making processes.

1.7.2. Limitation

The researchers involved in this study have identified several limitations that should be carefully considered when interpreting and applying the findings. These limitations are rooted in the researcher understanding and observations during the course of the research. One key limitation is relates to the sample size and scope of the data analyzed. The researchers acknowledge that the number of cars in the sample or the amount of fleet data that can be analyzed may have a significant impact on the study's conclusions. A small sample size could potentially limit the applicability of the findings to larger fleets or different industries. To address this limitation, the researchers have committed to striving for the largest dataset possible, given the constraints of the available data. Also plan to conduct sensitivity analyses to understand the impact of sample size on the findings and clearly communicate the limitations of the sample size and its implications for the generalizability of the results.

Another limitation concerns the availability and accuracy of the data collected. The researcher recognize that the robustness of the study's conclusions is closely tied to the quality of the data collected. Any gaps, inconsistencies, or other issues in the data could impact the reliability of the findings. To mitigate these risks, the researchers have review the data for potential problems, work closely with EABSC to understand the data collection and validation processes, and implement robust data cleaning and validation procedures.

Additionally, the researchers acknowledge that the specific industry and geographic context of EABSC's operations may limit the direct applicability of the findings to other regions or sectors. Differences in factors such as road infrastructure, regulations, and operational practices could influence the effectiveness of fleet management strategies. To address this limitation, the researcher also suggest the need for further research to understand the applicability of the findings in different contexts.

1.8. Organization of the study

The research is organized under five chapters. The first chapter represents background of the study, statement of the problem, objective of the study, significance and scope of the study. The second chapter deals with review of related literature, conceptual frame works and literature gaps. The third chapter presents about procedures and methods of data analysis and the like. The fourth chapter presented results and discussions about the research topic based on the result of third chapter. Finally, the fifth chapter, the conclusion, recommendations on the way to improve the performance and future research points have listed.

Chapter Two

2. Literature review

2.1. Introduction

This chapter provides a comprehensive overview of the key concepts and considerations in the field of vehicle fleet management research. The discussion covers a wide range of subjects that are central to understanding this domain.

First, the chapter establishes a clear definition of fleet management, outlining the core principles and objectives of this discipline. It then delves into the different types of vehicle fleets, exploring the unique characteristics and management requirements of various fleet configurations. The chapter examines the practical aspects of fleet management, discussing the day-to-day processes, strategies, and best practices employed by fleet managers. This includes an examination of the factors that can impact the effectiveness of vehicle fleet management, such as operational efficiency, cost optimization, and regulatory compliance.

The chapter also reviews the theoretical foundations of vehicle fleet management, drawing upon relevant management theories and frameworks. This includes an exploration of concepts related to competitive advantage, resource allocation, and decision-making in the context of fleet operations.

Following this comprehensive literature review, the chapter transitions to a discussion of the conceptual framework underpinning the current research. This framework is developed based on a thorough analysis of the existing knowledge and the identification of gaps in the literature. The chapter then summarizes the key insights and takeaways from the literature, setting the stage for the specific research objectives and methodologies to be employed in the study.

By providing this multifaceted overview of vehicle fleet management research, the chapter lays a solid foundation for the subsequent investigation. The coverage of definitions, fleet types, practical considerations, theoretical perspectives, and the conceptual framework serves to equip the reader with a deep understanding of the complexities and nuances inherent in this field of study. This comprehensive approach sets the stage for a robust and impactful research endeavor.

Hence, this chapter offers an extensive overview of the key concepts and considerations in vehicle fleet management research. It defines fleet management, examines different fleet types, and explores the practical aspects of fleet operations and strategies. The chapter also reviews the theoretical foundations underpinning the field, including relevant management theories and frameworks. Finally, it presents a conceptual framework developed from a thorough literature analysis, setting the stage for the subsequent research objectives and methodologies.

2.2. Practices of Fleet Management

One of the primary asset management tasks is fleet management, which encompasses more than just keeping and managing fleet vehicles. Justification, specification, purchase, assignment, distribution, scheduling of tasks, maintenance, usage, disposal, and replacement are all part of an ongoing cycle (Tariq, 2021).

According to Samchuk et al. (2021), organizations may encounter internal and external factors that have an impact on their operations. Similarly, fleet management in a company may encounter dynamic problems like unplanned situations occurring during operations. Fleet management system is the operation and administration of fleet vehicles and related cases in an organization and the study implies that businesses must possess the ability to react when faced with market competition (Chiparo et al., 2021 and Borrug et al., 2009).

Fleet management comprises all actions needed to maintain and operate pieces of equipment throughout its life from the beginning stages of equipment acquisition to the final stages of asset disposal. Fleet management in a corporation may face dynamic difficulties such as unforeseen circumstances occurring during operations. Businesses may encounter both internal and external elements that impact their operations. As a result, the study comes to the conclusion that businesses must be prepared to act when market competition intensifies. Fleet management encompasses all of the tasks required to operate and maintain equipment, from the initial stages of asset acquisition to the final stages of asset disposal. Examples include training, inventory control, maintenance and repair, and safety issues. (Chiparo et al., 2021, Damaskinos et al., 2020 and Hamzi et al, 2013).

Fleet management in Europe is a profitable industry with key success factors including strong funding and service mindset, shifting from vehicle-related services to driver-related-service, size matters, and multi-brand (Jalba et al., 2010 and Popovic and Habjan, 2012). In New Zealand, fleet managers face barriers due to transport tasks, road environment, fleet composition, fleet ownership structures, fleet management culture, regulations, compliance, and enforcement. Factors preventing fleet managers from adopting fuel-saving measures include lack of formal training in financial management, reliance on previous generations of fleet managers, and insufficient monitoring of fuel consumption (Raposo et al., 2021, Aji et al., 2021 and Munahar et al., 2023). Driver training does not adequately cover fuel-efficient driving practices, and fleets generally use GPS tracking systems to solve specific issues rather than looking for trends. GPS-based fleet management systems are important for monitoring and tracking commodity distribution, saving energy, improving scheduling, operating efficiency, and effectiveness. Key factors for introducing GPS-based fleet management systems include top executive support, funding and budget, consultant experience, project team composition, user recognition, timely and correct information, and degree of transmission equipment completeness. Various logistics projects are implemented by firms using latest technologies such as GPS and wireless technologies in most developed nations, with the usage of wireless technology expanding in developing countries like Kenya (Gitahi and Ogollah, 2014, Galende-Hernández et al., 2024 and Fan et al., 2023).

Ambaye (2019) did a study on fleet management practice in drinking water companies and its implications for operational performance: the case of Aqua Addis drinking water company Asku Plc. The study shows that all of the Fleet Management activities influence the operational performance of the organization. However, vehicle tracking contributes the most to the operational performance of the company, followed by fuel management. Ayenew (2016) did a study on logistics practices in Ethiopian medium and large leather footwear manufacturing firms and concluded that in the globalized world, producing quality footwear alone is not a guarantee of being competitive. Building a mutual relationship with suppliers and customers through on-time delivery of finished footwear to customers, making the custom processes efficient, and having reliable transportation systems are among the other factors that contribute to the creation of a good image in the eyes of potential customers and suppliers. Wesson and Nagy (2014) argued that the vehicle routing problem with deliveries and pickups contributes to most of the logistics problems. Developing the best vehicle routing models considers the cheapest routes, the least time-consuming routes, and resource-consuming routes. Hence, identifying the core problems of an organization during the delivery of goods helps to include major variables in routing model preparation.

Fleet management performance quantifies the responsiveness, efficiency, and effectiveness of actions, reducing costs and improving timely and effective service delivery. However, measuring fleet management performance is challenging for organizations due to difficulties in obtaining accurate data, limited information technology, the exhaustive nature of the task, and limited motivation of professionals (Yi-Chung Hu et al., 2015). Fleet management is an administrative function that coordinates the operations of vehicles to ensure efficiency, effectiveness, responsiveness, and compliance with government requirements. It includes vehicle finance, maintenance, telematics (tracking and diagnostic), driver management, and fuel management (Romero et al., 2024). Maintenance is a scheduled preventative measure taken before a vehicle fails to work, while repair is an unplanned measure that takes place after the malfunction. Maintenance saves organizations from operational interruptions due to vehicle failures and can save money incurred as a consequence of total vehicle failure (Hu et al., 2015).

In conclusion, fleet management is a complex and multifaceted component of asset management for organizations across various sectors. It encompasses a diverse range of activities, from the initial justification and specification of fleet vehicles, to their purchase, assignment, scheduling, maintenance, usage, and eventual disposal. Effective fleet management requires navigating both internal and external factors that can introduce dynamic challenges, necessitating the ability to respond to changing market conditions and competitive pressures. The literature highlights the crucial role of technologies like GPS-based fleet management systems in enhancing operational efficiency, energy savings, and overall responsiveness. Additionally, the importance of preventive maintenance practices and the measurement of fleet management performance cannot be overstated, as they contribute to cost savings and improved service delivery. While fleet management is a profitable industry in certain regions, such as Europe, fleet managers in other contexts, like New Zealand, must contend with unique barriers related to infrastructure, regulations, and cultural factors. Ultimately, the successful implementation of comprehensive and adaptable fleet management strategies can yield significant benefits for organizations, positioning them for long-term competitive advantage in an increasingly dynamic business environment.

2.2.1. Vehicle Repair and maintenance

A comprehensive approach to fleet management, fleet maintenance management includes the endorsement, encoding, and recording of a vehicle's state, including its history of operation, maintenance, and breakdowns. Fleet equipment will eventually deteriorate and experience more downtime. Thus, to increase its service life, the planned maintenance must be carried out correctly. The fleet repair and maintenance system gives the organization's car fleets access to real-time data, such as the expected total fleet lifetime costs throughout the course of the fleet's service life as well as disposal and replacement costs. As a result, fleet managers may budget for preventative and corrective maintenance by using Fleet Maintenance Management. Fleet maintenance management operations anticipate when vehicles should be serviced and provide emergency kits and consumable replacement parts (Feng et al., 2020, Mechlia et al., 2021, Massaro et al., 2020, Borirug et al, 2009 and Schneider and Cassidy, 2004).

Maintenance procedures are initiated when equipment in the fleet requires repair or experiences an unplanned breakdown. But by creating a maintenance plan, unforeseen repairs can be averted and the car can be kept in top shape for an extended period of time. For maintenance, consumable/recommended spare parts, instruments, and qualified personnel (supervisors, mechanics, service engineers, etc.) are needed in addition to material resources. Maintenance operations focused on repairing and replacing sections of fleet equipment, while maintenance plans audited when spare parts needed to be changed or repaired. The two categories of maintenance strategies scheduled/planned maintenance and preventive/corrective maintenance classified repair techniques as "Modification" procedures. Usually, modification repair is determined by non-periodic and project-specific factors, like repurposing parts of similar equipment to improve equipment performance. While preventing unplanned breakdowns and replacing components in line with the equipment's service schedule are the main objectives of preventive maintenance strategies, unplanned breakdowns or corrective maintenance strategies do not replace spare parts prior to failure (Sebastjan and Edgar, 2020, Raposo et al., 2021 and Arts, 2013).

Hence, fleet maintenance management involves comprehensive processes to record vehicle status, plan preventative maintenance, and access real-time data on fleet lifetime costs. This allows fleet managers to budget for maintenance and anticipate service needs. Maintenance strategies include scheduled/planned upkeep as well as reactive/corrective repairs to prevent breakdowns and extend vehicle service life. Key resources for effective maintenance include consumables, spare parts, and qualified personnel to carry out modification and replacement work as needed.

2.2.2. Spare part management

The three types of spare parts are consumables, maintainable, and serviceable, according to Arts (2013) and Zhang et al. (2021). For examples, such as aircraft engines and complex armament or radar systems aboard frigates, to illustrate his definition of serviceable parts, which are components that make up a sizable enough subsystem of the original equipment to justify a distinct usage-based maintenance plan. Maintainable items are those that can be fixed after replacement and then made ready for use (RFU) once more. As a result, unlike serviceable, maintainable typically lack individual tracking and tracing and lack their own usage-based maintenance plan. Compressors and pumps are two examples of the various sorts of maintainable that a repair shop may fix. The consumables are things that are purchased new from a source and thrown away after replacement. These are often rather inexpensive products, like gaskets. As a result, these various part kinds often correspond with various maintenance approaches (Bhalla et al., 2021, Aji et al., 2021 and Baas, 2012).

Hence, Spare parts in fleet management are categorized as consumables, maintainable, and serviceable. Consumables are inexpensive, single-use items that are replaced when worn. Maintainable parts can be repaired and reused, while serviceable parts are complex subsystems that warrant their own usage-based maintenance plans. These part classifications correspond to different maintenance approaches, with serviceable parts requiring more advanced tracking and planning compared to simpler consumables. Understanding these part types is crucial for effective fleet maintenance management strategies.

2.2.3. Driver Management and training

Contends that increases in fuel efficiency and safe driving techniques immediately enforce changes in driver behavior and education. Thus, the goals of driver education are to enhance fuel-efficient driving and lower incident rates. A skilled driver and a bad driver can differ in fuel usage by up to 35%. Many programs were launched in response to their findings with the goal of enhancing driver education and behavior. There is a common, and frequently false, belief among drivers that driving faster and more aggressively will significantly cut down on trip time. Therefore, the majority of the variance is caused by variations in road speed, gear choice, engine speed at which gears are changed, aggressiveness with which the accelerator and brake pedals are used, and length of time the driver keeps the car idling (Kostakis and Kargas, 2021, DFT, 2004).

Noted several actions made to enhance driver management, each of which had a degree of recognition that was closely correlated with people's safety practices, levels of customer service, and incident frequencies. Sincere reporting was encouraged by the drivers' recognition program. Creating a thorough prestart check sheet, making sure drivers understand their accountability and responsibility for their actions, enhancing the hiring process, teaching and coaching drivers about vehicle standards and visual inspections, hosting frequent monthly drive forums, and creating an environment where a driver can step in creating a culture where drivers can step in to stop unsafe or noncompliant behavior, organizing regular monthly drive forums, creating feedback reports on individual driver performance and vehicle performance in terms of speed and fuel consumption, creating a culture of continuous improvement within the driver teams to concentrate on total fuel consumption and driving techniques, including urban operation, and having all drivers take part in a driver recognition/incentive scheme that rewards positive behaviors and outcomes (Wygal et al., 2021, Kostakis and Kargas, 2021).

Hence, fuel-efficient and safe driving can significantly reduce fleet fuel consumption and incident rates. Driver education and behavior modification are key to achieving these goals, as skilled drivers can improve fuel usage compared to poor drivers. Common misconceptions about aggressive driving saving time need to be addressed through training. Effective driver management strategies include recognition programs, comprehensive pre-start checks, accountability training, and regular forums to coach drivers on best practices. The ultimate aim is to foster a culture of continuous improvement in fuel efficiency and safety within the driver team.

2.2.4. Fuel Management

According to Munahar et al. (2023), Fuel management is a crucial aspect of fleet operations, requiring businesses to maintain maximum fuel efficiency and reduce hazards like fuel theft and price swings. Factors affecting fuel consumption include driving conditions, vehicle age, maintenance schedule, and driving style. Adopting driver education and choosing fuel-efficient car models can lead to financial savings and enhanced operations. Companies can increase fleet management efficiency and reduce costs by understanding fundamental ideas and implementing strategic corrective measures. Monitoring fuel consumption is essential for businesses to identify inefficiencies and streamline processes (Borirug et al., 2009 and Ruiz-Garcia et al., 2009). Fleet managers can use fuel management software and telematics systems to collect comprehensive data on fuel usage, preventing fuel theft and preventing operational and financial losses. Strengthening defenses against fuel misuse involves strong security measures, encouraging an accountable culture among drivers, respecting environmental laws, and fuel-related reporting requirements. Hedging and bulk buying can help control price swings and obtain better terms. Fleet managers are exploring alternative fuel sources like electric cars, hybrid systems, or biofuels to support environmental sustainability (Romero et al., 2024 and Chiparo et al., 2022).

