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Cost-Benefit and Safety Comparison of Road and Pipeline Transport for Petroleum Products in Kano Depot, Nigeria

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ABSTRACT
The Nigerian downstream petroleum sector faces numerous challenges, including underutilised refineries, poorly maintained pipelines and storage facilities, vandalism, and inadequate transportation infrastructure, all of which hinder the efficient supply and distribution of refined petroleum products nationwide. Originally intended as a supplementary method, road transportation has largely replaced pipeline transport for petroleum product delivery. This descriptive study examines the supply sources, safety implications, costs, and socioeconomic impacts of shifting from pipeline to road truck transportation at the Kano Depot. Data were collected from primary sources through a questionnaire-based survey of 81 randomly selected participants from ten oil transport companies and secondary sources, including interviews, journals, articles, online resources, reports, and templates from relevant petroleum sector agencies. Data analysis was conducted using descriptive and inferential statistics via the Statistical Package for Social Sciences (SPSS). The results identify key supply sources and highlight safety challenges such as poor road conditions, accidents, mechanical failures, and human factors, with correlations indicating interrelationships among these constraints. Cost-related issues, including delivery shortages and transportation expenses, were also quantified. The study further evaluates the positive and negative socioeconomic impacts of this transportation shift, with significant p-values derived from various analytical methods.

Keywords: *Petroleum products, Road haulage, Safety constraints, Cost factors and Socio-economic impacts*

INTRODUCTION

The transportation of petroleum products is a critical component of the supply chain, facilitating the movement of these commodities from production hubs to consumption centres (Arosanyin, 2005). Given that many global refineries are situated at considerable distances from areas of consumption, the fluid nature of petroleum products renders them suitable for transport via pipelines, road tankers, railways, and maritime vessels (Ehinomen and Adeleke, 2012; Abba Adam *et al.,* 2019). In Nigeria, approximately 85% of petroleum product movements rely on road transport, driven by the degraded state of pipeline infrastructure, which has precipitated a marked increase in the use of road tankers. It is estimated that around 5,000 tankers transport approximately 150 million litres of fuel daily across Nigerian roads (Olagunju, 2015). Major oil marketers, including the state-owned NNPC Retail and indigenous operators such as African Petroleum, Oando, and Conoil, account for 60% of distributed products (FSDH and MOMAN, 2020). Independent marketers affiliated with the Independent Petroleum Marketers Association of Nigeria (IPMAN) also play a significant role.

The Nigerian petroleum industry faces multifaceted challenges, particularly in the downstream sector, where inadequate government policies have led to underutilisation of refineries, poor maintenance of pipelines and storage facilities, vandalism, and deficient transportation infrastructure for product bridging.

Originally intended as a supplementary method, road haulage has emerged as the primary alternative to pipeline transport. However, this mode is susceptible to disruptions, incurs relatively high costs, and is exposed to various hazards (Jibril, 2023). The initiation of Turnaround Maintenance (TAM) in refineries prompted the introduction of a supply intervention scheme aimed at ensuring adequate product supply to dry depots.

Numerous studies in Nigeria (Obasanjo *et al.,* 2014; Tanimowo, 2014) have explored distribution challenges within the downstream sector, frequently identifying poor road quality, highway robbery, and road accidents as significant operational impediments to road transportation of petroleum products. Despite these challenges, road haulage remains the predominant mode for moving petroleum products across the country.

This study seeks to evaluate the safety implications and cost-related factors associated with the road haulage of petroleum products to the Kano Depot in northern Nigeria. Employing a rank-ordered analytical technique, the data collected provides insights into the safety and cost-related challenges and constraints linked to the supply of petroleum products via road transport to the depot.

METHODOLOGY

Study Design, Data Collection and Analysis

This study employed a quantitative research approach to systematically measure and analyse respondents' perspectives through a structured survey instrument.

The quantitative methodology was chosen to ensure objective data collection, enabling a detailed assessment of safety and cost-related challenges associated with the road haulage of petroleum products to the Kano Depot in northern Nigeria. The design facilitated the collection of numerical data, which was subjected to statistical analysis to identify patterns, correlations, and significant trends in the responses.

The survey was administered to a randomly selected sample of 81 drivers from ten oil transporting companies responsible for supplying petroleum products to the Kano Depot. Random sampling was utilised to ensure representativeness and minimise selection bias, thereby enhancing the generalisability of the findings within the study's context. Drivers were selected as the primary respondents due to their direct involvement in the transportation process and their firsthand experience with the operational and safety challenges encountered during road haulage.

A structured questionnaire was developed as the primary data collection tool, designed to capture comprehensive information on frequently encountered safety challenges, cost-related factors, and the socio-economic impacts of road haulage. The questionnaire incorporated a five-point Likert scale to assess key variables, including the source of supply, the safety of road truck haulage, and its relative impact on socio-economic activities.

