Acta logistica - International Scientific Journal about Logistics
Volume: 11 2024 Issue: 1 Pages: 1-12 ISSN 1339-5629

https://doi.org/10.22306/al.v11i1.433 *Received: 04 June 2023; Revised: 04 Jan. 2024; Accepted: 12 Feb. 2024*

Environmental sustainability and operational performance in the road freight sector

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Keywords: operational performance, canonical correlation analysis, environmentally sustainable practices, trucking industry and road freight, logistics management.
Abstract: Road freight plays a pivotal role in the movement of goods from the point of production to the point of consumption. Transportation of freight by road is associated with high operational costs which increases cost of landed goods. The use of trucks is associated with greenhouse gas (GHG) emissions and congestion especially in urban areas. The trucking industry dominates freight movement in many countries including South Africa, necessitating the need to improve its operational performance. While researchers argue that implementation of environmentally sustainable practices (ESP) by trucking firms is likely to influence operational performance (OP), the actual effect is unknown. The purpose of this study was to investigate the effect of ESPs on OP among trucking firms. A survey of 124 trucking firms was conducted and the data was analysed using canonical correlation analysis. The ESPs identified were energy efficiency, driver behaviour, and advanced technology. The results revealed that there is an inverse relationship between ESPs and OP, with advanced technology being a major contributing practice to the relationship. Limited funding was identified as a major inhibitor to the implementation of ESPs among the trucking enterprises. This study informs managers of trucking enterprises that the implementation of environmentally sustainable practices would not likely result in higher operational performance, as such, they should implement the practices as a social good as opposed to for profits. The study investigated a complex phenomenon in an important sector of the economy in South Africa and provide some policy directions.

1 Introduction

The likely adverse effect of greenhouse gas emissions (GHG) calls for far-reaching changes in the approaches towards sustainable transportation systems [1]. The negative environmental effects of road freight transportation are huge in terms costs to the firms and society, thus require innovative tactics on the utilisation of transportation systems in a more sustainable manner [2]. Environmental concerns are fast becoming a top managerial concern due to customers' desire to trade with environmentally conscious enterprises. Numerous international studies have probed the intricacies of road freight sustainability research from developed economies like the United States and European countries exploring diverse strategies such as alternative fuels, smart logistics, and vehicle electrification to mitigate environmental impact [3]. Studies by [4-7], collectively highlight the challenges faced by the road freight sector in South Africa in achieving environmental sustainability while maintaining operational efficiency. [4] Identifies operational challenges such as poor road infrastructure, traffic congestion, and poor maintenance strategies that hinder optimal delivery of goods. [5] Emphasizes the importance of addressing socio-economic factors within the transport sector to promote sustainability. [6] Discusses the negative environmental impacts of the freight system, including air pollution and energy consumption. [7] Explores strategies for sustainable freight transportation, considering the balance between economic welfare and environmental impact. These papers provide insights into the challenges and provide potential strategies for achieving sustainability in the South African road transport sector.

While most companies strive for flexibility, reliability, and cost reduction in the transportation of goods, there has been a growing trend to implement environmental sustainability initiatives to achieve the stated efficiency and effectiveness objectives. Implementation of sustainable practices in transportation requires top management support [8]. Transport operations activities contribute greatly to GHG emissions problems yet research on the potential of environmental sustainability to promote efficiency and competitiveness among trucking firms remains inadequate [9]. When analysing systems to do with freight transport activities, three main topics emerge, namely business operations, operational performance, and environmental influence [10]. Operational performance (OP) refers to the efficiency and effectiveness of an organisation's efforts to achieve its set objectives [11]. Within trucking companies, the objectives might include fuel efficiency, reduced logistics costs and minimal environmental impact (noise, pollution, and accidents) [11] . Thus, trucking firms might focus on monitoring their energy efficiency, maintenance costs and reliability metrics to remain competitive. Carbon emissions from trucks are quite harmful to the environment; as such, some countries impose payment of carbon taxes which subsequently erode profitability [12]. Therefore, firms should implement sustainable practices that lessen the cost of logistics as well as cost of goods to improve their operational performance.

In South Africa, freight movement is predominantly by road, which makes trucking services critical to the manufacturing and distributive industries. The trucking sector is even more important in the port cities, which link the inter-land and the international shipping lines [13]. This implies that the port cities are likely to bear the cost of GHG emissions from the large number of trucks that drop and pick freight from the ports. Despite the likely known benefits of adopting sustainable road freight transport, there is little that is known regarding the relationship between environmentally sustainable practices and operational performance of trucking firms. Prior research on sustainable freight transport and operational efficiency focused on the movement of goods through the sea in Finland and established the practices can lead to developing a competitive advantage [13]. A study from Belgium [14] investigated the implementation of sustainable practices to minimise GHG emissions and operational costs by using an optimal truck chassis size. Prior research has also established that technology and innovation play a pivotal role in improving timeous cargo delivery in the road freight industry [15]. The limited research on the effect of environmental sustainability and operational performance of trucking firms calls on researchers to fill the knowledge gap. The polemic objectives of greening the transport industry as well as minimise the cost of transport make spell the significance of this study to shippers, operators, practitioners and relevant public agencies. The study addressed the following research questions:

1. What is the extent of the implementation of environmentally sustainable practices (ESPs) among trucking firms?
2. What is the relationship between ESPs and OP of trucking firms?
3. What challenges do trucking companies face when implementing ESPs?