Fleet management tools currently in use, identified fleet fuel management based on research findings. Noted that fuel management has proven to be an essential tool for vehicle operation when included in a dynamic fleet management system. All fuel-related transactions should be made using personalized cards in order to help stop any illegal or irregular activity and to collect relevant data such as date, time, location, odometer reading, driver name, product type, and unit. The price per unit as well as the total cost. Mention how a variety of factors affect fuel efficiency. After that, they provide a list of possible strategies to increase fuel economy, such as maintenance management, in-cab temperature control, fleet management procedures, speed management, driver training, and vehicle matching to transportation tasks (Romero et al., 2024, Chiparo et al., 2022, Singh and Kumar, 2024, Zhang et al., 2021 and Latto and Baas et al., 2005).

Hence, fleet operations to remain efficient and minimize risks such as fuel theft and price fluctuations, fuel management is essential. The condition of the vehicle, age of the vehicle, maintenance schedule, and driving style are all factors that affect fuel consumption. Choosing fuel-efficient models and implementing driver education programs can result in improved operations and cost savings. Fleet managers can prevent fuel theft and minimize operational and financial losses by using telematics and fuel management software to make well-informed decisions. It's also critical to bolster defenses against fuel misuse, encourage an accountable driving culture, and uphold environmental laws. In an effort to promote environmental sustainability, alternative fuel sources such as biofuels, hybrid vehicles, and electric vehicles are being investigated. Fleet management can be improved with the use of fuel management technologies, such as customized cards.

2.2.5. Fleet tracking and controlling systems

Vehicles transport passengers and their belongings, but factors beyond on-time delivery include location, destination, schedules, traffic, preferred routes, detours, parking, and fuel levels (Mjosund and Hovi, 2022 and Kuehling, 2018). Dynamic fleet management models assume deterministic travel times, but unfavorable weather, equipment malfunctions, and traffic congestion can cause significant variability in travel times. These events can seem random to modelers (Kibatu, 2016). GPS technology, originally designed to pinpoint the exact location of any object on Earth, has become a significant market for vehicle tracking and location. GPS-based fleet management systems have achieved management goals such as commodity distribution, energy savings, safety, and quality. Vehicle tracking and location have become a synergy for transportation businesses, achieving management goals such as tracking and monitoring commodity distribution, energy savings, safety, and quality (Toilier and Gardrat, 2024 and Yi-Chung Hu et al., 2015).

Yi-Chung Hu et al. (2015) highlight the evolution of fleet management systems from basic functions like vehicle tracking to planning tools. Fleet management involves overseeing vehicle usage, maintenance, and administrative activities like task coordination and distribution. Global positioning system (GPS) technology is crucial for vehicle fleet management and monitoring. Asset management systems today require constant observation and communication with fleet cars equipped with these technologies to maximize utilization and respond quickly to client demands. Managing a fleet of cars is challenging due to increasing maintenance expenses, escalating fuel prices, and safety concerns (Galende-Hernández et al., 2024). Sorensen and Bochtis, (2010) and Borirug et al. (2009) argue that sophisticated technologies are necessary for fleet and logistics management to enhance the logistic information system. Information and communication technology (ICT) has become a crucial component of businesses to reduce operating costs and increase customer satisfaction. Real-time and dynamic tracking of vehicle movements, maintenance plans, fuel, and financial management are essential. Dynamic fleet management systems provide fleet managers and users with the tools to perform their responsibilities quickly and successfully (Zohari and Nazri, 2021 and Merkebe and Lina, 2024).

Hence, although deterministic travel times are the assumption of dynamic fleet management models, considerable variability can be introduced by unforeseen circumstances such as bad weather, equipment failures, and traffic jams. In order to meet management objectives like commodity distribution, energy savings, safety, and quality, GPS technology has grown to be a significant market for vehicle tracking and location. Monitoring vehicle use, upkeep, and administrative tasks is part of fleet management. For fleet and logistics management to lower operating costs and boost customer satisfaction, advanced technologies like ICT are required. Financial management, maintenance schedules, fuel, and real-time dynamic tracking of moving vehicles are all crucial.

2.2.6. Fleet Utilization

Effective management of vehicle fleets is crucial for an organization's competitive edge. Fleet utilization measures the efficiency of a fleet and directly impacts the organization's bottom line. Strategic approaches to optimize fleet utilization can unlock cost savings, enhance operational efficiency, and drive long-term profitability (Mylonas et al., 2023). It involves efficient vehicle allocation, alignment of fleet size with operational demands, and optimization of usage. A well-utilized fleet reduces expenses, enhances productivity, and responds to customer needs. Underutilized assets can lead to unnecessary capital expenditures, increased overhead, and suboptimal resource allocation, while over utilized fleets can result in excessive wear and tear, decreased vehicle lifespan, and compromised employee morale (Goulias and Shi, 2023).

Fleet utilization is the planning and execution of operations focusing on efficient use of a fleet. It involves understanding the potential of a fleet and regularly evaluating its usage to adapt to changing company demands (Saprykin et al., 2022 and Loennechen et al., 2024). To optimize fleet utilization, organizations should consider strategies such as fleet rightsizing, route optimization, asset monitoring and utilization tracking, driver behavior management, and maintenance and downtime reduction. Fleet rightsizing adjusts fleet size and composition to align with operational requirements, while route optimization uses advanced routing software to plan efficient routes and minimize empty miles (Skara et al., 2023). Asset monitoring and utilization tracking can be achieved through telematics systems or fleet management software, while driver behavior management involves training programs and incentives to promote safe driving habits. Proactive maintenance plans can reduce operational costs, increase productivity, improve asset longevity, and provide a competitive advantage in the market place (Mark et al., 2021 and Yan et al., 2024).

Hence, optimizing fleet utilization has become a critical requirement for businesses looking to boost productivity, cut expenses, and promote sustainable growth in the ever-changing business landscape. Fleet managers can optimize their vehicle assets and set themselves up for long-term success by utilizing data-driven insights, implementing cutting-edge technologies, and cultivating a continuous improvement culture.

2.2.7. Fleet Sizing

Organizations face a significant challenge in determining the ideal vehicle fleet size because a sufficient number of vehicles is necessary to meet operational demands, maintain cost-efficiency, and guarantee a flawless customer experience (Ratnaji and Venkateswaran, 2020). While an oversized fleet may result in excessive capital expenditures and increased maintenance costs, an undersized fleet may result in unmet customer needs and lost business opportunities. Organizations can balance satisfying customer demands, maximizing resource utilization, and upholding a lean, economical operation with the help of effective fleet sizing (Jin et al., 2021). Striking a balance between management demands, driver demands, and vehicle requirements is essential to fleet maintenance. Correctly sizing the fleet establishes the foundation for future growth and is the first step towards ensuring that the operations are economical and sustainable. Fleets are expensive assets, so reducing costs might require parting with some of the cars in the fleet. Appropriate size can help achieve process optimization (Fan et al., 2023).

When evaluating the appropriate size of a vehicle fleet, fleet managers should consider several key factors, including operational demands, vehicle utilization patterns, growth and expansion plans, replacement cycles, technological advancements, and financial constraints. Strategies for determining the optimal fleet size include scenario-based modeling, benchmarking and industry insights, data-driven analysis, and adopting an agile fleet management approach. The greatest way to extend the life of current fleets into the future is to size them appropriately. The procedure entails assessing and implicitly defining the collection of duties that a particular fleet must do (Vanga and Jayendran, 2020 and Li et al., 2022).

By determining the optimal vehicle fleet size, organizations can unlock a range of benefits, including improved operational efficiency and responsiveness to customer needs, enhanced financial performance through reduced capital expenditures and operating costs, increased asset utilization and extended vehicle lifespans, streamlined maintenance and fleet management processes, and reduced environmental impact through better fuel efficiency and emissions management (Ratnaji and Venkateswaran, 2020). Striking the right balance in fleet size is a strategic imperative for organizations seeking to drive operational excellence, financial sustainability, and competitive advantage (Choia and Lee, 2023). A corporation may reduce its fleet size and lower its capital expenditure by using a fleet sizing action plan that is integrated and implemented on time the duties must be completed quickly and without stopping. To guarantee the most fuel-efficient and cost-effective cars for your needs, this process should be supported and guided by a fuel-efficient vehicle purchase plan. The following are some advantages of vehicle and fleet right-sizing: improved operational procedures, lower greenhouse gas emissions and associated pollutants, less fuel consumption, lower operating and insurance expenses, and more cash released (Silva et al., 2024).

Hence, the literature review focuses on the importance of vehicle management in minimizing risks, improving efficiency, enhancing responsiveness, and reducing transportation costs. Fleet management involves managing an organization's vehicle assets, including light, heavy, and motor vehicles. It captures vehicle information such as distances, fuel consumption, repair and maintenance, spare part consumption, and servicing. However, gaps in empirical studies reveal that Fleet management variables vary, and driver management is not considered as an activity. Fleet management performance has not been measured using KPIs due to difficulty in acquiring baseline data. Instead, Fleet management practices are studied using agreed-upon assessment parameters. The implications of Fleet management practice on fleet planning (FP) remain unexplored. In Ethiopia, conducted studies on Fleet management practices in drinking water companies and leather footwear manufacturing firms. Found that vehicle tracking and fuel management significantly impact operational performance and highlighted the importance of building mutual relationships with suppliers and customers, efficient custom processes, and reliable transportation systems for competitiveness in the globalized world. On other hand, argued that vehicle routing problems contribute to most logistics problems, and developing the best vehicle routing models considers the cheapest, least time-consuming, and resource-consuming routes. Identifying core problems during delivery helps in preparing routing models, ensuring efficient delivery of goods and addressing logistics issues.

2.3. Vehicles Classification

Autolist Editorial (2019) defines a fleet vehicle as an assortment of various motor vehicle equipment, such as cars, buses, sedans, SUVs, trucks, trailers, forklifts, motorbikes, and so forth that are primarily used to transport people, goods, or services to the designated location by an organization that is owned by a governmental body, business, or individual. Such fleet cars can be categorized into several groups according to particular standards and criteria for management and identification purposes (Nichante, 2017). According to U.S Federal Highway Administration (U.S.F.H.A.), (2014) and Kim et al. (2014), fleet vehicles are divided into 13 classes according to the number of axles and tires.

Table 2-1 Vehicle Category Classification

Vehicle Model	Vehicle Class	Description	Vehicle Features
-	1	-	Motor cycle
P (Multi-Purpose)	2	Mobile car	Passenger car
P	3	Mobile car	Four tires, single unit
B (Bus)	4	Bus	Buses
T (Truck)	5	Small truck	Two axles, six tire single unit
T	6	Small truck	Three axles, single unit
TT (Ton Truck)	7	Mid-sized truck	4 or more axle, single trailers
TT	8	Mid-sized truck	4 or fewer axle, single trailers
TT	9	Mid-sized truck	Five axle tractor semi-trailers
ST (Stake Truck)	10	Heavy Truck	Six or more axle, single trailers
ST	11	Heavy Truck	Five or less axle, multi trailers
ST	12	Heavy Truck	Six axles, multi trailers
ST	13	Heavy Truck	7 or more axle, multi trailers

Source: U.S.F.H.A.), (2014) and Kim et al. (2014)

Hence, fleet vehicles encompass a diverse range of motor equipment used by organizations to transport people, goods, or services. These fleet vehicles can be categorized into different groups based on specific standards and criteria for management purposes. Proper classification and identification of fleet vehicles is crucial for effective fleet management strategies across organizations. This classification system helps fleet managers understand the various vehicle types, their characteristics, and how to best maintain and manage each class within the overall fleet.

2.4. Concept of Vehicle characteristics

Understanding a vehicle's performance, safety, and efficiency depends on its characteristics, which are also critical factors in the engineering, design, and operation of vehicles that determine their capabilities, performance, and behavior (Yükseltürk et al. 2021). These traits can be broadly divided into three categories: kinetic, dynamic, and static characteristics. Static vehicle characteristics are defined as a collection of vehicle attributes that are largely constant, do not change over time, or vary gradually over time in the study by Shokry et al. (2017). The performance and handling qualities of a car are referred to as its dynamic characteristics, and they can alter dramatically while it is being driven. Fuel efficiency, ride quality, handling and cornering, acceleration, and braking performance. A vehicle's motion and the forces operating on it are described by its kinetic characteristics includes momentum, kinetic energy, centrifugal force, acceleration and deceleration, and velocity (Simoni et al., 2017; André et al., 2016).

Fleet standardization is the practice of maintaining a homogeneous fleet of vehicles, often of the same make, model, and configurations (Bolanos et al. 2022). This approach offers several benefits, such as simplified maintenance, improved driver familiarity, economies of scale, enhanced data tracking, and cost and operational effectiveness. Mechanics only need to be familiar with a limited number of vehicle types, allowing for streamlined parts inventory, specialized training, and more efficient repairs. Pedraza-Martinez & Van Wassenhove (2012) and Brunheroto et al. (2022) mention that drivers can operate any vehicle comfortably due to consistent controls and features across the entire fleet, enhancing safe and efficient operation. Economies of scale make purchasing, leasing, and negotiating with vendors easier, leading to bulk discounts and favorable contract terms. Enhanced data tracking simplifies maintenance records, fuel usage, and other metrics, allowing for more meaningful data analysis to optimize performance. Narcizo et al. (2020) found that standardizing the airline fleet significantly impacts costs and operational effectiveness. They used econometric analysis to create an empirical model that helps companies choose the best operational course of action, indicating that the new model is more accurate overall.

A term that is frequently used to describe the administrative and commercial advantages of operating a fleet of aircraft that shares parts, requirements for maintenance, or other characteristics (Pedraza-Martinez & Van Wassenhove, 2012; Brüggen & Klose, 2010; Ivana, 2017). Fleet commonality is related to but distinct from full standardization. It refers to the degree to which a fleet utilizes a limited number of vehicle models, engine types, and option packages (Wolf et al. 2023). Even without 100% standardization, high commonality can still deliver many benefits. For example, if 80% of the fleet consists of the same model, that level of commonality enables simplified parts stocking, training, and data tracking - just to a lesser degree than complete standardization (Atay et al. 2022). Fleet commonality provides flexibility to accommodate specialized vehicle requirements while still capturing efficiencies.

The average age of vehicles in a fleet is an important metric that an elderly fleet may have unidentified effects on cost and dependability (Castillo et al., 2023). It is concerned about how old the vehicle population is in relation to working age and kilometer coverage. Both Christopher et al. (2016) and Pedraza-Martinez & Van Wassenhove (2012) have agreed that older vehicles typically have higher maintenance costs and lower fuel efficiency. However, replacing vehicles too frequently can also increase capital expenditures. Fleet managers aim to find the optimal balance of vehicle age, condition, and replacement timing. Fleet managers must find the optimal balance, aiming to maximize the useful life of each vehicle while avoiding escalating operating costs from aging fleets (Atay et al. 2022). Developing a strategic vehicle replacement plan based on factors like mileage, condition, and total cost of ownership is essential.