Additional closed-ended questions, such as multiple-choice items, were included to standardise responses and facilitate quantitative analysis. The questions were carefully formulated to address critical factors, such as road conditions, accident frequency, mechanical breakdowns, human factors, delivery shortages, and transportation costs. To ensure clarity and relevance, the questionnaire was pre-tested on a small subset of drivers, with feedback incorporated to refine the instrument before full deployment.

The survey was conducted in person at the premises of the oil transporting companies to maximise response rates and ensure accurate data collection. Trained enumerators facilitated the process, providing clear instructions to respondents and addressing any queries to minimise errors in interpretation. The random administration of the survey across the selected companies ensured a broad representation of drivers operating under diverse conditions and routes supplying the Kano Depot.

In addition to primary data, secondary data were sourced to complement the survey findings. These included the approved freight-rate template provided by relevant agencies in the Nigerian petroleum sector, as well as interviews conducted with operational staff at the Kano Depot. The interviews offered qualitative insights into operational challenges and complemented the quantitative data collected through the survey.

Further secondary data were obtained from peer-reviewed journals, articles, online resources, reports, and templates from relevant petroleum sector agencies, providing contextual understanding of the broader operational, safety, and cost-related dynamics in the downstream petroleum sector.

Data collected from the survey were analysed using both descriptive and inferential statistical techniques via the Statistical Package for the Social Sciences (SPSS).

Descriptive statistics, including frequencies, percentages, and means, were used to summarise respondents' opinions and highlight the prevalence of specific safety, cost, and socio-economic impact-related challenges.

Inferential statistics, such as correlation analysis and significance testing (p-values), were applied to explore relationships between variables, including the interplay between road conditions, accidents, human factors, and socio-economic impacts, and to assess the statistical significance of the findings.

The results from the five-point Likert scale were subjected to statistical analysis to evaluate the sources of supply, safety concerns, and socio-economic implications of road haulage, providing a robust basis for the study's conclusions.

DISCUSSION OF RESULTS

Socio-economic characteristics

The socio-economic characteristic of respondents was assessed. The age of respondents has significant implications for the performance and behaviour of drivers, as shown in Figure 1.

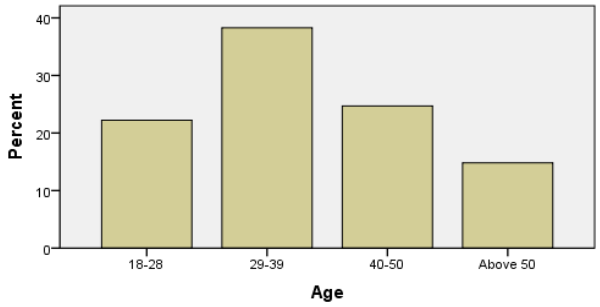

Figure 1: Age distribution

Figure 1 shows the age distribution in percentages. A higher percentage of the sample falls within the age of 29-39 years.

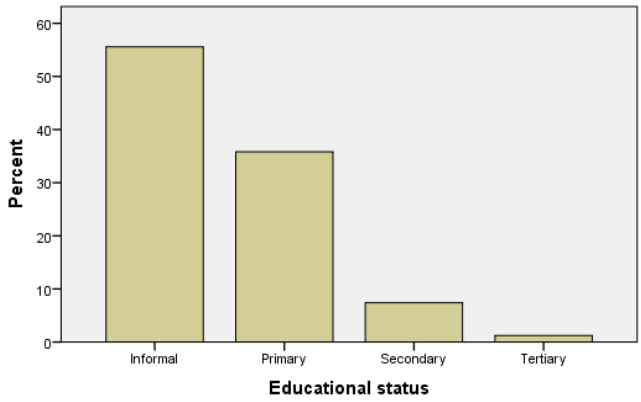

Figure 2: Education

The level of education influences attitude when driving and implications such as comprehending signs, traffic rules and regulations, etc.

Sources of Petroleum Product Supply to Kano Depot

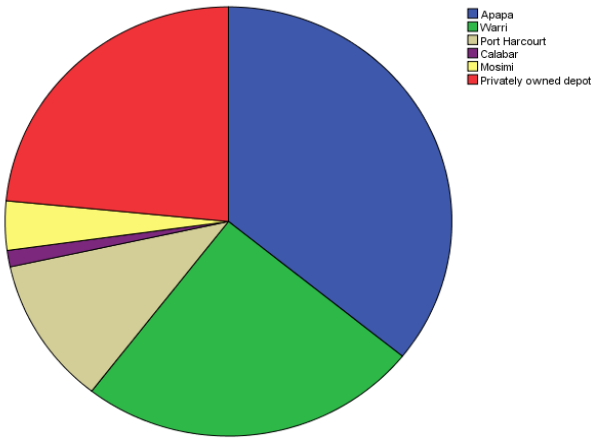

Figure 3: Sources of petroleum supply (Source: Kano depot)

The supply of petroleum products to the Kano Depot in northern Nigeria originates from multiple locations, each contributing to the overall distribution network based on its infrastructural capacity and operational significance.