The rest of this paper is divided into literature review, material and methods, results, discussion, conclusion, and recommendations.

2 Literature review

2.1 Road freight sector in South Africa

South Africa has the largest and most developed transport and logistics infrastructure in the Sub-Saharan Africa. South Africa is identified as a key emerging economy owing to its membership in the BRICS. The freight and logistics market in South Africa is worth about USD 21.53 billion in 2023 and is expected to grow to about USD 30 billion by 2030 [16]. The road freight sector is one of the largest as it accounts for about 75 percent of commercial cargo in South Africa. The road freight sector comprises of a few large players such as Imperial Logistics and many medium and small enterprises. The micro players are also well represented where there are owner drivers. The sector has low entry and exit barriers, thus, there are many competitors offering varying quality of service. The lack of strict regulation implies that operators are profit focused and initiatives related to sustainable transport might not be a priority as they require extra capital investments. Most South African industries rely heavily on trucks, which have become the dominant mode of transporting about 80 percent of commercial freight in South African. As such, road transport is the heartbeat of the South African economy [17]. Like any other industry in South Africa, the road freight industry has been affected by several challenges, such as electricity outages, fuel price hikes and continuous industrial unrests. The instability in electricity supply is characterised by many hours of load shedding a day, thus increasing warehousing and transport costs as retailers order more frequently [18]. In addition, fuel prices are going up not only in South Africa but worldwide and this has impacted the cost of road freight services and the logistics industry at large. Consequently, the logistics increase resulting in an increase of the price of goods [18]. The increasing trucking costs can also be associated with labour issues resulting in protests that increase security costs. The protests result in congestions, and higher emissions from the trucking industry in South Africa. In addition, deliveries are delayed resulting in temporary shortages of goods and services and in some cases damages, especially where perishable goods are involved [7]. The reliability, dependability, efficiency, and effectiveness of logistics activities have thus been jeopardised by such challenges. While one of the areas that affect operational performance is Driver Behaviour (DB), their constant dis-satisfaction over their conditions of service has worsened their behaviour [19].

2.2 Operational performance of trucking enterprises

Operational Performance (OP) refers to the ability of an organisation to streamline its processes to maximise its outputs by minimising costs, improving speed of service, flexibility, and quality of service [10]. Further it is contended that trucking firms strive for consistent delivery of freight to as contracted by shippers. Given that business environments are constantly changing, the trucking industry still needs to remain competitive by improving its OP [9]. Whereas there are different ways to measure operational performance, the common metrics have been to make use of both financial and non-financial methods [20]. In this study, energy efficiency, maintenance costs and reliability were used as measure of OP. Prior studies have argued that operational performance can be improved by diligently managing the related activities to ensure optimal results by reducing costs and improving service levels, which might involve acquiring some capabilities from experts, [21]. While research on operational performance is mature, little is known about whether environmental sustainability practices can improve operational performance of trucking firms.

2.3 Environmental sustainability

The three pillars of sustainable freight transportation are economic, social, and environmental [22]. This present study, however, focused on environmentally sustainable practices (ESPs) within trucking companies. Environmental challenges happen on land, water, and in the air and are mainly caused by business operations, human activities, and/or natural disasters The environmental sustainability is described as the ability to utilise the environment without hindering the present and future inhabitants [15]. Transport, which is part of logistics is a key contributor to sustainable development because of its impact on the environment in terms of accidents, pollution (land, water, and air), energy consumption, and the noise it generates [14]. The sustainable freight logistics systems require transportation that is safe, fuel-efficient, and environmentally friendly as the costs associated with this heavily erode profitability and reduce the overall OP of firms [23]. is solely concerned with conveniently planning the movement of goods using the minimum cost in a sustainable way [22]. Thus, trucking firms are expected to implement some environmentally sustainable practices to reduce the negative impacts of transportation to the environment. This is because road freight movement activities harm the atmosphere and the environment through the emission of gases and consumption of non-renewable energy [22]. Prior research has also argued that implementation of transport sustainable practices such as fuel-efficient engines, advanced technologies, improved driver behaviour require significant initial capital investments which is sometimes not readily available. Furthermore, it not known whether firms that implement the sustainable practices can improve their operational efficiencies and effectiveness.