The total number of fleets that a company or agency has under common ownership and control, regardless of whether those fleets are a part of different departments or branches within the organizational structure (Pedraza-Martinez & Van Wassenhove, 2012; Sawik et al., 2020). The total number of vehicles in a fleet is the fleet size. Factors like operational needs, budget constraints, and utilization rates determine the appropriate fleet size. Having the right number of vehicles is crucial to meeting transportation requirements efficiently. Effective fleet management leverages these concepts to maximize the performance, cost-effectiveness, and useful life of a vehicle fleet. Balancing standardization, commonality, age, and size is key to maintaining an optimal fleet. A company's operating costs can be reduced by allocating the proper fleet size for the correct customer and route (Castillo et al. 2023 and Repoussis & Tarantilis, 2010). Using probabilistic semi-parallel building heuristics and adaptive memory programming, the researchers in this study created an optimal vehicle routing management model. Once the model was put into practice, they were able to recover it and produce an extremely successful and efficient solution.

The study conducted by Ballo et al. (2020), Zhou et al. (2016), Ahmed et al. (2022) and Liu et al. (2021) demonstrated that several vehicle parameters, including mass, height, front and side structural geometry, front and rear suspension characteristics, and wheelbase, might affect fleet management performance. These attributes may also affect labor intensity, tires, batteries, spare component usage, fuel consumption, and frequency of repairs (Amirah et al., 2013). Studies by Pedraza-Martinez & Van Wassenhove (2012) and Narcizo et al. (2020) have shown that a thorough understanding of the characteristics of the fleet population can offer valuable insights into fleet performance, cost, and behavior. The fleet's size, age, communality, and standardization are the population characteristics that are mentioned. Studies by Pander et al. (2010) indicate that the aviation sector contributes significantly to environmental pollution, and aviation companies should regularly conduct evaluations to determine the extent of the pollution. As a result, the most accurate environmental assessment model in this study was created by taking into account several parameters like fleet age and emission level while also utilizing system dynamics methodologies.

Hence, the importance of understanding and managing the various characteristics of a vehicle fleet highlighted in order to maximize its performance, cost-effectiveness, and useful life. Key factors to consider include the static, dynamic, and kinetic characteristics of the vehicles, as well as the overall standardization, commonality, age, and size of the fleet. By carefully balancing these elements, fleet managers can achieve an optimal balance that delivers benefits such as simplified maintenance, improved driver familiarity, economies of scale, and enhanced data tracking. Additionally, the article notes that the aviation sector, which contributes significantly to environmental pollution, should regularly evaluate its fleet characteristics and utilize advanced modeling techniques to accurately assess its environmental impact. The article draws a clear distinction between the concepts of fleet standardization and fleet commonality. While fleet standardization involves maintaining a homogeneous fleet of the same make, model, and configurations, fleet commonality refers to the degree to which a fleet utilizes a limited number of vehicle models, engine types, and option packages. The article suggests that high commonality can still deliver many of the same benefits as full standardization, while providing more flexibility to accommodate specialized vehicle requirements. This comparative analysis highlights how fleet managers can balance the need for operational efficiency with the need for adaptability, in order to optimize the performance and cost-effectiveness of their vehicle fleets.

2.5. Fleet management challenges

Organizations that depend on vehicle-based operations need to have effective fleet management, but it is not without its difficulties. Fleet managers frequently encounter a variety of challenging situations that call for cautious maneuvering as they attempt to maximize the efficiency, economy, and sustainability of their fleets of vehicles. Finding a balance between fleet customization and standardization is one of the main issues. Fleet standardization can have advantages like easier maintenance, increased driver familiarity, and economies of scale, as the article on vehicle characteristics discussed. Nonetheless, a lot of businesses also have unique car needs that call for a certain amount of personalization or fleet variety (Chiparo et al., 2022, Mark et al., 2021, Yan et al., 2024, Narcizo et al., 2020).

Fleet managers need to strike the right balance between meeting specific operational needs and capturing efficiencies. Keeping an eye on fleet age and replacement schedule is another big challenge. Even though wholesale fleet replacement can be costly, older cars usually have higher maintenance costs and worse fuel economy. To avoid either an early or late vehicle turnover, fleet managers must carefully examine vehicle condition, usage patterns, and total cost of ownership in order to determine the best replacement schedule. Concerns over sustainability and the environment are also becoming more pressing for fleet managers (Saprykin et al., 2022, Loennechen et al., 2024, Skara et al., 2023).

Fleet managers are under increasing pressure to find ways to lower the carbon footprint of their vehicles due to societal pressure and regulatory requirements regarding emissions and energy efficiency (Besiou et al., 2012 and Chiparo et al., 2022). This could entail investigating possibilities like vehicle-to-grid integration, deploying telematics and driver behavior monitoring, or switching to alternative fuel technologies. Analytics and data management present yet another important difficulty. Large volumes of data are produced by fleet operations, including GPS tracking, fuel usage, and maintenance logs. Many organizations find it difficult to build and maintain sophisticated data systems and analytical capabilities needed to use this data to drive meaningful insights and informed decision-making. The landscape of fleet management is further complicated by the effects of new trends and technologies like electrification, mobility-as-a-service, and autonomous vehicles. It is imperative for fleet managers to remain up to date with the latest innovations and assess their potential for augmenting fleet performance and competitiveness (Goulias and Shi, 2023, Saprykin et al., 2022 and Loennechen et al., 2024).

Hence, Effective fleet management is critical for vehicle-dependent organizations, but fraught with challenges. Fleet managers must navigate a variety of complex situations to maximize efficiency, economy, and sustainability. Balancing fleet standardization and customization is a key issue - standardization offers advantages like easier maintenance and economies of scale, but many businesses have unique operational needs requiring fleet variety. Fleet managers must strike the right balance to meet specific requirements while capturing efficiencies. Monitoring and optimizing fleet age and replacement cycles is another major challenge, with wholesale replacement costly but older vehicles less efficient. Sustainability concerns are increasing pressure on fleet managers to reduce carbon footprints through technologies like alternative fuels and telematics. Data analytics and management present significant difficulties, with large volumes of fleet data requiring sophisticated systems to extract meaningful insights. The landscape is further complicated by emerging trends like electrification and autonomy, requiring fleet managers to stay agile and adaptable to new innovations that could impact fleet performance and competitiveness.

2.5.1. Strategic challenges

Network design for humanitarian fleet management must balance the dual goals of development and emergency alleviation. At the regional level, this involves maintaining stockpiles of emergency vehicles. At the national level, it requires establishing a reserve of vehicles for high-probability crises like natural disasters. The network must be designed to optimize both cost and service level, while accounting for two main types of uncertainty - the unpredictable timing and scale of emergencies, as well as the evolving needs of development programs. OR models could help reduce operational costs for development projects and speed up response times for relief efforts, by incorporating these dual objectives. These models should include mechanisms to efficiently transfer spare vehicle capacity from development use to emergency relief when needed. However, funding constraints impact humanitarian fleet composition, as institutional donors often donate vehicles rather than cash, frequently purchasing from domestic automakers. This can lead to higher costs, longer downtime, and lower service quality. The use of allocated vehicles improves transparency and accountability for donors by keeping them informed on how their funds are being utilized. However, this designated vehicle use can also hamper coordination between different aid organizations, reducing program effectiveness and accountability overall. Balancing these competing considerations is critical for optimizing humanitarian fleet networks (Stapleton et al., 2009, Pedraza-Martinez et al., 2011, Besiou et al., 2012, Bolanos et al. 2022, Castillo et al. 2023, Wolf et al. 2023).

Hence, fleet networks must balance development and emergency preparedness goals, optimizing cost and service levels while accounting for uncertainty. OR models can help, but funding constraints and donor practices around vehicle donations can lead to higher costs and coordination challenges. Balancing these competing factors is critical for effective humanitarian fleet management.

2.5.2. Tactical challenges

Demand estimation is a crucial task in meeting development and relief transportation demands. It is difficult to satisfy two distinct forms of stochastic demand, and fleet size is influenced by demand estimation (Jin et al., 2021 and Fan et al., 2023). The ideal emergency vehicle stock for disaster response aids in relief efforts, but the size of the nation is a variable. The use of earmarked vehicles from earmarked funds impacts fleet growth and discourages resource sharing. For example, a sizable IHO in northern Mozambique has two development initiatives that coincide in geographic coverage but are funded by different contributors, leading to duplication in the number of cars (Ratnaji and Venkateswaran, 2020 and Atay et al. 2022). Equity-oriented initiatives may have incentives to mislead demand when reporting to the logistics function, as they are not entirely responsible for the fleet's operational costs. The logistics function bears complete accountability for the fleet's expense, aiming to balance equality and efficiency by targeting a service level. This results in a smaller footprint size that reduces system costs than the program's costs. The performance of various flower configurations, such as devoted flowers, pooled flowers, and mixed flowers (partially pooled), can be compared using OR models, demonstrating the potential for improved performance (Pedraza-Martinez et al., 2011 and Besiou et al., 2012).

Hence, demand estimation is crucial but challenging, as fleets must satisfy stochastic development and emergency relief demands. Optimal emergency stockpile size depends on national scale. Earmarked vehicle funding can lead to duplication and hinder resource sharing. Equity-focused programs may understate demand to reduce fleet costs. Logistics managers balance equality and efficiency by targeting service levels, resulting in smaller fleet sizes than programs desire. OR models can compare different fleet configurations like dedicated, pooled, and mixed fleets to improve performance.

2.5.3. Operational challenges

Vehicle dispatching is crucial in humanitarian operations, especially during crises. IHO often assigns its most reliable vehicles to difficult missions, such as determining damages and organizing relief activities (Brunheroto et al. 2022). This presents a challenge for humanitarian fleet managers to balance fleet usage to reduce overuse of newer cars and underuse of older vehicles. Decentralization and competing goals in humanitarian logistics often impact vehicle replacement policies, with strategic decisions made at the head office and tactical decisions dispersed throughout the field (Skara et al., 2023 and Chiparo et al., 2022). Demanding funds, which are allotted to specific purposes, can lead to logistical difficulties. Donors can select the program they wish to support and receive information on the impact of their contributions. However, this also leads to logistical difficulties. Additionally, many stakeholders within IHO's logistics network may own disparate and incompatible goals, such as the program function being driven by equity and the logistics function being driven by efficiency (Goulias and Shi, 2023). Conflicting objectives can lead to incentive misalignment in decentralized networks, which may discourage the use of OR models based on central planning solutions (Saprykin et al., 2022 and Loennechen et al., 2024). The workforce management issues brought on by decentralization of humanitarian logistics include strategic difficulties, network design, and incentive coordination. The complexity of coordinating a multi-level, multi-objective logistics network may require the creation of new methodological instruments to investigate and obtain ideas for potential fixes (Mark et al., 2021 and Yan et al., 2024).

Hence, Vehicle dispatching is critical, as assign reliable vehicles to demanding missions, creating challenges to balance fleet utilization. Decentralized humanitarian logistics with competing goals impact vehicle replacement policies, with strategic decisions centralized but tactical ones dispersed. Earmarked funding leads to logistical difficulties, as donors can select programs but this also causes misaligned objectives. Conflicting goals between equity-driven programs and efficiency-focused logistics can discourage use of centralized OR models. Workforce management issues from decentralization, like strategic challenges and incentive coordination, require new methodological approaches to this complex multi-level, multi-objective logistics network.

2.6. Methods Used In Fleet Management

Linear mathematical programming (LP), a technique that includes integer, mixed integer, and binary variables, has been used for fleet management since its inception (Balac et al., 2020). It has various applications in fleet management, including the fleet sizing problem (FSP), fleet composition problem (FCP), fleet replacement problem (FRP), vehicle assignment problem (VAP), vehicle routing problem (VRP), mixed FCP/VRP , and make-or-buy problem (MoB) (Figliozzi et al., 2011; Boudart and Figliozzi, 2012). These problems can be solved using robust optimization approaches, such as the Fuzzy Analytic Hierarchy Process method, the Fuzzy Analytic Hierarchy Process, the vehicle assignment problem, the vehicle routing problem, the mixed FCP/VRP, and the make-or-buy problem (Wolf et al. 2023, Atay et al. 2022). These techniques have been applied to various fleets, including pooled automated vehicles (AVs), autonomous electric vehicles (AEVs), and autonomous vehicles. The LP has proven effective in solving fleet management issues and promoting efficiency in the transportation sector (Zhang et al., 2020; Bojovic et al., 2010, Parthanadee et al., 2012; Li et al., 2015; Buyuktahtakin and Hartman, 2016; Stojanovic and others, 2011).

Objective mathematical programming and nonlinear programming have become significant applications in fleet management applications. The FSP and the RP are considered nonlinear problems and are subjected to nonlinear methods (Li et al., 2018, Feng and Figliozzi, 2013). For the mixed FCP/VRP, goal programming is used. On the other hand, Dynamic programming is one of the most crucial techniques in fleet management, with FRP being the main application. Other approaches with more specialized uses include queuing theory, simulation, network models, and heuristics (Ahani et al., 2016, Mathew et al., 2010). Heuristics have been widely applied to fleet management problems, with examples including savings algorithms, sweep algorithms, giant TSP-tour, construction algorithms, and multilevel composite algorithms (Chiparo et al., 2022, Mark et al., 2021, Yan et al., 2024). Metaheuristics have also been widely applied to fleet management problems, such as local search, simulation, deterministic annealing, threshold accepting, tabs search, and genetic algorithms (Hsu et al. 2011, Inegbediona and Aghedob, 2018, Petering, 2011, Fagnant and Kockelman, 2018, Redmer et al., 2012).

The fleet management field includes the Fuzzy, stochastic, random, and a combination of these approaches to solve fleet management issues. The Fuzzy optimal control approach (FSP) is the primary application of these approaches, and they are sometimes used in conjunction with other fleet management issues (Saprykin et al., 2022, Loennechen et al., 2024, Skara et al., 2023). The FRP becomes interesting when applied to stochastic and random approaches, such as the fuzzy logic model of the fleet investment problem combined with the FSP, the combined model of the life cycle cost, Monte Carlo simulation, and stochastic analysis considering both vehicle age and mileage (Milenkovic and Bojovic, 2013 and Milenkovic et al., 2015; Cap et al., 2018). The three primary strategic fleet management problems (FCP, FRP, and MoB) are interdependent and cannot be solved simultaneously. The FSP is resolved by considering vehicle availability and maintenance and repair expenses, while the ILP model combines route assignment and the FRP but cannot be used for unplanned transportation. The MoB issue is also omitted by the model (Ansaripoor and Oliveira, 2018). Two studies combine the FSP and the FRP, proposing a deterministic, integer programming model and portfolio theory to diversify the fleet mix to minimize total risk and obtain the best possible total cost of ownership. Both studies examine electric cars (EVs) and vehicles with diesel engines (DVs). The deployment of well-liked and contemporary solution methodologies, such as heuristics and met heuristics found in spreadsheets, is constrained when handling strategic fleet management problems (Zheng and Chen, 2018, Ahaniet al., 2016, Stojic et al., 2018, Riechi et al., 2017, Raposo et al., 2017). The adoption of spreadsheet-based issue modeling and solving techniques greatly decreases the effort needed by managers and analysts.