The findings, derived from both primary survey data and secondary sources, provide a comprehensive overview of the key supply sources, their proportional contributions, and the underlying factors influencing their roles in the supply chain. The data are based on responses from 81 drivers across ten oil transporting companies, supplemented by secondary data from interviews, industry reports, journals, and relevant petroleum sector agencies.

1. **Lagos (Apapa)**: Lagos, specifically the Apapa area, accounts for 35.8% of the petroleum products supplied to the Kano Depot, making it the primary source of supply according to the survey responses. Secondary sources highlight the critical role of the NNPC Apapa jetty, a major facility where vessels berth and discharge refined petroleum products to surrounding storage terminals. The strategic location of Apapa, coupled with its robust port infrastructure and proximity to numerous storage facilities, enables it to serve as a central hub for the distribution of petroleum products across Nigeria. The high volume of supply from this location underscores its dominance in the downstream petroleum sector and its pivotal role in bridging products to depots in northern Nigeria, including Kano.

2. **Warri (Delta)**: Warri contributes 24.7% of the petroleum products supplied to the Kano Depot, as reported by survey respondents. Secondary data attributes this significant share to the presence of the Oghara storage facility, a key infrastructure in the region. The Oghara facility supports the storage and distribution of refined petroleum products, facilitating efficient supply chains to northern depots. Warri's role as a supply hub is further enhanced by its proximity to refining and import facilities in the Niger Delta, making it a vital node in the petroleum distribution network.

3. **Privately Owned Depot Facilities**: Privately owned depots collectively account for 23.5% of the supply to the Kano Depot, according to survey data. Secondary sources identify key players in this category, including independent marketers such as A.A. Rano and major oil

companies like NIPCO and MRS. These private depots play a critical role in complementing the state-owned infrastructure, providing additional storage and distribution capacity. The involvement of independent and major marketers highlights the diversified nature of the supply chain, with private entities contributing significantly to the availability of petroleum products for road haulage to the Kano Depot.

4. **Port Harcourt (Rivers)**: Port Harcourt accounts for 11.1% of the supply, driven by the presence of the Onne Port in Bonny, as noted in secondary sources. The Onne Port serves as a major entry point for imported refined petroleum products, which are subsequently distributed to depots across the country, including Kano. The port's strategic importance in the Niger Delta, a key oil-producing region, enhances its role in ensuring the availability of petroleum products for onward transportation. The contribution of Port Harcourt to the supply chain reflects its significance as a regional hub for petroleum product imports and distribution.

5. **Mosimi NNPC Depot (Ogun)**: The Mosimi NNPC Depot contributes 3.7% of the petroleum products supplied to the Kano Depot. Secondary data indicate that this relatively low share is due to the partial operation of the Lagos-Mosimi pipeline, which limits the depot's capacity to supply products efficiently. Despite its proximity to Lagos, the operational constraints of the pipeline infrastructure restrict Mosimi's contribution compared to other supply sources. However, its role remains notable within the context of Nigeria's pipeline-dependent distribution network.

6. **Calabar (Cross River)**: Calabar accounts for the smallest share of supply at 1.2%, as reported by survey respondents. Secondary sources suggest that Calabar's limited contribution is due to its relatively smaller-scale infrastructure and lower volume of petroleum product imports compared to other major hubs like Lagos and Port Harcourt. Nevertheless, Calabar serves as a supplementary source, contributing to the diversity of supply points for the Kano Depot.

The distribution of supply sources reflects the complex interplay of infrastructural capacity, geographic proximity, and operational efficiency in Nigeria's downstream petroleum sector. The reliance on multiple supply points highlights the need for robust transportation networks, particularly road haulage, to bridge products from these locations to the Kano Depot.

These findings provide a foundation for assessing the safety and cost-related implications of road transportation, as explored in subsequent sections of the study.

Analysis of Safety Challenges in Road Haulage of Petroleum Products to Kano Depot

The work investigated frequently encountered challenges in transporting petroleum products by presenting a set of problems to drivers on a five-point Likert scale questionnaire. Table 1 gives frequencies in percentages and means.