2.3.1 Fuel efficiency

Fuel constitutes a large share of the cargo movement operating costs incurred in the road freight industry, which are mostly related to GHG emissions from an environmental perspective [14]. In the UK, freight transport had a 38% share of the total fuel consumed in 2017 [24]. Fuel consumption per km is a very important indicator of the efficiency of the vehicles used in a trucking industry as well as impact on the environment [9]. Making vehicles more fuel efficient can be necessitated by proactive or cost-driven fleet acquisitions [1]. The road freight industry needs to employ technical elements of logistics within their businesses to ensure that sustainability goals and aims are attained [25]. They further argue that the development of road transportation policies on fuel efficiency measurements will help attain GHG emission reduction goals within the road freight industry. The key to carbon-free freight transportation lies in fuel-efficient initiatives on road transportation systems to achieve a green circular economy and, in that regard, various activities can be undertaken to ensure fuel-efficient transport operations. The activities include proper scheduling, less idling time, speed reduction, and congestion avoidance as some practices that can help to improve fuel efficiency [7]. The achievement of fuel efficiency within the trucking industry goes further to include various operational measures, such as vehicle utilisation optimisation, empty leg minimisation, right vehicle size and type choice for each operation, and promoting efficient driving [26].

2.3.2 Advanced technology (AT)

Application of advanced technologies helps to achieve high efficiencies in truck fleet management by facilitating the use of automated routing and scheduling systems, automated documentation and billing systems, vehicle and freight track and trace capabilities, and maintenance planning systems among others. Some technologies can monitor driver behaviour and road surface conditions to prevent accidents and avoid mobility disruptions. Some of the advanced technologies can monitor GHG emissions and the likely air, noise and water pollution and to help management take corrective actions in good time through maintenance or decommissioning some of old vehicles. Environmental sustainability was not a popular concern until the 1980s but interest in the inclusion of transportation technology had started long before that [7]. Many road freight transport companies are making use of advanced technology (AT) in all areas of operation in the industry due to the benefits that it brings. The complexity of transportation activities renders the use of advanced technology a necessity [27] while it is found that the use of advanced technology had significantly improved tracking of cargo in transit [13]. Technology plays a pivotal role in enhancing environmental quality and company performance. A study on the Japanese transport industry found that technology innovation improved performance and that the incorporation of high efficiency and low carbon reporting technologies was important to achieve environmental sustainability [23].

2.3.3 Driver behaviour (DB)

Freight transportation is highly dependent on drivers who provide timeliness and safety along the route[19], besides infrastructural and technical developments, there is a need for policy and driver behaviour changes if the trucking industry is to continue to thrive [2]. The performance of truck drivers has a huge bearing on how customers perceive the service offered by trucking companies[28]. A fossil fuel-based transportation system is heavily dependent on human (especially drivers) interactions with the environment [28]. Aggressive driving wastes energy, while improved driver behaviour (DB) reduces the amount of fuel consumed. Thus, it is important to have precise knowledge of human aspects that impact OP as this will help in the manufacturing of vehicles that are easy to use and provide much-needed constant feedback for decision making [29]. DB is concerned with dynamic driving characteristics, such as road safety, fuel efficiency, and good driving patterns [26]. The six (6) components of the total cost of ownership (TCO), three (3), namely fuel, insurance, and service, maintenance, and repair (SMR), are heavily influenced by DB [30]. Improved DB, where drivers drive smoothly and make informed cautious driving decisions, keep insurance premiums constant, or reduce them, reduce fuel consumption and overall truck maintenance costs. However, the debate whether driver behaviour as sustainable transport practice can affect operational performance of a trucking firm remains inconclusive.

3 Methodology

The study followed a positivism paradigm. Positivism targets accuracy, generalisability, consistency, and replicability [31]. The quantitative approach allowed for the testing of the relationship between ESP and OP objectively. The main objective was to investigate the relationship between operational performance and environmentally sustainable practices. A survey was conducted, and data was collected using a structured questionnaire. The scale questions made use of the five-point Likert-type scale where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree and 5 = strongly agree. The sample for this study consisted of trucking companies in the Western Cape, South Africa. A total of 124 valid responses was received from respondents who comprised of owner, logistics managers, operations managers, supervisors, or their equivalents involved in day to day running of the trucking enterprises.

Descriptive statistics were used to determine the extent to which trucking enterprises have implemented ESPs. Exploratory factor analysis was used as a concept validity technique. Reliability analysis assessed the internal consistency of the scales. Canonical correlation analysis (CCA) examined the relationships between the measures of ESPs (driver behaviour, advanced technology, and fuel efficiency) and measures of OP (energy efficiency, cost per km, maintenance costs and reliability). The data analysis model is depicted in the Figure 1.