The Capacitated Vehicle Routing Problem (CVRP) is a well-known optimization problem in the field of logistics and transportation, where the goal is to determine the optimal routes and vehicle assignments to serve a set of customers with known demands while minimizing the total cost (Adam, 2020 and Florent et al., 2023). There are several aspects that are directly relevant to the CVRP like Fleet Composition Optimization, this is a key aspect of the CVRP, where the goal is to determine the optimal mix of vehicle types and the number of vehicles of each type to be used in the delivery network (Prananda et al., 2022). Total Cost of Ownership (TCO), the need for fleet managers to analyze the TCO for each vehicle option, which includes fixed costs (e.g., purchase, financing, maintenance) and variable costs (e.g., fuel, labor, environmental impact). This is a crucial consideration in the CVRP, as the objective function typically aims to minimize the total operational cost of the delivery network (Ibrahim et al., 2019). Regulatory Compliance, the challenges of adhering to evolving regulations and standards in the automotive industry, which can impact the fleet composition and operations. This aligns with the CVRP, where fleet managers must ensure that the selected vehicles and routes comply with various legal and environmental constraints (Adam, 2020). Technological Advancements, the opportunities and challenges presented by the rapid technological advancements in the automotive industry, such as the introduction of electric vehicles and autonomous features. These innovations can improve the efficiency and sustainability of the delivery network, which is a key consideration in the CVRP (Ningyi et al., 2024 and Prananda et al., 2022). By considering these factors, fleet managers can develop comprehensive strategies to optimize their vehicle fleets, which is directly applicable to the CVRP framework for a holistic approach that balances operational requirements, financial constraints, and environmental considerations

Hence, the use of linear mathematical programming (LP) techniques, including integer, mixed integer, and binary variables, in fleet management applications. The main fleet management problems addressed include Fleet Sizing Problem (FSP), Fleet Composition Problem (FCP), Fleet, Replacement Problem (FRP), Vehicle Assignment Problem (VAP), Capacitated Vehicle Routing Problem (CVRP), Mixed FCP/VRP, Make-or-Buy Problem (MoB). These problems can be solved using various optimization approaches such as Fuzzy Analytic Hierarchy Process, vehicle assignment/routing, and make-or-buy methods. The techniques have been applied to different fleet types including pooled automated vehicles, autonomous electric vehicles, and autonomous vehicles. Beyond LP, the text mentions the use of objective mathematical programming, nonlinear programming, goal programming, dynamic programming, queuing theory, simulation, network models, and heuristic/metaheuristic approaches for fleet management optimization. The text notes that the three primary strategic fleet management problems (FCP, FRP, MoB) are interdependent and cannot be easily solved simultaneously. It discusses some studies that have combined the FSP and FRP, but integration of the key strategic problems remains limited in the literature. Overall, the text highlights the variety of mathematical and optimization techniques that have been applied to different fleet management problems, while also noting the challenges in comprehensively addressing the interdependent strategic concerns.

2.7. Literature gaps

Various studies demonstrate that although the idea of taking into account fleet characteristics is well-established in airline fleet management, it has not received as much attention when it comes to fleet management scenarios involving vehicles (Narcizo et al., 2020 and Brunheroto et al., 2022). The researcher finds numerous significant gaps in the body of current literature, including neglecting to consider how fleet size and composition affect operational effectiveness and fleet efficiency. The way in which these fleet-level factors affect efficiency has not been adequately considered in many studies, particularly when it comes to manufacturing and service organizations. However, there hasn't been much study done on how car fleet management is done in production and maintenance settings. It appears that most of the literature currently in publication is more narrowly focused on specific fleet operations than it is comprehensive including in Ethiopia (Ambaye, 2019, Ayenew, 2016, Wesson and Nagy, 2014, Chiparo et al., 2022, Mark et al., 2021). Instead of taking a comprehensive approach to vehicle fleet management in these kinds of organizations, a large portion of the literature currently in publication appears to be focused on specific fleet operations. Additionally, rather than thorough studies of vehicle fleet management strategies and best practices, there is a predominant focus on factor identification and efficiency assessment for particular fleet operations (Backman et al., 2016, Yan et al., 2024, Ambaye, 2019). The literature review recommends that since vehicle fleet management is an essential but understudied aspect of asset management, future research should focus more on it. Significant gaps exist in our knowledge of the methods and strategies for efficient vehicle fleet management when taking into account the characteristics of the vehicles, despite the abundance of evidence in the transportation, industrial, and humanitarian aid sectors. According to the studies, there is room for further investigation into the ways that fleet size, composition, and organizational context affect vehicle fleets' operational performance and efficiency, particularly in manufacturing and service environments. Closing these gaps may result in a deeper comprehension of the strategic significance of vehicle fleet management.

2.8. Conceptual frameworks

The conceptual framework is a diagrammatical representation that shows the relationship between dependent variables and independent variables. In the study, the conceptual framework is an assessment of the fleet management practices of East Africa Bottling S.C. (EABSC).

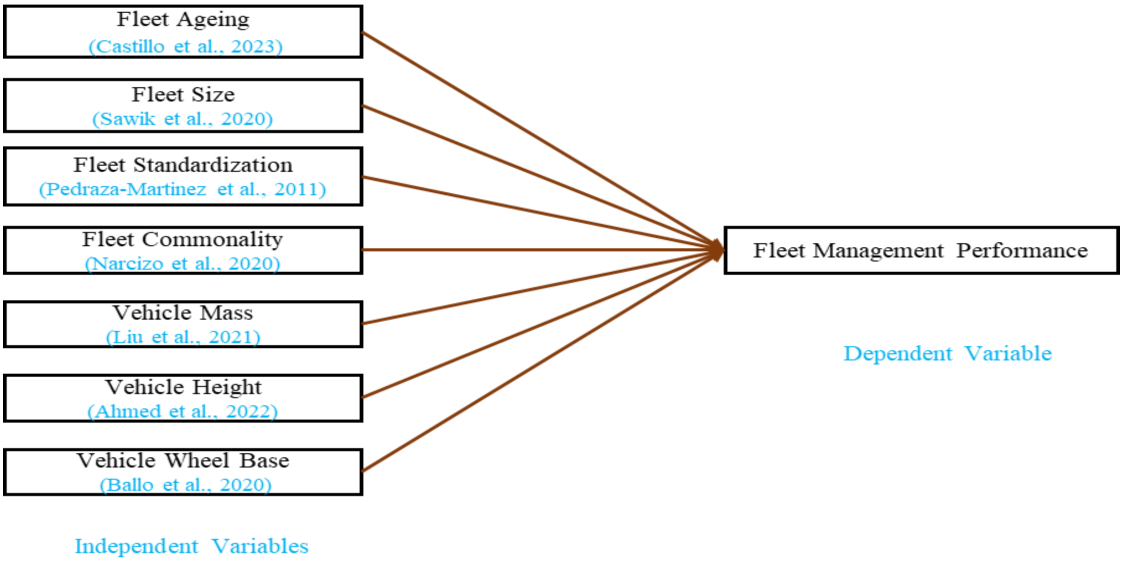


Figure 2-1 Conceptual Frame Work

Chapter Three

3. Research Methodology

3.1. Introduction

Rigorous research is essential for advancing scientific knowledge and informing practical applications across diverse fields. A well-designed research methodology is the foundation for ensuring the validity and reliability of research findings. It encompasses the philosophical assumptions, research design, data collection methods, and analytical techniques employed in a study. The choice of research methodology should be guided by the research objectives, the nature of the research problem, and the researcher's epistemological and ontological perspectives.

One fundamental aspect of research methodology is the distinction between quantitative and qualitative approaches. Quantitative research relies on numerical data and statistical analysis to examine relationships and test hypotheses, while qualitative research focuses on understanding complex phenomena through in-depth exploration of experiences, perceptions, and contextual factors. Another key consideration is the research design, which determines the overall strategy for addressing the research question and the level of control the researcher has over the variables of interest. Data collection methods are a crucial component, ranging from surveys and interviews to observations and laboratory experiments. The reliability and validity of these methods are essential for ensuring research quality. Data analysis techniques span a wide range of statistical and qualitative approaches, depending on the research objectives and the type of data collected. Throughout the research process, ethical considerations are paramount. Researchers must adhere to principles such as informed consent, confidentiality, and minimizing harm to participants.

Hence, a well-designed research methodology ensures the validity and reliability of findings, and rigorous research is crucial for the advancement of scientific knowledge. An overview of research methodology is given in this article, which covers data collection and analysis methods, research design, and philosophical presumptions. Approaches can be classified as either quantitative or qualitative, depending on whether they use numerical data or investigate complex phenomena.

3.2. Research Design

The proposed study aims to analyze and improve fleet management performance at East Africa Bottling S.C. (EABSC) using co-relational and regression analyses. By examining the relationships between various quantifiable variables, the study seeks to identify key factors that influence fleet efficiency without establishing direct cause-and-effect relationships.

A mixed-methods approach, incorporating both qualitative and quantitative research, is utilized. The process begins with identifying problems in current fleet management practices, followed by a literature review to gather existing knowledge. An analysis model is then developed to explore how different vehicle characteristics affect performance.

Data collection involves selecting appropriate tools to ensure that the optimization decisions are based on empirical evidence. The study focuses on determining the critical vehicle characteristics that drive efficiency and cost-effectiveness, enabling EABSC to make informed decisions about fleet optimization.

The process includes a feedback loop for continuous improvement, allowing EABSC to monitor performance, gather new data, and refine the analysis model over time. Ultimately, the study aims to provide actionable recommendations for enhancing fleet management, ensuring EABSC can adapt to changes and maintain a competitive advantage in the industry.

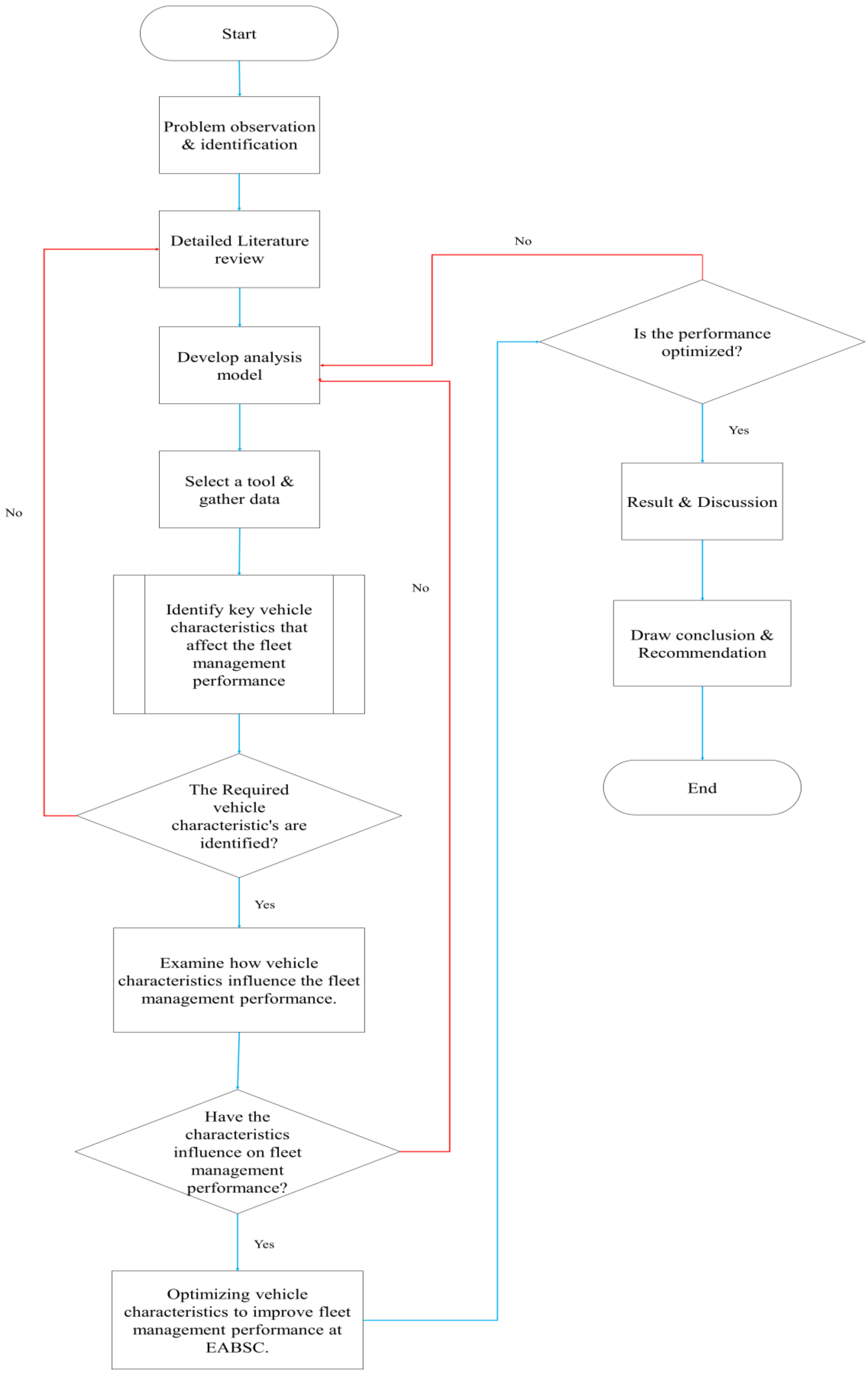


Figure 3-1 Research Flow Diagram

3.3. Instruments of data collection and Source of data

The study used both primary and secondary sources of information. A primary source of information was limited to structured questionnaires, and it was collected from the sample population of the study. The researcher selected the survey method as a data source because it was less expensive, permitted anonymity, and the results were more honest than other methods.

Secondary sources of information include research papers, published conference papers, speeches, web sites, research publications, books, reports, magazines, and so forth. A structured questionnaire was developed to gather opinions on vehicle characteristics and their impact on fleet management performance.

The research, focusing on East Africa Bottling S.C. (EABSC), used Likert scale questions and attitudinal questionnaires to gather primary data. The questionnaire was prepared in English and translated into Amharic, ensuring validity. It was then re-translated, pretested, and edited for accuracy. Data collection involved gathering numeric information, document reviews, and text information during interviews.

The purpose of the study was to determine how vehicle characteristics affected the performance of fleet management. To do the analysis data have collected. The data was rated on a five-point Likert scale by the study, with strongly agreed to strongly disagree representing the highest to lowest rating. The dependent variable's variance as explained by the sum of the independent variables was displayed by the coefficient of determination.

This study focuses on 205 company employees in fleet and distribution departments across the country. The questionnaire distribution and collection were carried out via email and physical communication. The sample size was determined using Hamed (2017) and Noordzij et al. (2010), with a 90% confidence level and a 5% confidence interval. The sample size was calculated to be 125.

$$n = \frac{N}{1 + (N * e^2)} = \frac{205}{1.6425} = 125$$

- Where, ‘n‘is the sample size,
- ‘N‘is the population size, and
- ‘e‘ is the confidence interval.

3.4. Method of data analysis

In this study, multiple regression analysis has used to determine the impact of each of the factors on the fleet management. This research was also carried out to determine which variables have had the greatest impact on fleet performance. To compile, input, and evaluate the measurements of multiple regressions, the researchers utilized the statistical program for social sciences (SPSS). The regression model equation has expressed as follows:

$$\boldsymbol{Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + e}$$

Where:

Y = Fleet management performance

α = Constant (coefficient of intercept)

X_1 = Fleet Ageing

X_2 = Fleet size

X_3 = Fleet standardization

X_4 = Fleet commonality

X_5 = Vehicle mass

X_6 = Vehicle height

X_7 = Vehicle wheel base

e = Error term

β1, β2, β3, β4, β5, β6, β7 = Regression coefficients for variables

The optimization model for fleet performance optimization is based on the Capacitated Vehicle Routing Problem (CVRP), a well-established framework in the field of logistics which solved by python. The mathematical formulation of the model is as follows:

Decision Variables:

Xi: Number of vehicles of type i in the fleet

Yjk: Binary decision variable, 1 if vehicle j is assigned to route k, 0 otherwise

Qjk: Delivery quantity assigned to vehicle j on route k

Objective Function:

Minimize the Total Operating Cost:

$$\sum(Ci * Xi) + \sum(Cjk * Yjk) + \sum(Mi * Xi) + \sum(Rj * Yjk) + \sum(Fi * Xi) + \sum(Hj * Yjk) + \sum(Ej * Yjk)$$

Where:

Ci: Fixed cost per vehicle of type i (e.g., acquisition, insurance, registration)

Cjk: Variable cost per vehicle j on route k (e.g., fuel, labor, maintenance)

Mi: Maintenance cost per vehicle of type i

Rj: Replacement cost per vehicle j

Fi: Financing cost per vehicle of type i (e.g., interest, lease payments)

Hj: Handling cost per vehicle j on route k (e.g., loading, unloading)

Ej: Environmental cost per vehicle j on route k (e.g., emissions, carbon taxes)

Based on the optimization result and considering the details of the characteristics impact strategic, tactical and operational recommendation developed of future better operational improvements.