Table-1: Responses

Challenges	Never	Rarely	Sometimes	Very-Often	Always	Mean
a) Highway robbery	7.4%	33.3%	45.7%	12.3%	1.2%	2.6667
b) Bad roads linking North-South	0%	9.9%	3.7%	45.7%	40.7%	4.1728
c) Road accidents	2.5%	8.6%	34.6%	27.2%	27.2%	3.6790
d) Mechanical breakdown	0%	2.5%	43.2%	45.7%	8.6%	3.6049
e) Leakages of the product tank	48.1%	24.7%	23.5%	3.7%	0%	1.8272
f) Bad weather conditions	4.9%	32.1%	43.2%	18.5%	1.2%	2.7901
g) Human factor, e.g. vision	4.9%	25.9%	17.3%	22.2%	29.6%	3.4568

The transportation of petroleum products via road haulage to the Kano Depot in northern Nigeria presents several safety and operational challenges, as evidenced by the survey responses from 81 drivers across ten oil transporting companies. The data, collected using a five-point Likert scale (Never, Rarely, Sometimes, Very Often, Always), provide quantitative insights into the frequency and severity of specific challenges encountered during road haulage. The challenges assessed include highway robbery, poor road conditions, road accidents, mechanical breakdowns, product tank leakages, adverse weather conditions, and human factors (e.g., vision-related issues). The responses were subjected to statistical analysis, with

mean scores calculated to evaluate the prevalence of each challenge. Table 1, shows that:

1. Highway Robbery (Mean: 2.6667): Highway robbery was reported as a moderate challenge, with 45.7% of respondents encountering it "Sometimes," 33.3% "Rarely," and only 1.2% "Always." The mean score of 2.6667 suggests that highway robbery is not a pervasive issue but remains a significant concern for a substantial proportion of drivers. This finding aligns with previous studies (Obasanjo *et al.,* 2014; Tanimowo, 2014), which identified highway robbery as a notable operational risk in Nigeria's downstream petroleum sector. The moderate prevalence may reflect regional variations in security, with northern routes to the Kano Depot potentially experiencing fewer incidents compared to other high-risk areas. However, the fact that 12.3% of drivers reported encountering robbery "Very Often" underscores the need for enhanced security measures, such as convoy systems or improved law enforcement presence along key transport routes.

2. Bad Roads Linking North-South (Mean: 4.1728): Poor road conditions emerged as the most significant challenge, with 40.7% of respondents reporting this issue "Always" and 45.7% "Very Often," resulting in a high mean score of 4.1728. Notably, no respondents indicated that bad roads were "Never" a problem, highlighting the universal impact of poor road infrastructure. This finding corroborates existing literature (Obasanjo *et al.,* 2014) that identifies poor road quality as a primary impediment to efficient petroleum product transportation in Nigeria. The deplorable state of roads linking northern and southern regions exacerbates operational costs, increases transit times, and heightens safety risks. The high mean score suggests that infrastructure deficiencies are a systemic barrier, necessitating urgent investment in road maintenance and upgrades to enhance the safety and efficiency of road haulage.

3. Road Accidents (Mean: 3.6790): Road accidents were reported as a frequent challenge, with 27.2% of respondents experiencing them "Very Often" and 27.2% "Always," yielding a mean score of 3.6790. Additionally, 34.6% encountered accidents "Sometimes," indicating that accidents are a widespread issue. This high incidence aligns with the poor road conditions discussed above, as degraded infrastructure is a known contributor to road accidents (Tanimowo, 2014). The data suggest a strong correlation between road quality and accident frequency, which warrants further statistical analysis to confirm causality. The prevalence of accidents poses significant safety risks to drivers and the public, as well as economic costs due to vehicle damage, product losses, and delays. These findings underscore the need for improved road safety measures, including driver training and stricter enforcement of traffic regulations.

4. Mechanical Breakdowns (Mean: 3.6049): Mechanical breakdowns were reported as a frequent issue, with 45.7% of respondents encountering them "Very Often" and 43.2% "Sometimes," resulting in a mean score of 3.6049. The absence of "Never" responses indicates that mechanical issues are a common challenge across the fleet. This finding may reflect the age and maintenance status of vehicles used for petroleum haulage, as well as the strain imposed by poor road conditions. The high frequency of breakdowns increases operational costs due to repairs and downtime, while also posing safety risks, particularly when transporting flammable petroleum products. These results suggest the need for stricter vehicle maintenance standards and regular inspections to mitigate mechanical failures.

5. Leakages of the Product Tank (Mean: 1.8272): Leakages from product tanks were the least prevalent challenge, with 48.1% of respondents reporting that they "Never" occur and 24.7% "Rarely," resulting in a low mean score of 1.8272. This suggests that tank integrity is generally maintained, possibly due to stringent regulations governing the design and maintenance of petroleum transport vehicles. However, the fact that 23.5% of respondents reported leakages "Sometimes" and 3.7% "Very Often" indicates that this issue, though less frequent, remains a critical safety concern due to the environmental and safety risks associated with petroleum spills. Further investigation into the causes of leakages, such as tank corrosion or loading errors, could inform targeted interventions.