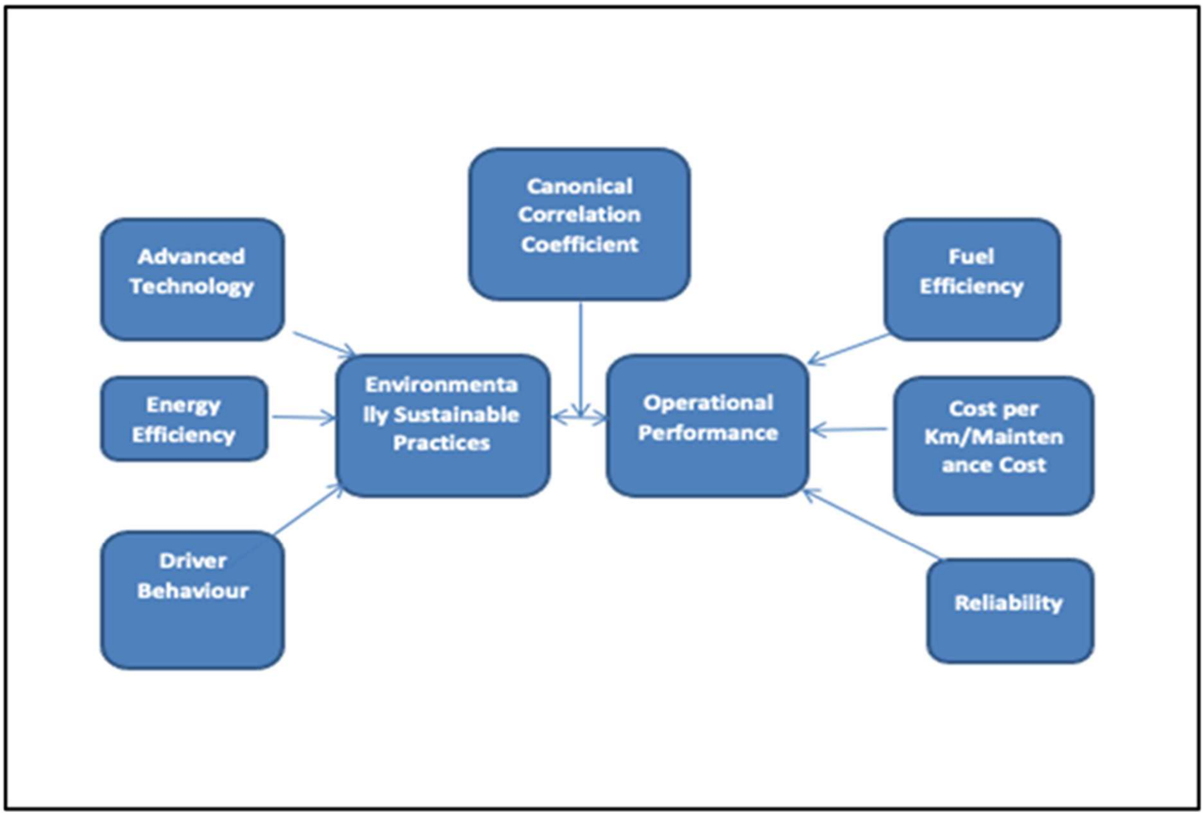

Figure 1 Data analysis model

Appropriate ethical considerations were considered during the formulation of the study and in the data collection procedures to ensure privacy and confidentiality of the respondents.

4 Results

4.1 Respondent demographics

The results show most of the respondents were males (see Table 1). In addition, 86.3 percent of the respondents had at least a diploma from a tertiary institution; implying some professional training in transport, logistics or management, thus, had the expected knowledge to understand the requirements of the research. In terms of job positions, most of the respondents were either managers, operations managers, or owner managers.

The study sought to find out whether companies were implementing some form of environmentally sustainable practices (ESPs). A dichotomous question was presented to the respondents where they were to answer yes/no. Surprisingly, most of the firms (80.6 per cent) were implementing ESPs, implying that many of the firms in the road freight industry were familiar of the concept of green transportation. One of the sustainable transport initiatives involves training drivers to improve their driving behaviour. The study sought to know whether the firms were offering any form of driver training. The results obtained (Table 2) indicated that most of the trucking firms (79.9 per cent) offered driver refresher courses at least once every two years. The results might imply that firms that offered driver refresher trainings were acknowledging that the behaviour of their drivers had a significant bearing on their operating costs as well as their overall OP, as argued by [3]. The majority of the firms were either small or medium confirming the national demographic of the road freight industry whereby there are few large enterprises with a majority of the firms being small and medium in size (Mordor Intelligence, 2023).

Table 1 Respondent demographics

Demographics	Percentage (%)
Gender	
Male	75.0
Female	18.5
Prefer not to say	6.5
Level of education	
High School certificate	8.1
National certificate	5.6
Diploma	15.3
Undergraduate degree	30.6
Honours degree	21.8
Masters/PhD	18.6
Job Position	
Owners	23.4
Operations Managers	23.4
Managers	23.4
Supervisors	12.1
Other	8.0

Table 2 Driver refresher courses

	Refresher course	Not at all	After two years	Yearly	Twice a year	Total
Firm size	Micro	13.7%	0.0%	0.8%	1.6%	**16.1%**
	Small	4.0%	4.8%	24.2%	12.1%	**45.1%**
	Medium	1.6%	2.4%	9.0%	21.8%	**34.8%**
	Large	0.8%	0.0%	0.0%	3.2%	**4.0%**
	Total	**20.1%**	**7.2%**	**34.0%**	**38.7%**	**100.0%**

4.2 Extent of ESP Implementation

The extent of ESPs implementation among the trucking firms was investigated and results were presented on Table 3. The extent was measured as either being low, moderate, or high. On average over 80.6 percent of the firms do implement the ESPs related to driver behaviour, advanced technologies and energy efficiencies. Therefore, the implementation of ESPs by trucking firms is to a high extent. This implies that many of the trucking firms are aware of the negative effect of GHG emissions from freight transport vehicles and are ready to implement some initiatives to minimise the effects.