3.5. Validity and reliability

According to Amirrudin, 2021, validity is the degree to which a measurement scale measures what it purports to measure. In this study, face, content, and constructs validity were used to assess the validity of questionnaires. Content validity was checked using literature reviews and expert opinions, while construct validity was evaluated using principal component factor analysis. Cronbach's alpha statistics were used to quantify the reliability of the research, with a Cronbach's alpha of more than 0.70 being considered trustworthy (Yusuf, 2023). The construct validity of each category was assessed using factor analysis, with items above 0.7 demonstrating high significance. Reliability refers to the consistency of scores that the same person would obtain if they took the same test at different times or under different conditions (Doval et al., 2023 and Yudhistir, 2022). A Cronbach's alpha of less than 0.7 indicates unreliability of variables and cannot be used to deduce findings. A Cronbach's alpha of 0.7 for all constructs was considered adequate for this study, as the test was based on ability (Yusuf, 2023). The Cronbach's alpha test was employed to ensure the instrument's reliability and measure the internal consistency of independent and dependent variables. The Pearson's product moment correlation was applied to test the questionnaire's reliability, with all items having values above 0.05, indicating good reliability. In conclusion, validity is crucial in ensuring the reliability of questionnaires and their ability to accurately measure the relationship between variables (Yusuf, 2023 and Yudhistir, 2022).

Table 3-1 Cronbach's Apha Result

	Variables	N	Items	Cronbach's Alpha
1	Fleet Ageing on Fleet Performance	125	6	0.743
2	Vehicle Mass on Fleet Performance	125	6	0.781
3	Fleet Size on Fleet Performance	125	7	0.817
4	Fleet Standardization on Fleet Performance	125	7	0.784
5	Vehicle Height on Fleet Performance	125	6	0.773
6	Fleet Commonality on Fleet Performance	125	7	0.766
7	Vehicle wheel base on Fleet Performance	125	6	0.769
8	Fleet performance	125	5	0.732

3.6. Ethical consideration

The study took into consideration issues of confidentiality and anonymity, informed consent, and the privacy of the respondents. A respondent has the right to have his or her identity remain anonymous. In this study, the indication of the business name was optional. Further, confidentiality and anonymity were achieved by asking participants not to write their names on the questionnaires. Participants in this study were identified by serial numbers rather than by name. Anonymity was also guaranteed through grouping data rather than presenting individual responses.

Informed consent is an ethical requirement that demands that respondents be allowed to choose to participate or not in the research after receiving full information about the possible risks or benefits of participating. In this study, the selected participants were informed about the purpose of the study. The participants were given the freedom to choose to participate or not participate in the study. The study assured privacy by securing data on the computer with a password to ensure that people could not access the data without authorization.

3.7. Research Dissemination Techniques

The researcher plan to disseminate the findings of the study through two primary channels. First, preparing a detailed report summarizing the key results, implications, and recommendations, and present it to the senior management team and relevant stakeholders at the case company. This will involve facilitating a discussion session to gather feedback, answer questions, and explore opportunities for further collaboration, with the aim of encouraging the case company to use the research findings to inform their strategic decision-making and operational practices. Second, developing a conference paper that provides a comprehensive overview of the research project, including the literature review, methodology, findings, and theoretical and practical contributions. The paper will be submitted for peer review and potential inclusion in the proceedings of a relevant academic conference or symposium. If accepted, the researcher will present the paper, allowing them to engage with a broader academic audience, receive feedback, and network with other scholars in the field. By utilizing these two complementary dissemination channels, the researcher aims to maximize the reach and influence of their study.

Chapter Four

4. Research Findings and Discussions

The main objective of this study was to assess the influence of vehicle characteristics that affect fleet management performance, the challenges to managing vehicle characteristics, the remedial ways to reduce the impact of the vehicle characteristics in the case company. This chapter presents the results and findings of the study as per the data collected from the sample population.

4.1. Demographic profile of the respondent

The aim of this section is to show the respondents qualification and experience in relation with the research concept and idea. The study sought data from 125 respondents from the case company, and the researcher was successful in collecting all questionnaires. The first section of the questionnaire consists of questions about the respondents demographics described as educational qualification, year of service in the company and leadership position in the company.

In terms of educational qualification, the vast majority of respondents were diploma holders which are 73 in count and covers around 58% of the total population. Also, 37 candidates have BSc which covers 30% from the total population. On the other hand, 13 and 2 candidates are certificate an MSc holders which covers 10% and 2% from the population respectively.

According to year of service distribution 49 respondents which covers 39% of the total population have been working less than 5 years. 54 respondents which covers 43% of the total population have been working 6 - 10 years in the company. On the other hand, 5 and 17 candidates have been working 11 – 15 and >15 years in the company which covers 4% and 14% from the population respectively.

On the subject of leadership position 12 respondents which covers 10% of the total population have been working middle management position. 8 respondents which covers 6% of the total population have been working in lower management position in the company. On the other hand, 105 candidates have been working in expert position in the company which covers 84% from the population respectively.

4.2. Descriptive Analysis

The first goal of this study have been to investigate how vehicle characteristics are influences the company's fleet management operations. As such, respondents were expected to express their opinions on how the vehicle characteristics influence the company and on the dependent variable side of their fleet performance (safety, efficiency and compliance) are expressed. To determine the vehicle characteristics influence on fleet management performance, the researcher used a Likert scale of 1-5, with 1 indicating strongly disagree, 2 indicating disagree, 3 indicating moderately agree, 4 indicating agree, and 5 indicating strongly agree. On the independent variable side, respondents were asked to indicate how much they agreed with various statements about the respective vehicle character namely fleet ageing, vehicle mass, fleet size, fleet standardization, vehicle height, fleet commonality, vehicle wheel base. On dependent variable side, fleet performance (safety, efficiency, compliance) of fleet management performances are stated. The results are presented and explained below.

Respondents responded to the seven different questions posed by to check the influence of fleet ageing on performance of different operations. The mean and standard deviation scores for the all question. As per the result the fleet ageing have low influence on vehicle tracking with 2.27 mean and 0.84 standard deviation value. Based on the remaining questions, fleet ageing have a significant influence on most fleet management performances.

Table 4-1: Fleet Ageing on Fleet Management

N=125	Mean	SD	Min.	Max.	Sum
The company’s vehicle availability have not been impacted by fleet ageing.	2.52	1.06710	1	5	315
The company’s vehicle maintenance cost have not raised due to aged vehicles.	2.49	1.02881	1	5	312
All aged vehicles maintenance catalogues are available in the workshop.	2.63	1.04369	1	5	329
The company can access aged vehicles spare parts are available in stock & in the market.	2.51	1.12606	1	5	314
The company can get quality spare parts for aged vehicles.	2.35	1.01803	1	5	294
Spare part tide up costs have not been affected by vehicle ageing.	2.29	0.83101	1	5	286
Vehicle tracking may affected by fleet ageing.	2.27	0.83643	1	5	284

Source: SPSS survey result

Respondents responded to the six different questions posed by to check the influence of vehicle mass on performance of different operations. The mean and standard deviation scores for the all question. As per the result the vehicle mass have low influence on spare availability and maintenance cost with 2.22 and 2.44 mean and 0.967 and 0.855 standard deviation value respectively. Also, vehicle mass have a significant impact on fuel management of the company.

Table 4-2: Vehicle Mass on Fleet Management

N=125	Mean	SD	Min.	Max.	Sum
The company vehicles have common mass range.	2.576	1.03382	1	5	322
Vehicle mass has a significant effect on safety.	2.536	1.02031	1	5	317
Fuel consumption has no direct relation with vehicle mass.	2.456	1.08140	1	5	307
The company have been incur higher maintenance cost for the vehicles with higher mass.	2.224	0.95769	1	5	278
The spare availability for higher mass vehicles are very low.	2.440	0.85572	1	5	305
The company have been provide trainings for drivers and technicians for better vehicle handling.	2.416	0.87237	1	5	302

Source: SPSS survey result

Respondents responded to the seven different questions posed by to check the influence of fleet size on performance of different operations. The mean and standard deviation scores for the all question. As per the result the fleet size have influence on stock management, cost management, maintenance cost, man power and fuel management.

Table 4-3: Fleet size on Fleet Management

N=125	Mean	SD	Min.	Max.	Sum
Fleet size have impact stock material requirement of the company.	3.0040	1.05970	1	5	375
Company's spare part tide up cost may raise in relation with fleet size.	3.4800	1.03643	1	5	435
Scrapped items are available on shelf that have no uses in the future.	2.6240	1.03693	1	5	328
Repairs have been executed for all vehicles with minimum cost.	2.5040	1.11893	1	5	313
Required technicians are available to maintain vehicles	2.3440	1.00084	1	5	293
Fleet size have significant impact on the company's driver management.	2.3040	0.84457	1	5	288
There are no higher investments for fuel stock management	2.2720	0.83643	1	5	284

Source: SPSS survey result

Respondents responded to the seven different questions posed by to check the influence of fleet standardization on performance of different operations. The mean and standard deviation scores for the all question. It appears to present challenges in setting uniform fuel consumption benchmarks, managing different fuel types used across the fleet, impact maintenance costs, the availability of maintenance tools and catalogues and vehicle downtime.

Table 4-4: Fleet standardization on Fleet Management

N=125	Mean	SD	Min.	Max.	Sum
The company's vehicles are using different kind of fuels.	3.500	1.12108	1	5	438
There is a challenge to set uniform fuel consumption bench mark.	3.4240	1.08705	1	5	428
Fleet standardization cannot reduce fuel management cost.	2.4480	1.03531	1	5	306
The company have been executed different maintenances for all vehicles with fair cost.	2.3120	1.01135	1	5	289
Required special tools for every models maintenance are available in the company's workshop.	2.3040	0.98557	1	5	288
All models maintenance catalogues are available.	2.3200	1.03643	1	5	290
Down time level may get vary from vehicle model to another model.	2.3200	0.98045	1	5	290

Source: SPSS survey result

Respondents responded to the six different questions posed by to check the influence of vehicle height on performance of different operations. The mean and standard deviation scores for the all question. As per the result the vehicle height have low influence on over fleet management operations and performances.

Table 4-5: Vehicle Height on Fleet Management

N=125	Mean	SD	Min.	Max.	Sum
The company vehicles have similarity on vehicle height.	2.4480	1.09586	1	5	306
Vehicle height have an impact on the safety concerns.	2.4800	1.23524	1	5	310
Fuel efficiency may affect by vehicle height.	2.7040	1.19153	1	5	338
Vehicle height have an impact on delivery and operational performance.	2.4240	1.02598	1	5	303
Vehicle height can reduce drivers & technicians performance.	2.3920	0.94097	1	5	299
The spare availability of higher vehicles are very low.	2.2160	1.02063	1	5	277

Source: SPSS survey result

Respondents responded to the seven different questions posed by to check the influence of fleet commonality on performance of different operations. The mean and standard deviation scores for the all question. As per the result the fleet commonality have influence on over fleet management operations and performances. Also, the company has no procedure to manage fleet commonality in the company fleet population.

Table 4-6: Fleet Commonality on Fleet Management

N=125	Mean	SD	Min.	Max.	Sum
Technicians have the ability to maintain every vehicle model in the organization.	2.3680	0.87562	1	5	296
The company have commonality for the interior part of a truck or any vehicle.	2.5760	0.97769	1	5	322
The company prefer two-wheel instead of four-wheels or vice versa.	2.5360	0.97999	1	5	317
Type of fuel used by a vehicles considered during the vehicle purchase process.	2.4240	1.06456	1	5	303

There is a clear consideration of the road condition, total product load and business activities for selection of suspension systems.	2.2560	1.03100	1	5	282
The company conduct vehicle model specification review every year.	2.4880	0.99690	1	5	311
The company follows some standards to evaluate the vehicle role and allocated area.	2.3920	0.91489	1	5	299

Source: SPSS survey result

Respondents responded to the six different questions posed by to check the influence of vehicle wheel base on performance of different operations. The mean and standard deviation scores for the all question. As per the result the vehicle wheel base have low influence on over fleet management operations and performances.

Table 4-7: Wheel base on Fleet Management

N=125	Mean	SD	Min.	Max.	Sum
The spare availability for vehicle wheel base parts are moderate.	3.0110	0.88478	1	5	377
Vehicle wheel base has a significant effect on safety.	2.6640	0.99955	1	5	333
Fuel consumption has direct relation with vehicle wheel base.	2.4880	0.98878	1	5	311
The company have been incur higher maintenance cost for different vehicles wheel base maintenance.	2.3840	1.09827	1	5	298
The company vehicles have similar on vehicle wheel base.	2.2640	1.00116	1	5	283
Vehicle wheel base complexity can reduce drivers and technicians performance.	2.5360	1.01238	1	5	317

Source: SPSS survey result

Hence, the study investigated the impact of vehicle characteristics on a company's fleet management operations. It examined how factors like vehicle aging, mass, size, standardization, and other characteristics influence fleet performance metrics such as safety, efficiency, and compliance. Fleet aging has a relatively low influence on vehicle tracking, but a more substantial influence on other metrics like vehicle availability, maintenance costs, and spare parts. Vehicle mass has a low influence on spare parts and maintenance, but a more significant impact on fuel consumption and safety. Fleet size has a significant influence on areas like stock requirements, spare parts costs, fuel management, and maintenance. Fleet standardization and fleet commonality have a considerable influence on fuel management, maintenance costs, and availability of maintenance resources. Other factors like vehicle height, wheelbase, and had relatively lower impacts on fleet operations. Overall, the data suggests the company performs well in safety and efficiency practices, but compliance appears to be a greater challenge area. Focusing on improving compliance processes and practices could lead to performance gains for the fleet. The variability in responses indicates the specific impacts may depend on the individual circumstances of each organization.

4.3. Correlation Analysis

A bivariate study of correlation examines the degree and direction of a link between two variables. The correlation coefficient goes from +1 to -1 in terms of the strength of the association. A value of 1 denotes that the two variables are completely interconnected. The association between the two variables decreases as the correlation coefficient values approach zero. The coefficient sign indicates the direction of the connection. The Pearson correlation coefficient is used to assess how closely the variables are connected. The Pearson correlation coefficient illustrates the relationship between the independent and dependent variables, as well as the direction of the relationship. A Pearson correlation coefficient value of 0.1 to 0.29 suggests a weak association, 0.30 to 0.59 shows a moderate relationship, 0.6 to 0.79 shows a moderately strong relationship and a value over 0.80 indicates a very strong relationship, with the positive and negative signs indicating the relationship's direction.

Table 4.8. Illustrates the relationship between predictor variables, fleet ageing, vehicle mass, fleet size, fleet standardization, vehicle height, fleet commonality, vehicle wheel base and the dependent variables fleet performance. Based on the analysis data, the dependent variable have moderately strong and positive relation with fleet standardization and fleet commonality with values of 0.63 and 0.60 respectively. Also, the dependent variable has a moderate and negative relation with fleet ageing with values of -0.56 and fleet size, has a moderate relationship with values of 0.53. On the other hand, vehicle mass has moderate and positive relationship with the dependent variables with the value of 0.425. Beside those variables, vehicle height and vehicle wheel base have weak relation with the dependent variables with the value of -0.143 and 0.114 respectively.