6. Bad Weather Conditions (Mean: 2.7901): Adverse weather conditions were reported as a moderate challenge, with 43.2% of respondents encountering them "Sometimes" and 18.5% "Very Often," yielding a mean score of 2.7901. Only 1.2% reported weather as an "Always" issue, suggesting that it is a seasonal or situational concern rather than a constant barrier. Weather-related challenges, such as heavy rainfall or flooding, can exacerbate poor road conditions and increase the risk of accidents or delays. This finding highlights the need for contingency planning, such as route adjustments during adverse weather, to ensure safe and timely deliveries.

7. Human Factors (e.g., Vision) (Mean: 3.4568): Human factors, such as vision-related issues, were reported as a significant challenge, with 29.6% of

respondents indicating they occur "Always" and 22.2% "Very Often," resulting in a mean score of 3.4568. The high prevalence of human factors may reflect issues such as driver fatigue, poor visibility due to inadequate lighting, or health-related impairments. This finding aligns with the broader literature on road safety, which emphasizes the role of human error in transportation accidents (Jibril, 2023). The data suggest a need for enhanced driver training, regular health screenings, and improved vehicle ergonomics to address human-related safety risks.

Some of these most problematic challenges were further examined to investigate their correlation using the Pearson correlation test (2-tailed) for normally distributed data.

Analysis of Pearson Correlation for Safety-Related Challenges in Road Haulage of Petroleum Products

The Pearson correlation analysis presented in Table 2 examines the relationships between three key safety-related challenges in the road haulage of petroleum products to the Kano Depot in northern Nigeria: bad roads, road accidents, and human factors (e.g., vision and stress). The analysis, based on responses from 81 drivers across ten oil transporting companies, utilises a two-tailed Pearson correlation test to assess the strength and significance of associations between these variables. The sample size (N = 81) provides a robust basis for statistical inference. Table 2 shows the correlation coefficients, their significance levels (p-values), and their implications for understanding safety challenges in Nigeria's downstream petroleum sector, situating the findings in the following ways:

1. Correlation Between Bad Roads and Road Accidents (r = .244, p = .028): The Pearson correlation coefficient between bad roads and road accidents is .244, with a statistically significant p-value of .028 ($p < .05$). This indicates a weak but positive and statistically significant relationship between poor road conditions and the incidence of road accidents. The positive correlation suggests that as the severity of bad road conditions increases, the likelihood of road accidents also rises, albeit to a modest degree. This finding aligns with prior studies (Obasanjo *et al.,* 2014; Tanimowo, 2014), which identify poor road infrastructure as a major contributor to road accidents in Nigeria's petroleum transportation sector. The significance of the correlation (p = .028) underscores the importance of road quality as a determinant of safety outcomes. However, the weak correlation coefficient (r = .244) suggests that other factors, such as driver behaviour or vehicle condition, may also influence accident rates, warranting further investigation into mediating variables.

2. Correlation Between Bad Roads and Human Factors (r = .209, p = .061): The correlation between bad roads and human factors, such as vision and stress, yields a coefficient of .209 with a p-value of .061, which is just above the conventional threshold for statistical significance ($p < .05$). This indicates a weak positive relationship that is not statistically significant at the 95% confidence level but approaches significance. The positive correlation suggests that poor road conditions may contribute to increased stress or vision-related challenges for drivers, potentially due to the physical and mental demands of navigating degraded roads. The near-significant p-value (.061) suggests that this relationship may be meaningful in a practical sense, particularly in the context of Nigeria's challenging road infrastructure, and could achieve significance with a larger sample size or more precise measurement of human factors. This finding complements existing literature (Jibril, 2023), which highlights the role of environmental conditions in exacerbating driver stress and fatigue.

Table 2: Pearson-Correlation for safety-related challenges/constraints (2-tailed)

		Bad roads	Road accidents	Human factor
Bad roads	Pearson-Correlation	1	.244*	.209
	Sig. (2-tailed)		.028	.061
Road accidents	Pearson-Correlation	.244*	1	.054
	Sig. (2-tailed)	.028		.631
Human factor	Pearson-Correlation	.209	.054	1
e.g. vision, stress	Sig. (2-tailed)	.061	.631	
	N	**81**	**81**	**81**

3. Correlation Between Road Accidents and Human Factors (r = .054, p = .631): The correlation between road accidents and human factors is extremely weak, with a coefficient of .054 and a non-significant p-value of .631 ($p > .05$). This indicates no meaningful statistical relationship between these two variables in the context of this study. The lack of a significant correlation suggests that human factors, such as vision or stress, do not strongly predict road accident occurrences within this sample, or that other

unmeasured variables may mediate this relationship. This finding contrasts with some literature (Jibril, 2023), which emphasizes human error as a significant contributor to road accidents. The non-significant result may reflect limitations in the measurement of human factors (e.g., reliance on self-reported data or insufficient granularity in capturing specific human-related issues) or the dominance of external factors, such as road conditions, in driving accident rates.