Table 3 Level of ESP implementation

Code	Indicators	Low extent	Moderate extent	High extent
Driver behaviour		**7.9%**	**11.4%**	**80.6%**
DB1	Bonus systems encourage good driver behaviour	38.7%	16.1%	45.2%
DB2	Internal driver training programmes help ensure hiring of good quality drivers	8.1%	34.7%	57.2%
DB3	The life span of trucks heavily depends on driver behaviour	0.0%	3.2%	96.8%
DB4	Driver training works – and it can save the business money	0.0%	11.30%	88.70%
DB5	Driving style affects other vehicle running costs (e.g., insurance)	0.8%	1.6%	97.6%

DB6	Driving performance has a huge bearing on how the customers perceive the trucking companies	0.0%	1.6%	98.4%
Advanced technology		**2.8%**	**14.0%**	**83.2%**
AT1	Automatic transmission trucks can reduce the carbon content of the fuel used	1.6%	16.1%	82.3%
AT2	Gas emission control technologies are an essential tool for managing vehicle emissions	0.0%	6.5%	93.5%
AT3	Driver monitoring software proactively tackles the source of potential accidents and ensures that drivers are not being put under pressure to take risks on the road to meet targets	4.8%	25.0%	70.2%
AT4	GPS allows timely sharing of information that can help improve environmental sustainability	7.3%	15.3%	77.4%
AT5	Telematics helps companies to quickly identify areas that need action to reduce a negative impact on the environment	1.6%	11.3%	87.1%
AT6	Vehicle tracking helps monitor where vehicles are in real time and provides information on traffic and best routes to use	0.0%	1.6%	98.4%
AT7	Remote vehicle diagnostics technologies help reduce the overall maintenance cost of trucks	0.8%	15.3%	83.9%
AT8	Remote vehicle diagnostics can help avoid downtime and possible fuel leaks	6.5%	21.0%	72.6%
Energy efficiency		**0.7%**	**8.9%**	**90.5%**
EE1	The amount of gas emitted, and the total energy consumed by trucks can be reduced by in-vehicle eco driving systems	0.0%	4.8%	95.2%
EE2	Optimal truck routing and scheduling has been seen as one of the means to help companies reduce their energy consumption	0.8%	2.4%	96.8%
EE3	Proactive and cost driven truck acquisition necessitates energy efficiency	0.8%	21.8%	77.4%
EE4	Energy consumption can be increased by driver behaviour	0.0%	0.8%	99.2%
EE5	Uncoordinated routing translates into further distances travelled and more energy consumption	0.0%	0.0%	100.0%
EE6	Following speed limits and cruising speeds aid fuel efficiency	2.4%	23.4%	74.2%

Exploratory factor analysis (EFA) was used to extract the latent components from the indicators related to ESPs and OP. Prior to conducting the exploratory factor analysis, two diagnostic tests were carried out to check the factorability of the data. These tests were Kai-ser-Meyer-Olkin of Sampling Adequacy (KMO) and Bartlett's test of sphericity. Bartlett's test of sphericity should have a p-value less than 0.05 ($p<0.05$) for the analysis to be considered significant, while the KMO index ranges from 0 to 1, with 0.6 being suggested as the minimum value for a good factor analysis [28,32]. Both the ESPs and OP had a KMO value of 0.687 and 0.867, respectively, which were above the minimum threshold of 0.6, signifying their suitability for factor analysis. Bartlett's test of sphericity was statistically significant ($p<0.05$) as expected.

A set of three components related to ESPs and OP were extracted using PCA based on eigenvalues greater than 1. The extracted components were rotated to obtain the factor patterns using the varimax rotation. The result is provided in Table 4. The extracted components were interpreted as advanced technology with three indicators (AT8, AT7, and AT6), energy efficiency with three indicators (EE2, EE4, and EE1) and driver behaviour with two indicators (DB3 and DB4) for the ESPs. The second set of three components was related to operations performance construct and were interpreted as operations maintenance had nine indicators, operations reliability with four (4) indicators and operations efficiency with two indicators. All the indicators that were selected for each component had a factor loading of 0.5 and above, which shows that they had sufficient variance explained for the given construct [32,33]. Reliability analysis was done to check if a given factor was consistently reflecting the construct it was measuring. Cronbach's alpha coefficient is the commonly used test, and it has a threshold of 0.6 [30,34]. Reliability analysis was tested and presented under Table 5. The results clearly show the highest value of 0.914 for operational maintenance and the lowest of 0.582 for driver behaviour. For ESP, advanced technology was within the acceptable threshold value, while driver behaviour and energy efficiency were below the threshold, however, they were retained for theoretical reasons. In terms of OP, both operational costs and reliability had high internal consistency reliability with Cronbach's alpha values above 0.8, which was acceptable.