Table 4-8: Correlation between independent variables and dependent variable

N = 125		Fleet Ageing	Vehicle Mass	Fleet Size	Fleet Standardization	Vehicle Height	Fleet Commonality	Vechicle Wheel Base	Fleet Perfromance (Saftey, Efficency, Compliance)
Fleet Ageing	Pearson Correlation	1	0.054	0.259	-0.680	-0.037	-0.005	0.012	-0.56
	Sig. (2-tailed)		0.550	0.004	0.453	0.682	0.958	0.895	0.536
Vehicle Mass	Pearson Correlation	0.054	1	-0.026	-0.115	-0.011	-0.112	0.085	0.425
	Sig. (2-tailed)	0.550		0.777	0.202	0.904	0.215	0.345	0.000
Fleet Size	Pearson Correlation	0.259	-0.026	1	-0.007	-0.006	0.115	0.051	0.53
	Sig (2-tailed)	0.004	0.777		0.935	0.950	0.200	0.574	0.719
Fleet Standardization	Pearson Correlation	-0.068	-0.115	-0.007	1	0.120	-0.027	0.073	0.63
	Sig. (2-tailed)	0.453	0.202	0.935		0.182	0.764	0.417	0.487
Vehicle Height	Pearson Correlation	-0.037	-0.011	-0.01	0.120	1	0.098	-0.01	-0.143
	Sig. (2-tailed)	0.682	0.904	0.950	0.182		0.275	0.912	0.113
Fleet Commonality	Pearson Correlation	-0.005	-0.112	0.115	-0.027	0.098	1	-0.019	0.60
	Sig. (2-tailed)	0.958	0.215	0.200	0.764	0.275		0.831	0.506
Vechicle Wheel Base	Pearson Correlation	0.012	0.085	0.051	0.073	-0.01	-0.019	1	0.114
	Sig. (2-tailed)	0.895	0.345	0.574	0.417	0.912	0.831		0.206
Fleet Perfromance (Saftey, Efficency, Compliance)	Pearson Correlation	-0.056	0.425	0.033	0.63	-0.143	0.60	0.114	1
	Sig. (2-tailed)	0.536	0.000	0.719	0.487	0.113	0.506	0.206	

Source: SPSS survey result

4.4. Regression Analysis

The regression coefficient assesses the linear link between variables and demonstrates their tight relationship. The analysis of regression are a statistical approach used to find the linear connection between two or more variables. Regression is used mostly to predict and detect causal connections. Regression, therefore, shows how variation arises in one variable with variation in the other. In this analysis of regression, the extent to which the independent variable explains the dependent variable is determined. It is also used to understand how much each independent variable (fleet ageing, vehicle mass, fleet size, fleet standardization, vehicle height, fleet commonality, vehicle wheel base) explains that the dependent variables competitive advantage (safety, efficiency, and compliance). Some assumptions must be taken for the theory to be validated and generalized in multiple regression models. Consequently, before conducting a multiple regression analysis, the researchers twice examined necessary assumptions, such as normality, multicollinearity and autocorrelation.

4.4.1. Normality test

The independent variables in multiple regressions must be regularly distributed. This test demands that there be no significant deviation from normality to derive appropriate inferences from the regression findings. The statistical tools skewness and kurtosis are used to determine whether data is regularly distributed or not. The data skewness and kurtosis test results should be within the allowed range (-1.0 to +1.0), indicating that the data is normally distributed.

Table 4-9: Normality Test Result

	Skewness		Kurtosis	
	Statistic	Std. Error	Statistic	Std. Error
Fleet Ageing	0.546	0.217	0.355	0.430
Vehicle Mass	0.913	0.217	0.849	0.430
Fleet Size	0.538	0.217	0.429	0.430
Fleet Standardization	0.384	0.217	0.800	0.430
Vehicle Height	0.625	0.217	0.969	0.430
Fleet Commonality	0.638	0.217	0.116	0.430
Vehicle Wheel Base	0.662	0.217	0.532	0.430
Dependent Variables	0.005	0.217	-0.613	0.430

Source: SPSS survey result

Based on the above result all variables skewness and kurtosis result are within the range and the data has normally distributed.

4.4.2. Multicollinearity test

Before performing the regression, the researcher examined to see if there was a problem with multicollinearity. The term "multicollinearity" refers to when the independent and predictor variables are significantly connected. There is “overlap” or sharing of predictive power when independent variables are multicollinear. The tolerance and variance inflation factors (VIF), which are the two Co linearity diagnostics parameters, can be used to check for multicollinearity. Tolerance and VIF are frequently used to evaluate multi-collinearity between two or more independent variables. Furthermore, tolerance values less than 0.1 (10%) indicate multicollinearity, whereas VIF > 10 and VIF 1 indicate multicollinearity. The correlation coefficient table below shows that the study's tolerance and VIF are within normal limits (Shrestha, 2020). According to the below table results, there is no multicollinearity between the dependent variable.

Table 4-10: Multicollinearity Test

	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	27.111	4.924		5.506	0.000		
Fleet Ageing	-0.129	0.119	-0.091	-1.089	0.279	0.924	1.082
Vehicle Mass	0.740	0.134	0.453	5.534	0.000	0.962	1.040
Fleet Size	0.072	0.121	0.050	0.594	0.554	0.916	1.092
Fleet Standardization	0.190	0.122	0.128	1.559	0.122	0.960	1.042
Vehicle Height	-0.280	0.136	-0.168	-2.064	0.041	0.974	1.027
Fleet Commonality	0.181	0.118	0.126	1.536	0.127	0.962	1.040
Vehicle Wheel Base	0.104	0.129	0.065	0.807	0.421	0.982	1.018

Source: SPSS survey result

4.4.3. Autocorrelation test

The Durbin-Watson test is used to develop a linear autocorrelation regression model. Durbin-d is evaluated to test the zero-hypothesis that the residuals are not linearly self-related. Watson's while d may have values between 0 and 4 there is no autocorrelation with values around 2. As a rule of thumb, 1.5 d 2.5 values suggest that the data are not self-correlated. On the other hand, the test from Durbin-Watson evaluates just the linear self-correlation and the first-order effect only between immediate neighbors. The below tables show a Durbin-d value of 1.649 it implies the variable are not correlated or there is no autocorrelation.

Table 4-11: Autocorrelation Test

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.496[a]	0.246	0.201	5.89323	1.649

a. Predictors: (Constant), fleet ageing, vehicle mass, fleet size, fleet standardization, vehicle height, fleet commonality, vehicle wheel base

b. Dependent Variable: PERFROMANCE

Source: SPSS survey result

4.4.4. Regression Analysis and coefficients.

In a linear regression model, the multiple correlation coefficients (R) quantify the linear correlation between the observed and model-predicted values of the dependent variable, or between the predicted and actual values of the dependent variable. Its high value demonstrates the strength of the relationship. On the Table below indicates that the model had an Adjusted R square value of 0.201. This means that the percentage of the dependent variable variance that was explained by the seven independent variables was 20.1% while the remaining percentage (79.9%) can be attributed to other factors other than fleet ageing, vehicle mass, fleet size, fleet standardization, vehicle height, fleet commonality, vehicle wheel base.

Table 4-12: Multiple Regression: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.496[a]	0.246	0.201	5.89323	1.649

a. Predictors: (Constant), fleet ageing, vehicle mass, fleet size, fleet standardization, vehicle height, fleet commonality, vehicle wheel base
b. Dependent Variable: PERFROMANCE

Source: SPSS survey result

The ANOVA tells us whether the model, overall, results in a significantly good degree of prediction of the outcome variable. F-ratio is the test statistic used to decide whether the model as a whole has the statistically significant predictive capability, considering the number of variables needed to achieve it. Since the significant result on the ANOVA Table is 0.000 which is $p< 0.05$ and the regression mean square is greater than residual mean square with F value 5.462, the regression model fit to a good degree of prediction.

Table 4-13: ANOVA result

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	1327.771	7	189.682	5.462	.000[b]
	Residual	4063.429	117	34.730		
	Total	5391.200	124			

a. Dependent Variable: PERFROMANCE

b. Predictors: (Constant), fleet ageing, vehicle mass, fleet size, fleet standardization, vehicle height, fleet commonality, vehicle wheel base

Source: SPSS survey result

Following ANOVA testing of the model's fitness, the next step is to assess each independent variable's contribution to the prediction of the dependent variable. The component may be evaluated using standardized beta depending on its influence on the dependent variable. A factor with a high standardized beta carries a lot of weight.

Table 4-14: Regression Coefficients

	Unstandardized Coefficients		Stand. Coefficients			Collinearity Statistics	
	B	Std. Error	Beta	T	Sig.	Tolerance	VIF
(Constant)	27.111	4.924		5.506	0.000		
Fleet Ageing	-0.129	0.119	-0.091	-1.089	0.279	0.924	1.082
Vehicle Mass	0.740	0.134	0.453	5.534	0.000	0.962	1.040
Fleet Size	0.072	0.121	0.050	0.594	0.554	0.916	1.092
Fleet Standardization	0.190	0.122	0.128	1.559	0.122	0.960	1.042
Vehicle Height	-0.280	0.136	-0.168	-2.064	0.041	0.974	1.027
Fleet Commonality	0.181	0.118	0.126	1.536	0.127	0.962	1.040
Vehicle Wheel Base	0.104	0.129	0.065	0.807	0.421	0.982	1.018

Source: SPSS survey result

The β values represent the relationship between fleet performance and each predictor. A positive coefficient indicates a positive link between the predictor and the result, whereas a negative coefficient indicates a negative relationship. The above table reveals that five predictors have positive values, indicating a positive connection, and two predictor have a negative value, indicating a negative link with the dependent variable. The unstandardized β coefficient value reflects the degree of influence or effect of each independent variable on the fleet performance. The highest value indicates that the independent value has the most influence or effect on the dependent value. Therefor the multiple regression model becomes:

$$\boldsymbol{Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + e}$$

Where:

Y = Fleet management performance
α = Constant (coefficient of intercept)
X_1 = Fleet Ageing
X_2 = Fleet size
X_3 = Fleet standardization
X_4 = Fleet commonality
X_5 = Vehicle mass
X_6 = Vehicle height
X_7 = Vehicle wheel base
e = Error term
β1, β2, β3, β4, β5, β6, β7 = Regression coefficients for variables

$$\boldsymbol{Y = 27.111 - 0.129X_1 + 0.740X_2 + 0.072X_3 + 0.190X_4 - 0.280X_5 + 0.181X_6 + 0.104X_7}$$

In this model, the intercept of 27.111 signifies the expected performance level when all independent variables (X1 to X7) are equal to zero, serving as a foundational reference point for assessing the impact of the predictors. Among the predictors, fleet size (X2) emerges as the most significant positive factor, with an increase in performance of 0.740 units for each additional unit of fleet size. This suggests that larger fleets may benefit from operational efficiencies, potentially due to better resource utilization and increased capacity for handling demand.

Conversely, fleet ageing (X1) and vehicle mass (X5) have negative coefficients, indicating detrimental effects on performance. Specifically, for every unit increase in fleet ageing, performance decreases by 0.129 units, suggesting that older vehicles may face challenges such as higher maintenance costs and reduced reliability. Similarly, a unit increase in vehicle mass leads to a decrease of 0.280 units in performance, highlighting that heavier vehicles may incur greater fuel consumption and operational inefficiencies.

The model also identifies several other positive contributors: fleet commonality (X4) enhances performance by 0.190 units for each unit increase, indicating that having a uniform fleet can streamline operations and reduce training costs. Vehicle height (X6) contributes 0.181 units to performance, potentially due to advantages in cargo space or visibility, while wheel base (X7) adds 0.104 units, suggesting that stability and handling improve with a longer wheel base. The coefficient for fleet standardization (X3) is 0.072, indicating a positive relationship with fleet management performance. This means that for every one-unit increase in fleet standardization, fleet performance increases by 0.072 units. Which refers to the extent to which the vehicles in a fleet are similar in terms of make, model, and specifications. Higher standardization can lead to improved cost savings and efficiency in maintenance, training, and operations, as staff can become more adept at managing a uniform set of vehicles.

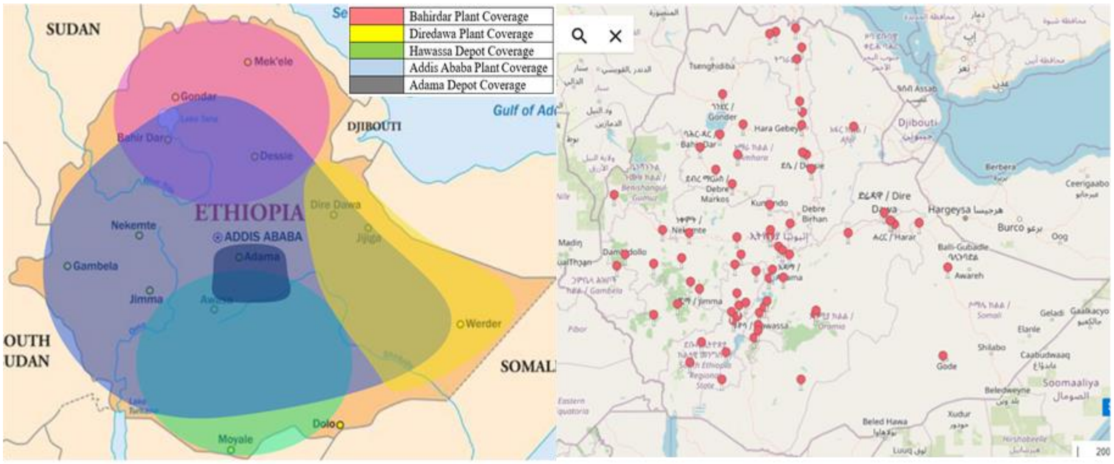
Overall, this regression model elucidates critical factors that fleet managers can target to optimize performance. By focusing on expanding fleet size, enhancing commonality, and considering vehicle specifications like height and wheel base, managers can develop strategic initiatives to improve efficiency. Conversely, attention must be given to mitigating the negative impacts of fleet ageing and vehicle mass, which can hinder operational effectiveness. This holistic understanding of the relationships among these variables empowers fleet managers to make informed decisions that drive performance improvements.

4.5. CVRP Optimization Model

The company's distribution strategy is designed to ensure thorough coverage across various regions, from four manufacturing plants and two depots to different distributors. In the central region, the Addis Ababa and Sebeta plants play a significant role in the company's production capabilities, collectively covering a radius of 500 kilometers. This extensive reach allows these plants to efficiently supply a large number of distributors in and around the capital city. The proximity of these facilities to major urban centers facilitates quick turnaround times for product availability, enhancing the overall efficiency of the supply chain. Additionally, the Adama depot covers a radius of 150 kilometers, further enhancing the company's ability to serve distributors in the surrounding areas. This depot plays a key role in ensuring that products are delivered efficiently to meet local demand.

Hawassa Depot serves as a vital hub for distribution in the southern region, covering an expansive radius of 200 kilometers. This depot is crucial for facilitating timely deliveries to numerous distributors within this area, ensuring that products reach their destinations promptly and reliably. The Bahirdar plant is strategically positioned to cover the entire northern region, extending its distribution capabilities within a 300 -kilometer radius. This plant is instrumental in meeting the needs of distributors in northern areas, ensuring they have access to the products required to serve their own customer bases effectively. In the eastern part of the country, the Diredawa plant provides robust support by covering a 350 -kilometer radius. This facility ensures that distributors in the eastern regions receive their products, contributing to the overall responsiveness of the company's distribution network.