The significance of Pearson-correlation between road accidents and bad roads led to further evaluation of these variables using the Chi-square which tests the relationship between categorical variables shown in Table 3.

Chi-Square Analysis of the Relationship Between Bad Roads and Road Accidents in Road Haulage

Table 3: Chi-square (bad roads/road accidents)

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	21.481[b]	12	.044
Likelihood Ratio	25.205	12	.014
Linear-by-Linear Association	4.760	1	.029
N Valid Cases	**81**		

The Chi-square analysis presented in Table 3 investigates the association between bad road conditions and road accidents in the context of road haulage of petroleum products to the Kano Depot in northern Nigeria. The analysis, based on survey data from 81 drivers across ten oil transporting companies, employs a Chi-square test to assess whether the frequency of road accidents is significantly related to the prevalence of poor road conditions. The data were collected using a five-point Likert scale, capturing the frequency of bad roads and road accidents as perceived by the drivers. This section provides an academic discussion of the Chi-square results, including the Pearson Chi-Square, Likelihood Ratio, Linear-by-Linear Association, and their implications for understanding safety challenges in Nigeria's downstream petroleum sector.

The Chi-square test results include three key statistics: the Pearson Chi-Square, the Likelihood Ratio, and the Linear-by-Linear Association, each with associated degrees of freedom (df) and asymptotic significance levels (2-sided p-values). The sample size (N = 81) provides sufficient data for reliable statistical inference.

The results are as follows:

a) Pearson Chi-Square: Value = 21.481, df = 12, p = .044
b) Likelihood Ratio: Value = 25.205, df = 12, p = .014
c) Linear-by-Linear Association: Value = 4.760, df = 1, p = .029
d) N Valid Cases: 81

The results are summarized as follows:

1. Pearson Chi-Square (Value = 21.481, df = 12, p = .044)*:* The Pearson Chi-Square test yields a value of 21.481 with 12 degrees of freedom and a p-value of .044, which is statistically significant at the 95% confidence level ($p < .05$). This indicates that there is a significant association between bad road conditions and the occurrence of road accidents. The significant p-value suggests that the frequency of road accidents is not independent of the quality of road infrastructure, supporting the hypothesis that poor road conditions contribute to increased accident rates. This finding aligns with prior studies (Obasanjo *et al.,* 2014; Tanimowo, 2014), which identify poor road quality as a major risk factor in Nigeria's petroleum transportation sector. The degrees of freedom (df = 12) reflect the contingency table structure, likely derived from the five-point Likert scale categories for both variables, resulting in a 5x5 table (minus one row and column for calculation).

2. Likelihood Ratio (Value = 25.205, df = 12, p = .014)*:* The Likelihood Ratio test, an alternative to the Pearson Chi-Square, produces a value of 25.205 with a p-value of .014, also indicating statistical significance ($p < .05$). The lower p-value compared to the Pearson Chi-Square suggests a stronger rejection of the null hypothesis that bad roads and road accidents are independent. The Likelihood Ratio is particularly useful when sample sizes are moderate or when expected cell counts in the contingency table are low, as it provides a robust measure of association. The consistency between the Pearson Chi-Square and Likelihood Ratio results strengthens the conclusion that poor road conditions are significantly associated with road accidents, reinforcing the critical role of infrastructure quality in transportation safety.

3. Linear-by-Linear Association (Value = 4.760, df = 1, p = .029)*:* The Linear-by-Linear Association test, with a value of 4.760, 1 degree of freedom, and a p-value of .029, tests for a linear trend in the relationship between bad roads and road accidents. The significant p-value ($p < .05$) indicates that there is a linear association between the ordinal categories of the two variables, suggesting that as the perceived severity of bad road conditions increases (e.g., from "Never" to "Always" on the Likert

scale), the frequency of road accidents also tends to increase. This linear trend is consistent with the earlier Pearson correlation analysis (r = .244, p = .028), which identified a weak but significant positive relationship between these variables. The Linear-by-Linear Association test is particularly relevant given the ordinal nature of the Likert scale data, providing evidence of a dose-response relationship where worsening road conditions correspond to higher accident risks.