Table 4 Rotated component matrix

Indicator code	Indicator description	Factor loadings	Reliability	Latent variable
	Environmental sustainability			
AT8	Remote vehicle diagnostics can help avoid downtime and possible fuel leaks	0.808	0.755	Advanced technology
AT7	Remote vehicle diagnostics technologies help reduce the overall maintenance cost of trucks	0.778		
AT6	Vehicle tracking helps monitor where vehicles are in real time, provides information on traffic and the best routes to use	0.657		
EE2	Optimal truck routing and scheduling has been seen as one of the means to help companies reduce their energy consumption	0.776	0.595	Energy efficiency
EE4	Energy consumption can be increased by driver behavior	0.712		
EE1	The amount of gas emitted, and the total energy consumed by trucks can be reduced by in-vehicle eco driving systems	0.647		
DB3	The life span of trucks heavily depends on driver behavior	0.81	0.582	Driver behaviour
DB4	Driver training works – it can save the business money	0.756		
	Operational performance			
OPC3	Fuel cost per km has been reduced over the past three years	0.856	0.914	Operations Maintenance
OPM3	Planned maintenance programs are in place for all our trucks	0.787		
OPC5	The total number fuel litres bought for the past three years has reduced	0.727		
OPM1	The rate of tyre replacement has reduced over the past three years	0.716		
OPC6	Tyre life span has improved over the past three years	0.713		
OPC4	Swiftness of identifying areas that need urgent attention has improved in the past three years	0.662		
OPM4	Total number of litres of oil bought in the past three years has reduced	0.599		
OPM5	Driver training scheme and behavior have improved in the past three years	0.57		
OPC1	Truck utilisation has improved over the past 3 years	0.501		
OPR2	Delivering cargo at the right location has improved in the past three years	0.837	0.86	Operations Reliability
OPR1	Information sharing with our customers has improved in the past three years	0.804		
OPR4	Customer service plan has improved for the past three years	0.779		
OPR3	On-time cargo delivery has improved over the past three years	0.76		
OPF3	Truck acquisition policies have changed to energy efficient models for the past three years	0.869	0.801	Operations Efficiency
OPF4	Satellite tracking technology systems are installed in all trucks for optimal routing to reduce operational cost	0.77		

4.3 Relationship between ESPs and operational performance

The study sought to establish the relationship between ESPs and OP among trucking enterprises. Each of the two constructs had three variables thus making it difficult to test the relationship through regression techniques, hence the choice of canonical correlation analysis (CCA) to establish the relationship. The canonical correlation coefficient measures the strength of the association between ESPs and operational performance. The CCA was used because it denotes the top level of gross linear modelling (GLM) and can test a relationship in situations where both the dependent and independent constructs have multiple variables [30,31]. CCA was conducted to ascertain the relationships or significant canonical variates that help justify the existence of a relationship between the two constructs. The Wilk's lambda (ʎ) was chosen because of its general applicability [28,32,42], however, it is important to note that all the other tests are statistically significant. Wilk's ʎ =0.71515, F=4.71540 and P=0.000 (Table 5) proved that the model was statistically significant, though it explained about 29% of the variance.

Table 5 Test statistics

Test Name	Value	Aprox. F	Hypoth.DF	Error.Df	Sig. of F
Pillais	0.30400	4.51032	9.00	360.00	0.000
Hotellings	0.37202	4.82244	9.00	350.00	0.000
Wilks	0.71515	4.71540	9.00	287.33	0.000
Roys	0.22356				

Three canonical correlation functions were noted with the first canonical correlation coefficients of 0.47282, an explained variance of 77.39476 percent and an eigenvalue of 0.28792 as illustrated on Table 6. Thus, confirming that the hypothesis is correct, that is, ESPs and operational performance are positively correlated. Sherry and Henson [33,35] claimed that functions that describe a sensible amount of variance among variables should be interpreted. In addition, function 1 explained a substantive 77.4% of the variance and should be considered for further interpretation.

Table 6 Eigenvalue and canonical correlation functions

Function No.	Eigenvalue	Pct.	Cum. Pct.	Canon Cor.	Sq. Cor
1	0.28792	77.39476	77.39476	0.47282	0.22356
2	0.05420	14.56819	91.96295	0.22674	0.05141
3	0.02990	8.03705	100.00000	0.17039	0.02903

The examination of the dimension reduction helped in testing the statistical significance of the hierarchically arranged functions. The examination confirmed that the roots 1 to 3 F (9; 287.33) = 4.72; (P<0.05); Wilk's lambda (ʎ) (0.71515) was statistically significant and was considered for interpretation as well as root 2 to 3. The results are illustrated on Table 7.

Table 7 Dimension correlation function

Roots	Wilk's L	F	Hypoth.DF	Error.DF	Sig.of F
1 to 3	0.71515	4.71540	9.00	287.33	0.00
2 to 3	0.92105	2.49762	4.00	238.00	0.043
3 to 3	0.97097	3.58790	1.00	120.00	0.061

To establish the relationship between ESP and OP, the standardized coefficients, communalities, and structure coefficients corresponding to the first and second functions were analysed as presented in Table 8. The function was chosen because they fulfilled the criteria regarding statistical significance and amount of variance explained [33,35].