Each year, the company distributes 80,000,000 products to 71 distributors, ensuring a seamless supply chain across its operations. This extensive distribution network is supported by 4 production plants and 2 storage depots, strategically located to optimize logistics and minimize delays. To facilitate this vast distribution, the company employs a fleet of 216 delivery trucks. These vehicles play a crucial role in transporting products from the plants to the depots and ultimately to the distributors, ensuring timely delivery and high levels of customer satisfaction. The total operational cost for this distribution process amounts to $164,752,078.30. This figure encompasses various expenses, including transportation, maintenance, labor, and overhead costs associated with running the production plants and depots.



Current Distribution Coverage   Current Distributors Coverage

Figure 4-1 Current Distribution Coverage

The optimization model for fleet performance optimization presented is not entirely unique, as it is based on the well-established Capacitated Vehicle Routing Problem (CVRP) framework. However, based on the above correlation and regression analysis there are four characteristics that have impact on the fleet performance then the comprehensive approach it takes by incorporating those key characteristics standardization, commonality, aging, and size as a factor makes it a more robust and valuable tool for fleet management. While the CVRP is a widely used model in logistics and transportation, the specific way this model integrates the additional considerations sets it apart from the standard CVRP formulations. Here are the key elements that make this model unique:

Inclusion of Standardization: The model explicitly includes a constraint on the maximum number of vehicle types in the fleet ($X_i \leq X\_max$). This allows organizations to achieve a standardized fleet, which can lead to improved maintenance, training, and operational efficiency.

Incorporation of Commonality: The commonality constraint ($\sum (Qi * Xi) \geq Q\_min$) ensures that the total capacity of the fleet meets a minimum requirement. This helps organizations maintain a common and balanced fleet composition, rather than relying on a diverse mix of vehicles.

Consideration of Aging: The model takes into account the aging of the vehicles by incorporating a replacement cost function ($Rj = f(Aj)$). This allows for better planning and budgeting for fleet renewal, ensuring the fleet remains reliable and up-to-date.

Optimization of Fleet Size: The model optimizes the overall fleet size ($\sum Xi = N$) to find the most cost-effective number of vehicles, considering factors such as fixed costs, variable costs, and capacity requirements.

While the individual components of the model, such as the CVRP, standardization, and aging considerations, have been explored in the literature, the comprehensive integration of these elements into a single optimization model is what makes this approach unique. The ability to simultaneously optimize the fleet's composition, operations, and environmental impact sets this model apart from the more traditional CVRP formulations. This holistic approach enables fleet managers to make more informed and data-driven decisions, leading to significant cost savings, operational efficiency, and sustainability benefits, ultimately enhancing the organization's overall competitiveness in the market.

Decision Variables:

Xi: Number of vehicles of type i in the fleet
Yjk: Binary decision variable, 1 if vehicle j is assigned to route k, 0 otherwise
Qjk: Delivery quantity assigned to vehicle j on route k

Objective Function:

Minimize the Total Operating Cost:

$$Minimize: \sum(Ci * Xi) + \sum(Cjk * Yjk) + \sum(Mi * Xi) + \sum(Rj * Yjk) + \sum(Fi * Xi) + \sum(Hj * Yjk) + \sum(Ej * Yjk)$$

Where:

Ci: Fixed cost per vehicle of type i (e.g., acquisition, insurance, registration)
Cjk: Variable cost per vehicle j on route k (e.g., fuel, labor, maintenance)
Mi: Maintenance cost per vehicle of type i
Rj: Replacement cost per vehicle j
Fi: Financing cost per vehicle of type i (e.g., interest, lease payments)
Hj: Handling cost per vehicle j on route k (e.g., loading, unloading)
Ej: Environmental cost per vehicle j on route k (e.g., emissions, carbon taxes)

The defined Constraints are:

- Fleet size constraint: $\sum Xi = N$ (Total number of vehicles in the fleet)
- Delivery demand constraint: $\sum Qjk \geq D$ (Total delivery demand)
- Vehicle capacity constraint: $\sum Qjk \leq Qj * Yjk$ (Vehicle capacity constraint)
- Vehicle assignment constraint: $\sum Yjk = 1$ (Each vehicle is assigned to at most one route)
- Standardization constraint: $Xi \leq X\_max$ (Maximum number of vehicle types)
- Commonality constraint: $\sum (Qi * Xi) \geq Q\_min$ (Minimum total capacity requirement)
- Aging constraint: $Rj = f(Aj)$ (Replacement cost based on vehicle age)
- Non-negativity & integrality constraints: $Xi \geq 0$ and integer, $Yjk \in \{0, 1\}$, $Qjk \geq 0$

Hence, The Capacitated Vehicle Routing Problem (CVRP) optimization tool is a valuable tool for logistics firms to optimize fleet efficiency and streamline operations. It helps determine the most economical fleet composition by considering vehicle types, expenses, and capacity needs. Logistics firms of all sizes can use CVRP to create a fleet composition specific to their operational needs and budget constraints, ensuring long-term success in a competitive industry.

To isolate the impact of each characteristic, a series of simulations developed where all but one constraint were held at their current values. This allowed to systematically evaluate how each individual factor, such as fleet standardization or vehicle aging, influenced the total operating costs. After running these single-constraint scenarios, the full CVRP equation solved while considering all four constraints simultaneously to determine the overall optimal operating cost. This multi-faceted modeling approach provided deeper insights into how specific vehicle attributes can drive performance and cost in fleet management operations, which set this study's methodology apart from standard CVRP applications.

Optimize the equation

Considering all the simulated scenarios in one function to generate the most effective and optimal fleet management performance cost explained as follows. The primary objective of this fleet optimization exercise is to determine the most economical fleet composition that can effectively meet the delivery demand of 80,000,000 cases while adhering to a strict 150,000,000 total cost target to deliver products for 71 distributors.. To achieve this, Capacitated Vehicle Routing Problem (CVRP) optimization model, which is a powerful mathematical technique used to optimize the deployment and utilization of a fleet of vehicles.

Finding the most economical fleet composition to meet delivery demand 80,000,000 cases while remaining within the 150,000,000 total cost target was the aim of this CVRP optimization. By using Python to analyses the equation six different vehicle types were available for selection, with a maximum of four vehicle types permitted in the final fleet, a total fleet size limit of 216 vehicles, a minimum required capacity of 300, and vehicle-specific fixed, variable, maintenance, and financing costs. 30 FSR vehicles, 30 NPR vehicles, 30 Eurocargo vehicles, 30 Nissan vehicles, 25 Trackker vehicles, and zero Eurotrakker vehicles make up the final ideal fleet composition. This fleet composition, which reflects the necessity to balance capacity and cost requirements under the stringent 150,000,000 budget, differs significantly from the unconstrained solutions.

The smaller fleet size of 151 vehicles—compared to 216 vehicles in the unconstrained solutions—is one important finding. This suggests that making better use of the vehicles that are available is necessary to meet the cost target. Additionally, the optimization has changed, with a greater emphasis now being placed on the less expensive Nissan and Trackker vehicles and a decreased use of the more expensive FSR, NPR, and Eurocargo vehicle types. All vehicle types are still only used for a maximum of 20 trips per route in spite of these cost-cutting measures, guaranteeing the best possible use of the resources.

The ideal fleet composition comes with a total cost of 149,760,000, falling within the 150,000,000 goal. This shows how well the optimization worked to find a workable solution that satisfies the operational and capacity requirements while adhering to the strict cost constraint. The optimization process should take into account not only the cost-effective fleet composition but also the age and uniformity of the fleet's vehicles. Keeping a fleet that is uniform in age and highly standardized can have a number of advantages, including lower maintenance costs, increased dependability, and higher resale value. The ultimate fleet composition can be further improved to strike the best possible balance between long-term sustainability, cost, and efficiency by taking these factors into account. In comparison to the unconstrained solutions, the fleet composition produced by the cost-constrained CVRP optimization is more economical while still meeting the operational and capacity requirements. Through meticulous consideration of the trade-offs between age, standardization, fleet costs, and utilization, the algorithm has determined the ideal fleet mix to function within the 150,000,000 budget.

```python
import numpy as np
from scipy.optimize import linprog

# Define the problem parameters
num_vehicle_types = 6
total_fleet_size = 216
min_total_capacity = 300
max_vehicle_types = 4
max_trips_per_route = 20
delivery_demand_per_trip = 1

# Vehicle-specific parameters
fixed_costs = [10000, 12000, 15000, 8000, 7500, 20000]
variable_costs = [50, 60, 70, 40, 35, 80]
maintenance_costs = [2000, 2500, 3000, 1800, 1600, 4000]
financing_costs = [1000, 1200, 1500, 800, 750, 2000]
capacity = [20, 25, 30, 18, 15, 35]

# Objective function coefficients
c = np.array(fixed_costs + variable_costs * max_trips_per_route + maintenance_costs + financi
ng_costs)


# Constraint matrices
A_eq = np.concatenate((np.eye(num_vehicle_types), np.eye(num_vehicle_types) * max_trips_per_r
oute, np.eye(num_vehicle_types), np.eye(num_vehicle_types)), axis=1)
b_eq = np.array([total_fleet_size, min_total_capacity, max_vehicle_types, max_vehicle_types])
A_ub = np.array([capacity] * total_fleet_size).T
b_ub = np.array([delivery_demand_per_trip * max_trips_per_route * total_fleet_size])

# Solve the optimization problem
res = linprog(c, A_ub=A_ub, b_ub=b_ub, A_eq=A_eq, b_eq=b_eq, bounds=(0, None))

# Extract the optimal fleet composition
x_opt = res.x[:num_vehicle_types].astype(int)
trips_opt = res.x[num_vehicle_types:2*num_vehicle_types].astype(int)

# Print the results
print("Optimal fleet composition:")
for i in range(num_vehicle_types):
    print(f"{x_opt[i]} {['FSR', 'NPR', 'Eurocargo', 'Nissan', 'Trackker', 'Eurotrakker'][i]}
vehicles with {trips_opt[i]} trips per route")

print(f"Total cost: ${res.fun:.0f}")
```

Figure 4-2 Python optimization code

In general, the key findings from the CVRP optimization process provide valuable insights on smaller fleet size that optimized fleet composition has a smaller overall size compared to the unconstrained scenario. This suggests that the CVRP model has identified opportunities to achieve the required delivery capacity with a more efficient and streamlined fleet. Greater emphasis on less expensive vehicles indicates optimized solution places a greater emphasis on the utilization of the less expensive Nissan and Trackker vehicle types. These vehicles offer a more cost-effective way to meet the delivery demand, while still ensuring operational capabilities. Decreased use of more expensive vehicles conversely, the optimization has resulted in a decreased reliance on the more expensive FSR, NPR, and Euro-cargo vehicle types. This strategic allocation of resources allows the organization to stay within the 150,000,000 cost target while maintaining the necessary delivery capacity. The final fleet composition, as determined by the CVRP optimization, meets the operational and capacity requirements while adhering to the 150,000,000 cost constraint. This underscores the effectiveness of the optimization approach in identifying the most economical solution that aligns with the organization's strategic objectives.

One significant change the company should consider is a comprehensive rearrangement of its distribution strategy. This plan involves closing the Adama depot, which has demonstrated minimal area coverage relative to its operational costs. By consolidating operations and managing the surrounding areas from the Addis Ababa and Sebeta plants, the company can enhance efficiency. It is proposed that both plants cover a maximum radius of 350 kilometers, enabling them to deliver products to all depots, including the Bahirdar and Diredawa plants, for stock transfers. The Hawassa Depot should continue to serve the entire southern region within a 260-kilometer radius, while the Diredawa plant should extend its coverage to encompass the southern region within a 450-kilometer radius. The Bahirdar plant should also serve the southern region within a 360-kilometer radius. Additionally, establishing a new depot in Nekemt represents a strategic move to improve westward distribution, allowing coverage of the western regions within a 400-kilometer radius. To facilitate this transition, operational costs and resources should be transferred from the Adama depot, and employees should be relocated to the new location, minimizing startup costs. By executing this optimized distribution strategy, the company should gain substantial operational benefits and insights. Furthermore, increasing the number of distributors around the plants and depots should enhance delivery capabilities, allowing the company to reach end-users more effectively. This expansion in distributor relationships not only increases area coverage but also reduces overall operational costs, ultimately positioning the company for greater market competitiveness and efficiency.

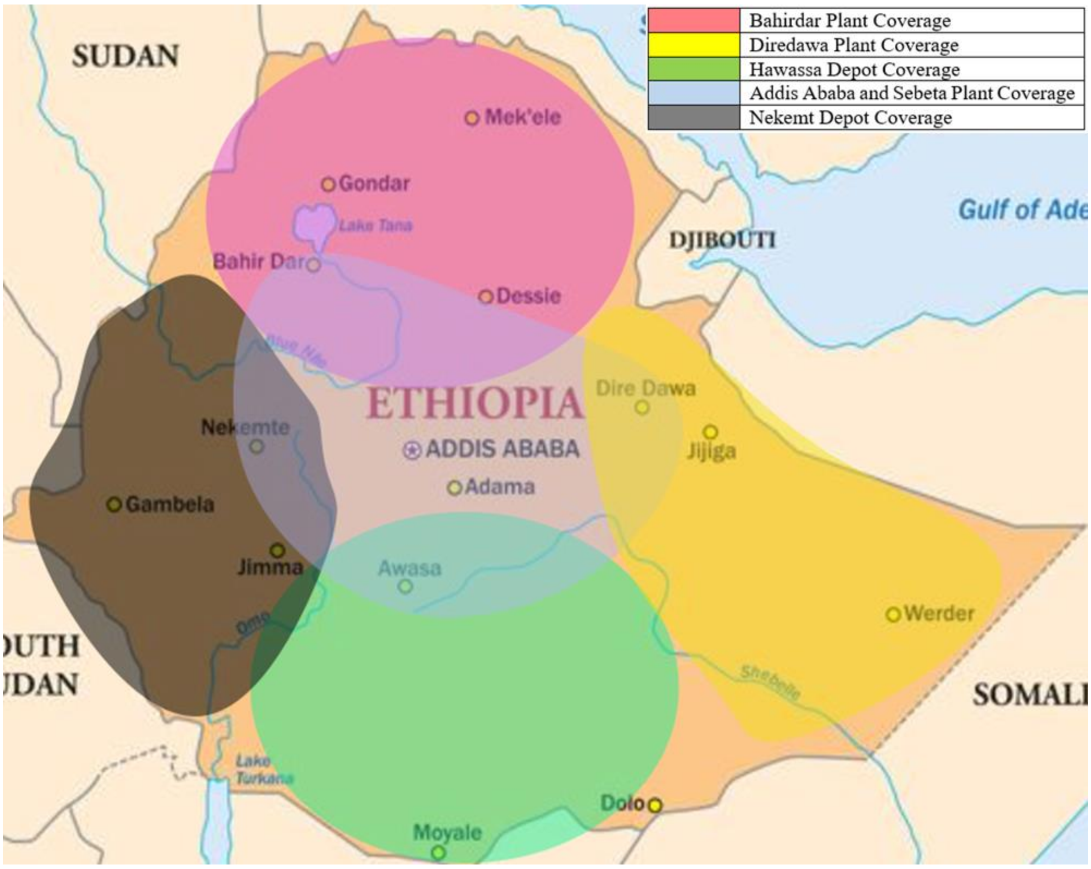


Figure 4-3 Proposed Distribution Coverage

Furthermore, the optimization process has highlighted the importance of considering factors beyond just cost-effectiveness, such as fleet age, fleet size, standardization, fleet composition and long-term sustainability. These additional factors can significantly influence the overall operational efficiency, cost management, and the organization's ability to maintain a robust and adaptable fleet management strategy. By carefully balancing these considerations, the organization can optimize its fleet operations and ensure long-term success.

4.6. Fleet Management - Way Forward

Below details provides best practice, strategic, tactical, and operational recommendations to help the organization leverage this optimization model to enhance their fleet's performance and efficiency.