The significant results from the Chi-square tests (Pearson, Likelihood Ratio, and Linear-by-Linear Association) collectively confirm a robust association between bad road conditions and road accidents in the road haulage of petroleum products to the Kano Depot. These findings highlight the critical impact of poor road infrastructure on transportation safety, corroborating earlier survey results that identified bad roads as the most prevalent challenge (mean = 4.1728) and road accidents as a frequent issue (mean = 3.6790). The statistical significance of the association underscores the urgent need for infrastructure improvements to mitigate safety risks in Nigeria's downstream petroleum sector. Poor road conditions not only increase the likelihood of accidents but also contribute to operational inefficiencies, such as increased transit times and vehicle wear, which elevate costs and exacerbate safety hazards due to the flammable nature of petroleum products.

The Linear-by-Linear Association result further suggests that the relationship between road conditions and accidents is not merely categorical but follows a trend where incremental deteriorations in road quality lead to progressively higher accident risks. This insight is critical for policymakers, as it emphasizes the need for targeted interventions to address road maintenance across varying levels of infrastructure degradation. The findings align with existing literature (Jibril, 2023), which highlights the systemic challenges of poor transportation infrastructure in Nigeria and its implications for the petroleum supply chain.

The result above is similar to an independent report obtained from the investigation by Daily-trust which revealed: "270 persons were killed while 221 others sustained varying degrees of injuries in different parts of the country as a result of fire outbreaks from petrol-tanker explosions between 2018 & August 2020" (Mac-Leva *et al.,* 2020). It revealed a total of 31 incidents reviewed were recorded in 15 states also led to the burning or destruction of property, including houses and vehicles in billions of naira. Stakeholders, including NUPENG, PTD, and PENGASSAN attributed tanker fire accidents to several factors such as bad roads, mechanical breakdown due to fake spare parts, drug addiction, and recklessness on the part of drivers

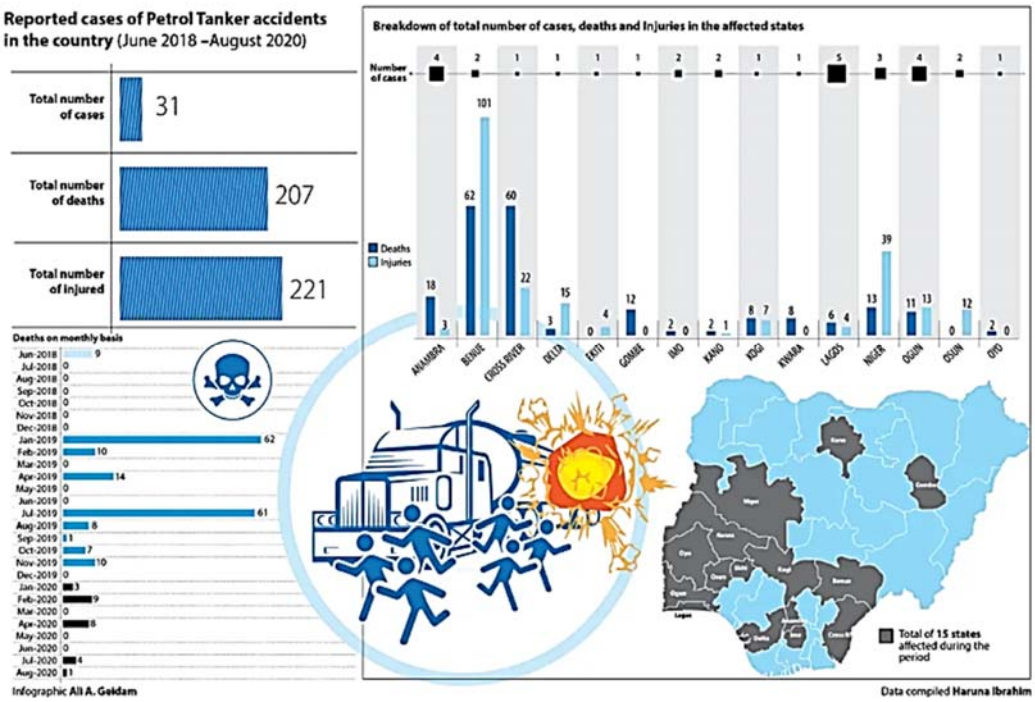

Figure 4: Daily-Trust report
(Source: https://dailytrust.com/tanker-fire-kills-207-injures-221-in-3-years)

The cost associated with haulage of petroleum product

Responses on some cost-related factors were obtained using SPSS. Factors such as shortages in liters delivered, union taxation, checkpoints extortion, and delays in offloading are cost-related.

The mean of rank order is shown in Table 4.

Table 4: Descriptive statistics for cost-related factors

	N	Mean
Delay in loading	81	3.0988
Delay in offloading	81	2.9259
Shortages in litres delivered	81	3.9136
Unions taxation	81	4.7778
Product siphoning	81	1.9136
Checkpoints extortion	81	3.8642
Truck inspection penalties at depots	81	3.4815
Delays in payment for haulage	81	2.8765
Valid N	**81**	

Table 4 deduced that union taxation with a mean of 4.7778 is one of the most challenging cost aspects. Other cost-challenging aspects include shortages in the quantity of products, extortion at checkpoints, and delays in loading and offloading amongst others.