Considering the standardised coefficients of function 1, operations maintenance (0.60359), operations reliability (-0,65932) and operations efficiency (-0.91282) reveal a significant amount of the relevance of the dependent variables in the relationship, although operations efficiency depicts an inverse magnitude. Considering the standardised coefficients of the independent variables for function 1, advanced technology (0.85568) was the most relevant, while and driver behavior had a weak negative relationship with the dependent variables. The energy efficiency (0.00717) variable was the least relevant in this relationship.

The structure loadings (r_s) show significantly high loadings for function 1, which depicts a negative relationship between operations performance and the canonical variables. Operations reliability (rs = -0.63385) and operations efficiency (rs =-0.80661) were noted as the most relevant dependent variables all loading on function 1. Driver behavior (rs = -0.52424), and advanced technology (rs = -0.88322) were the most relevant predictor variables based on their correlations with the canonical variates and confirmed the negative relationship (see Table 8). The canonical effect (R_c^2) for function 1 is observed to be 22.356.

Table 8 Canonical solution for ESP and OP

	Function 1			Function 2			
	Coeff	r_s	r_s^2	Coeff	r_s	r_s^2	h^2
Operations maintenance	0.60359	-0.25547	6.527	1	0.82045	67.314	73.341
Operations reliability	-0.65932	-0.63385	40.177	-0.67005	-0.0082	0.0067	4.1837
Operations efficiency	-0.91282	-0.80661	65.062	0.18094	0.54844	30.079	95.141
R_c^2			22.356			5.141	
Driver behaviour	-0.47084	-0.52404	27.462	-0.59233	-0.45063	20.307	47.769
Advanced technology	-0.85568	-0.88322	78.008	-0.00495	0.25476	6.490	84.498
Energy efficiency	0.00717	-0.34763	12.085	0.9055	0.81098	65.769	77.854

The communalities (h^2) showed that some of the variables were relevant and useful, while others were not. Communalities above 45% are claimed to be giving a solution to the problem in question [33,35]. The dependent variables (operations maintenance, and fuel efficiency) had communalities values above 70%, similarly, advanced technology and energy efficiency also had values above 70% for the independent variables revealing the significance of the four variables in the relationship. The use of CCA as a statistical method helped establish the relationship between ESPs and OP of trucking companies. Function 1 showed operations efficiency as key response factors of OP, while advanced technology was the most relevant independent variable. The results for function 1 also imply that only a single relationship dimension exist between ESPs and OP based on the canonical effect. Therefore, there is a relationship between ESP variables and OP variables based on the high structure loadings. Theoretically, advanced technology increase should result in operations reliability and efficiency, but the model depicts an inverse relationship [36]. The complexity of the technologies associated with green transportation makes them costly, thereby contributing to non-implementation, as most companies consider the costs in direct comparison with the benefits to be attained. It might be important to examine the specific technologies that are needed to improve reliability and fuel efficiency.

4.4 Challenges of implementing ESPs

Ascertaining the challenges faced by trucking companies when implementing the environmental practices was one of the research objectives of this study. The challenges related to implementation of ESPs among the sampled enterprises were classified into low-level challenges, moderate challenges and high-level challenges as illustrated in Table 8. Various challenges were noted in the literature and this question sought to find out how the respondents would rank the challenges in the order of importance. From the results depicted on Table 9, most respondents 88.7% of the firms ranked financial challenges as a high-level, implying that it is a major impediment, followed by technical challenges which might be related to the difficulty of obtaining the relevant skills within the industry. Lack of the relevant information regarding green transportation was considered a low as well as moderate challenge thus requiring government to create more awareness. The policy, market issues as well managerial and organizational issues were considered low level challenges. The result might imply that the non-implementation of ESPs could be because of lack of funding and/or technical expertise.

From the result, one might conclude that financial challenges are huge because the implementation of any ESP comes with a financial outlay. The reason why technology was ranked second in the order of importance could be linked to the ever-changing technologies, meaning companies will need to always outsource expertise in this area, thereby causing more financial and technical challenges. The results might also imply that, despite having technical expertise and being knowledgeable about the policies, faced with inadequate finances to fund implementation of environmental practices could remain a big challenge.

Table 9 Challenges of implementing ESPs

Variables	Low	Moderate	High	Total
Financial Challenges	5.6%	5.6%	88.7%	100.0%
Technical Challenges	24.2%	29.0%	46.8%	100.0%
Lack of Information	41.1%	35.5%	23.4%	100.0%
Policy and market issues	53.2%	15.3%	31.5%	100.0%
Managerial and organisational challenges	71.0%	12.9%	16.1%	100.0%