A study highlights the role of Fleet Management Information Systems (FMIS) in enhancing operational efficiency. The integration of software solutions can streamline processes and improve data accuracy, leading to better decision-making (Santos, F.J. R.D., 2021). Regular maintenance schedules are critical for reducing breakdowns and extending vehicle lifespan. Research shows that proactive maintenance can decrease overall costs and improve fleet reliability (Zhang et al., 2020). Implementing comprehensive driver training programs has been shown to reduce accident rates significantly. A study found that fleets adopting targeted training saw a reduction in incidents by up to 30% (Mohsin et al., 2023). Fuel management strategies, including monitoring and optimizing fuel consumption, have been linked to significant cost reductions. Research indicates that telematics can enhance fuel efficiency by providing insights into driving behavior (Rojaset al., 2020). Utilizing GPS and route optimization tools can lead to decreased travel times and fuel costs. A study demonstrated that optimized routing reduced fuel expenses by up to 20% and improved delivery times (Oloko, 2024). Telematics systems provide real-time tracking and performance metrics, improving fleet safety and efficiency. Research shows that fleets using telematics experience lower accident rates and better vehicle utilization (Ghaffarpasand et al., 2022). Continuous analysis of fleet performance data allows for identifying trends and areas for improvement. Effective inventory management of vehicles aids in understanding asset utilization and planning for replacements. Studies show that maintaining accurate records can enhance decision-making regarding fleet expansion and retirement (Portal-Garcia et al., 2021). The adoption of electric or hybrid vehicles is becoming increasingly important for reducing environmental impact. Research indicates that sustainable practices not only improve corporate image but can also lead to long-term cost savings (Slowik et al., 2022). Open communication channels between drivers and management can significantly improve operational efficiency. Studies suggest that effective communication strategies lead to better problem-solving and coordination. Also, developing an emergency response plan is crucial for minimizing downtime during unforeseen events. Research highlights the importance of preparedness in enhancing fleet resilience and safety (Chiparo et al., 2022).

In addition of the above best practices the company should consider the below recommendation to get the best performance. Strategic recommendation, fleet optimization should be closely aligned with the organization's overall business objectives, including cost reduction, service level enhancements, and sustainability initiatives. Achieving this alignment necessitates strong cross-functional collaboration among key stakeholders such as leadership, operations, finance, and sustainability teams. By involving these diverse groups, organizations can ensure that fleet management strategies are effective and resonate with broader business priorities. Additionally, the optimization strategy should be an ongoing process that adapts to evolving business needs and market conditions, with regular reviews to maintain its relevance. A data-driven approach is essential, emphasizing comprehensive data collection, management, and advanced analytics to inform decision-making. Equipping fleet managers with the necessary tools and training enables more informed, evidence-based decisions that enhance fleet efficiency and performance.

For tactical recommendations, optimizing fleet composition is critical for enhancing operational efficiency and sustainability. This involves using optimization models that focus on standardization, commonality, and vehicle aging. Standardization minimizes the number of unique vehicle types, streamlining maintenance and improving driver familiarity. Commonality ensures that the fleet meets capacity requirements based on load and delivery schedules. Additionally, considering vehicle aging helps balance replacement costs with operational performance. Regular reviews of fleet composition are necessary to adapt to changing operational requirements and market conditions. The integration of mathematical frameworks, such as the Capacitated Vehicle Routing Problem (CVRP), enhances fleet optimization by considering vehicle capacity, travel distances, and time constraints when generating optimal routes. Continuous monitoring and adjustment of fleet composition, supported by robust performance tracking systems, foster a culture of improvement and ensure alignment with strategic objectives.

For operational recommendations, streamlining maintenance and training through vehicle standardization is crucial for effective fleet management. Utilizing the standardization constraint within the CVRP model allows organizations to maintain a fleet with a limited number of vehicle types, simplifying management and reducing downtime. Standardizing models enables technicians to develop expertise in common maintenance processes, leading to quicker issue resolution. Moreover, focused training programs enhance technicians' skills, resulting in cost savings and increased fleet availability. Aligning fleet composition with delivery demands and operational needs is essential, with the CVRP model aiding in the analysis of delivery patterns and customer requirements. Regular monitoring and adjustments ensure that vehicle types and capacities are matched to specific routes. Implementing robust data collection and analysis processes is fundamental for optimizing fleet performance, as comprehensive systems provide valuable insights into vehicle usage, maintenance history, and operational costs. By integrating advanced technology solutions, organizations can automate data collection, refine optimization models, and ultimately enhance fleet management practices and operational relevance.

In summary, enhancing fleet performance and efficiency requires a multifaceted approach that incorporates best practices and strategic, tactical, and operational recommendations. Key strategies include aligning fleet optimization with overall business objectives, fostering cross-functional collaboration, and adopting a data-driven decision-making process. Tactical recommendations emphasize the importance of optimizing fleet composition through standardization, commonality, and the use of mathematical frameworks like the Capacitated Vehicle Routing Problem (CVRP) to enhance routing efficiency. Operationally, streamlining maintenance and training through vehicle standardization, alongside robust data collection and analysis, is crucial for effective fleet management. By implementing these strategies, organizations can achieve significant improvements in operational efficiency, cost savings, safety, and sustainability, ultimately positioning themselves for long-term success in a competitive landscape.

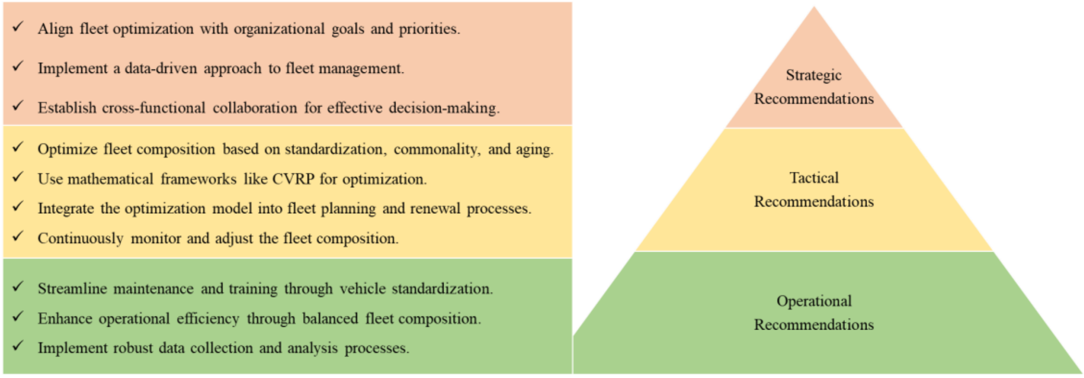


Figure 4-4 Ways for Enhancing Performance and Efficiency

4.7. Finding Comparison

This thesis investigates contemporary fleet management strategies for vehicles, emphasizing areas such as maintenance, fuel management, vehicle replacement, safety, driver management, and routing. Effective Vehicle Fleet Management (VFM) is essential for businesses to meet client demands and minimize fuel costs, ensuring that the right vehicles are purchased in appropriate quantities and at optimal times. A robust fleet management system enhances logistics efficiency, lowers operating costs, and improves service quality. The research contrasts with Florent et al. (2023), which focuses specifically on optimizing emergency logistics during flooding crises, while this thesis presents a more generalized fleet performance optimization model. It employs regression models to identify influencing factors in the manufacturing sector, differing from the two-phase solution approach of the first article, which utilizes a greedy heuristic and local search algorithm.

This thesis provides detailed insights into the Capacitated Vehicle Routing Problem (CVRP), discussing its mathematical formulation, solution techniques, and various constraints, such as delivery demand and vehicle capacity. It emphasizes the importance of factors like vehicle standardization, commonality, aging, and size in the optimization process. While Ibrahim et al. (2019) offers a broad overview of CVRP, this research highlights a specific application focused on fleet optimization, aiming to minimize total operating costs while addressing delivery requirements. Comparisons with related studies underscore the unique attributes of the proposed optimization model and its potential for enhancing operational efficiency and sustainability.

Further, the research reviews works like Ningyi et al. (2024), which explores a hybrid genetic algorithm-based approach, and Prananda et al. (2022), which applies CVRP to optimize natural gas distribution in Indonesia. These studies highlight specific applications of CVRP, while this thesis emphasizes a comprehensive model applicable across diverse logistics and transportation sectors. By incorporating additional real-world considerations and constraints, such as vehicle aging and commonality, the thesis aims to provide organizations with a powerful decision-support tool for improving their transportation and distribution operations. Additionally, the work of Fadhil et al. (2024) on optimizing rice distribution in Indonesia is examined, showcasing the adaptability of CVRP frameworks across various industries. Overall, this thesis contributes to the field by presenting a holistic optimization model that addresses the complexities of modern fleet management.

Hence, this research paper presents a comprehensive fleet performance optimization model that builds upon the Capacitated Vehicle Routing Problem (CVRP) framework, a critical issue in logistics and transportation focused on efficient routing and vehicle assignments under capacity constraints. The study enhances previous CVRP research by incorporating real-world factors such as vehicle standardization, commonality, aging, and size to optimize vehicle mix and utilization, reduce complexity, and address the operational impacts of aging vehicles. Unlike prior studies that targeted specific applications, this model offers a generalized approach suitable for various transportation and logistics industries. Detailed technical elements include an objective function aimed at minimizing total operating costs, constraints related to delivery demands and vehicle capacities, and considerations of cost factors like fuel and maintenance. By comparing this model with existing CVRP literature, the research highlights its unique features and potential benefits, such as improved operational efficiency, cost savings, and sustainability. Ultimately, this advanced CVRP-based optimization model serves as a valuable decision-support tool for organizations and logistics providers, enhancing their transportation and distribution operations.

Chapter Five

5. Conclusion, Recommendations and Future Research

5.1. Conclusion

The study followed a positivist research philosophy using a causal, mixed-methods research design. It collected primary and secondary data, employed multiple regression analysis using SPSS software, and aimed to quantify the relationships between vehicle characteristics and fleet management performance in case company of EABSC. Identify that vehicle characteristics have an impact on fleet performance and optimizing a company's vehicle fleet is important for operational efficiency and profitability. As per the results fleet size, fleet age, fleet commonality and fleet standardization have an impact on fleet management performances.

One powerful technique for this is the Capacitated Vehicle Routing Problem (CVRP), which allows fleet managers to determine the optimal mix of vehicle types to minimize total costs while meeting capacity and service demands. Applying CVRP considering vehicle characteristics to get benefits like selecting the most cost-effective vehicle types to avoid underutilization, enhancing asset utilization, route optimization, and logistics efficiency, considering vehicle characteristics like size, age, commonality and standardization that impact fleet performance.

The CVRP optimization process is also valuable for long-term strategic planning, as it enables analysis of different scenarios and their impact on total cost of ownership. This supports informed decisions about fleet composition, replacement, and new technology investments. Overall, integrating CVRP and other advanced optimization techniques is critical for modern fleet management. It allows companies to gain deeper understanding of their fleet dynamics and make data-driven decisions to enhance competitiveness.

Hence, the study adopted a positivist research philosophy and a causal, mixed-methods design, collecting primary and secondary data. Using SPSS, the researchers employed multiple regression analysis to quantify the relationships between vehicle characteristics and fleet management performance at the case company, EABSC. The findings indicate that vehicle characteristics have a significant impact on fleet performance, underscoring the importance of optimizing a company's vehicle fleet for operational efficiency and profitability. Specifically, fleet size, age, commonality, and standardization were found to influence fleet management outcomes. One powerful technique for optimizing fleet composition is the Capacitated Vehicle Routing Problem (CVRP), which helps determine the optimal mix of vehicle types to minimize costs while meeting capacity and service demands. Applying CVRP while considering vehicle attributes can yield benefits such as selecting cost-effective vehicles, enhancing asset utilization, route optimization, and improved logistics efficiency. The CVRP optimization process also supports long-term strategic planning, enabling the analysis of different scenarios and their impact on total cost of ownership. This informs decisions about fleet composition, replacement, and new technology investments. Integrating CVRP and other advanced optimization methods is critical for modern fleet management, providing a data-driven approach to enhance a company's competitiveness.

5.2. Recommendations

Based on the result of the study findings, the researcher recommend some points to improve vehicle fleet management problems. The organization has acceptable fleet replacement practices, but they rank lowest due to prioritizing cannibalization, modification, and corrective repair over disposing of older cars. This results in exorbitant maintenance costs, downtime, and failure risk. The fleet administrator must regularly assess and examine vehicles for replacement and compile a list of suggested replacements and expected changeover costs.

To improve fleet availability, the company must develop a daily fleet operation plan, which should involve consulting a fleet analyst and active participation from the remaining fleet department members. Regular maintenance, safety inspections, and driver education can increase fleet durability, safety, and uptime. Fleet management works to keep the fleet in good working order for its economic usable life and may hire a replacement if necessary.

East Africa Bottling S.C. (EABSC) has strong fleet utilization practices, particularly in GPS vehicle monitoring, fuel optimization, and fleet size. However, these practices still require improvements by training program for all workers and vehicle users. In terms of auto repair and maintenance, the company employs best preventive techniques, such as planned maintenance intervals and technician education. Driver education is crucial to prevent unanticipated breakdowns, promote driver safety, and maintain vehicles in good working order. Open communication between technical and managerial teams is required to implement these programs.

Hence, the researchers recommend that the organization assess and regularly examine its fleet for replacement, compiling a list of suggested replacements and expected changeover costs. This is crucial, as the firm currently prioritizes cannibalization, modification, and corrective repair over vehicle disposal, leading to high maintenance costs, downtime, and failure risk. To improve fleet availability, the company should develop a daily fleet operation plan, involving consultation with a fleet analyst and active participation from the fleet department. Regular maintenance, safety inspections, and driver education can increase fleet durability, safety, and uptime. The firm has strong fleet utilization practices, such as GPS monitoring and fuel optimization, but these require further improvements through comprehensive training programs for all workers and vehicle users. In terms of maintenance, the company employs best preventive techniques, which should be complemented by driver education to prevent breakdowns and promote safety. Effective implementation of these recommendations will necessitate open communication between the technical and managerial teams to ensure the successful integration of these fleet management strategies and achieve operational efficiency and profitability.

5.3. Future Research Area

Future researchers can build on the current study by exploring additional dimensions of vehicle characteristics and their impact on fleet management performance. One avenue for further investigation is to include more dynamic and kinetic vehicle characteristics, such as acceleration, deceleration, and cornering capabilities. These factors can significantly influence various aspects of fleet operations, including fuel efficiency, driver safety, and routing optimization. Incorporating these vehicle-level parameters into the analysis may yield additional insights into the tradeoffs and synergies between fleet characteristics and overall performance.

Furthermore, the researchers could explore the implications of applying this research framework to other sectors beyond the traditional commercial fleet setting. For instance, investigating the impact of fleet characteristics on performance in the service or humanitarian sectors could provide valuable insights. These domains often involve different operational requirements, stakeholder considerations, and environmental constraints that may influence the relationship between fleet attributes and management outcomes. Expanding the research to these alternative sectors could uncover new perspectives and generate findings with broader applicability.

Additionally, the researchers may consider examining the role of geographical factors in shaping the relationships between fleet characteristics and management performance. The physical environment, infrastructure, and regulatory landscape can vary significantly across different regions and countries, potentially affecting the optimal fleet composition and management strategies. Replicating the study in diverse geographical contexts or conducting comparative analyses could shed light on how location-specific factors moderate the observed findings.

Hence, by incorporating these additional dimensions – dynamic vehicle characteristics, alternative sector applications, and geographical variations – future researchers can build upon the foundation laid by the current study. This multifaceted approach can lead to a more comprehensive understanding of the complex interplay between fleet attributes and operational performance, ultimately informing more effective and adaptable fleet management practices across a wide range of industries and settings.

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