Secondary sources reveal shortages in quantity delivered have an impact on cost because transporting companies are paid based on the quantity of product delivered. Upon arrival, trucks are unloaded and litres recorded. Any shortage would reflect on the transporters' pay slips. This led to further examination of variables using Chi-square to test for inter-dependence of some variables.

Table 5 shows the value of chi-square statistics involving delays in offloading and shortages. A P-value of 0.003 indicates a significance level at $p < 0.05$. Interpreted as delays in offloading might lead to losses due to the volatile nature of the product.

Table 5: Chi-Square (Delay in offloading and shortages)

	Value	Df	Asymp Sig. (2-sided)
Pearson Chi-Square	36.186[b]	16	.003
Likelihood Ratio	37.859	16	.002
Linear-by-Linear Association	2.280	1	.131

The cost of transportation by road is calculated per litres delivered using a template of approved freight rates. The approved freight rate from Lagos-Kano is N19.05/liter, Warri-Kano is N17.32/liter, Mosimi-Kano is N18.57/liter, etc. (NEITI, 2019). Hence shortages impact the cost of haulage. (Freight rate is subject to periodic review)

Delays in transit occasioned by frequent harassment from law enforcement are critical instances where un-receipted payments are made (Ubogu *et al.,* 2011). This adds up to the ever-increasing delivery costs of products to destined locations (Obansanjo *et al.,* 2014)

Assessment of some positive and negative impact of road transportation on socio-economic activities

Positive Impact

From the survey, job creation was ranked extremely significant because the trucking system provides thousands of jobs to youths; drivers, the popularly called ‘motor boys’, mechanics, spare parts suppliers, etc. Payment of taxes to governments and unions contributes to revenue generation.

Relationships between some variables were examined using Pearson correlation obtained from SPSS shown in Table 6;

Table 6: Pearson-correlation

		Job creation	Revenue generation	Stimulate economic activities
Job creation	Pearson-Correlation	1	.320**	.161
	Sig. (2-tailed)		.004	.151
Revenue generation	Pearson Correlation	.320**	1	.120
	Sig. (2-tailed)	.004		.284
Stimulate economic activities at stop-overs	Pearson-Correlation	.161	.120	1
	Sig. (2-tailed)	.151	.284	
	N	**81**	**81**	**81**

Table 6 shows the correlation between the three variables. Interpretation of the result reveals a moderate degree correlation; job creation and revenue generation with a Pearson-correlation value of 0.320** and significance level of 0.004 with a p-value less than 0.05, implies statistically significant. It concludes that transportation by road trucks has a significant positive impact on socioeconomic activities.

Negative Impact

Table 7: Descriptive Statistics

	N	Mean
Nuisance to road users	81	2.8025
Stopovers cause gridlocks	81	2.6914
Loss of product quality	81	1.6420
Environmental pollution	81	2.0988
Unions strike leading to scarcity	81	4.5432
Immoral activities at stop-overs	81	2.9630
Valid N	**81**	

The result above shows road transportation has a negative impact as much as positive. Constitute nuisance to road users through reckless driving, illegal parking, blockade, and industrial actions by their unions showing grievances against policies/regulations thereby creating scarcity.

Road accidents involving petrol tankers and reports of reckless driving by road users led to further examination of two variables; Road accidents and reckless driving. The result of the cross-tabulation is given by Pearson chi-square for independent variables shown in Table 8;

Table 8: Chi-Square (road accidents and reckless driving)

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	30.245[b]	16	0.017
Likelihood Ratio	34.862	16	0.004
Linear-by-Linear Association	4.526	1	0.033
N of Valid Cases	**81**		

The resulting asymptotic significance of 0.017 is significant because it is less than the designated alpha level selected for this study (i.e. α=0.05). Thus the data suggest that the variables road are indeed associated.

Conclusion

The study on road haulage of petroleum products to the Kano Depot concludes that major safety constraints include poor road conditions, road accidents, mechanical breakdowns, and human factors, highlighting the need for infrastructure improvements and driver training. Petroleum product supply sources are primarily Apapa (Lagos), Warri, Port Harcourt, Mosimi, and privately owned depots, reflecting a diversified supply chain reliant on road transport. Cost-related factors, such as shortages in delivered litres, unions' taxation, checkpoint extortion, and truck inspection penalties, significantly increase transportation costs. Road haulage has both positive socio-economic impacts, including job creation, revenue generation, and nationwide product availability, and negative impacts, such as safety risks and economic inefficiencies, necessitating targeted interventions to enhance safety and efficiency.

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