5 Discussion

The main objective of this study was to establish the relationship between ESPs and OP among trucking companies. The ESPs activities among trucking firms include enhancing driver training to achieve optimal driver behaviour, implementation of advanced technologies such as telematics for routing and scheduling, as well vehicle tracking and fuel monitoring as well as energy efficiency initiatives that require adopting fuel economy engines, electric or hydrogen trucks. The findings reveal that majority of the trucking firms are implementing ESPs to a moderate or high extent. The finding aligns with the [17] which developed a 30-year green transport strategy that requires operators to implement initiatives to lower GHG emissions. Some on the green transportation activities identified in the strategy include application of intelligent transportation technologies, fuel economy and energy efficiency. It is established in this study that the implementation of ESPs has a one-dimensional inverse relationship with operational performance. Advanced technology (AT) was found to have the strongest relationship with OP, although it was inverse. This finding disagreed with [37] who observed that AT has a significant positive relationship on logistics and transport operations. The likely explanation would be that sophisticated technologies, such as trailer tracking, remote diagnostics technologies, and dynamic routing, require high initial capital outlay in terms of the installation equipment as well as skills, which in turn increases operational cost. The majority of the sampled enterprises were either small or medium in size implying the huge financial challenges SMEs face, thus, making it difficult for them to invest in the advanced technologies related to green transportation [21].

Energy efficiency has an inverse relationship with OP, implying that while trucking companies need to ensure all measures are in place to attain high levels of energy efficiency, the measures are likely to be costly and discourage especially the medium, small and micro firms. While [14], observed that fuel accounts for a large share of logistics operating costs in the freight industry, the measures to ensure high energy efficiency are costly and discouraging to profit seeking enterprises. In addition, [12] also observed that technological advances enhance fuel efficiency of freight vehicles and reduce the carbon content of the fuel used, however, the sampled enterprises of which many are small or medium might find it difficult to invest in these technologies. This then implies that trucking companies need to incorporate technologies that aid energy efficiency and reduction in GHG emissions. In line with this, [17] also argued that shorter time frames for vehicle replacement play an important role in fuel efficiency, thus implying that trucking companies need to have better scrappage policies based on the number of kilometers travelled as opposed to the age of the trucks.

The operational performance construct was divided into three metrics viz. maintenance, reliability and efficiency. Operations efficiency and reliability were established as the most relevant response variables. The research findings highlight costs related to repairs, breakdowns, idle time, low utilisations, and generally poor fleet management as key determinants operational performance. This is confirmed by [3], who claimed that fuel costs had greater influence than other variables on the overall performance of the transport industry. The results also imply that trucking companies need to closely monitor their operational reliability in terms meeting their clients requirements consistently through effective routing and scheduling. While reliability is key component of a transport service quality it would be inversely related to environmental sustainability initiatives based on the amount of capital investment required to achieve the required service levels. Further, a by [6] affirms that advanced technologies help in keeping both the transport operator and the shipper satisfied, resulting in improved operations reliability. It is also important to note that operations reliability can be affected by congestion in the cities which result in delayed deliveries, in such cases real-time sharing of traffic data sharing technologies can be of help to assist in rerouting trucks to ensure high delivery reliability as well as reduced costs and GHG emissions due to congestion. This implication is supported by the [22], which argued that advanced technologies were in minimal use by road freight enterprises. Therefore, it is argued in this paper that the implementation of sustainable practices such advanced technologies, energy efficiency and better driver behaviour is not likely to result in high operational performance in terms of efficiency and effectiveness. As such, the implementation of sustainable practices should be done as a social good by responsible enterprises without a major focus on profits. In addition, it is critical to highlight that the financial burden associated implementing the sustainable practices makes it very difficult for SMEs in the trucking sector, this requires government to introduce tax rebates or any form of incentives to encourage compliance with the relevant environmental laws.

While the results reveal that many of the sampled enterprises had implemented the environmentally sustainable practices to some extent, they equally faced myriad challenges such as financial, technical expertise and lack of relevant information related to environmentally sustainable practices. The finding implies that managers of road freight enterprises should be able to overcome these challenges before they can successfully implement the said green practices.

6 Conclusion

We establish that majority of the enterprises involved in trucking business in South Africa are SMEs and are aware of the negative impact of fossil fuels and GHG emissions to the environment. Many of these firms also implement environmentally sustainable practices to some extent, but within the confines of their financial and technical capabilities. Within the trucking industry it is observed that implementation of sustainable practices does not result in improved operational efficiencies and effectiveness. The finding implies that trucking firms should implement environmentally sustainable practices as a social good as opposed to for profit. The high competition and low margins in the road freight sector is likely to discourage small and medium firms from participating in environmental sustainability due to financial and technical challenges. This calls for government agencies to consider lowering tax on environmentally friendly technologies, fuels, vehicles and associated training or expertise services to encourage adoption for the social good. Action from government is likely to result in moving closer to achieving UN SDG 11 related to sustainable transportation.

Managers in the trucking sector are informed that the implementation of sustainable practices is not likely to result in improved operational performance. In addition, the implementation of sustainable practices requires financial and technical resources. Thus, implementation of sustainable practices should be a strategic decision that requires to be well thought before and resources allocated in the long-term to avoid operational inefficiencies.

The findings of the study are limited to the trucking industry in South Africa and may not be generalised for all countries in Africa. The data was also collected cross-sectionally. In future a multicounty longitudinal study would help compare the various regions to establish the relationship over time. Data from developed countries where the implementation of sustainable practices is mature would help to understand the relationships better in the future.

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Review process
Single-blind peer review process.