

# COMPARATIVE STUDY ON LOAD CARRYING CAPACITY OF TRUCK AND TRAIN FOR POSSIBLE INTERMODAL INTERCHANGE IN NIGERIA

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## ABSTRACT

*An intermodal interchange is a point at which a seamless transition between two or more transportation modes is obtained. In Nigeria today, the only such facility is at the ports after which all inland transportation of freight is done by truck. Lack of an intermodal interchange has prevented Nigeria as a nation to join in the economy of scale that many nations are using to boost their gross domestic product (GDP). The aim of the study is to highlight the importance of the new trend in train freight carrying capacity for the realization of the impact of economy of scale from intermodal transport system. This study assessed the need to incorporate intermodal interchanges between road and rail as the nation is now constructing new big gauge railway access. Assessment of volume of freight carried by truck in Nigeria was compared with the capacity of a modern 60 and 100 car train. Findings indicate that the modern 60 and 100 car train carries much more tonnage of freight as compared to truck; in fact a few trains can serve Nigeria's freight lifting need optimally and also help in decongesting and sustaining the overall transport infrastructure. It was also found that, introducing intermodal interchanges between road and rail will go a long way in facilitating movement of goods and services and also create a means for economic diversification in the form of better economy of scale. It was recommended that there should be better synergy between government and major players in the private sector to optimize the opportunity offered by an intermodal interchange between rail and road in Nigeria.*

**Keywords:** Intermodal, Interchange, Seamless, Economy, Scale

## 1 INTRODUCTION

The terminal is a key component of the intermodal system since it has to ensure an efficient interchange between road, rail and other transport modes. The higher the carrying capacity of the mode vehicle, the better for transporting especially bulk freight. Intermodal interchanges are always located where smaller carrying capacity vehicles will converge to off load onto a larger single vehicle for onward delivery or vice-versa. This makes information and security on the cargo cheaper and accessible. Also if the cargo is fluid and transported through pipe, it can be pumped directly into a waiting vehicle at the interchange terminal [1]. The high rate of road deterioration, traffic congestion resulting into time and fuel loss due to delays on transit, loss of goods and lives to accidents and fast wearing of vehicles are eminent when only one mode in this case, road transport is utilized. Although road deterioration can be caused by other means, excessive and repetitive axle and wheel loads from traffic and freight cause more damage to roads. The use of intermodal transportation system will ease the major highways of frequent fatigue failure, thereby reducing maintenance cost. But ultimately, intermodal transportation system increases the important effect of economy of scale where by the cost of transportation is inversely proportional to the volume of freight lifted. This phenomenon is essential in leveling the end cost of commodities across the nation as the cost of transportation is low, but at present, this is not effective in Nigeria as cost of transportation is very high due to bad roads and lack of intermodal interchange to connect existing modes for intermodalism

Nigeria is facing formidable challenges in its transportation sector: road deterioration and rehabilitation has become the order of the day, congestion has reached an unprecedented level in many cities, and commerce has been crawling for long. All of these and more are as a result of a single transport mode being over exploited in Nigeria, this mode is the “road” transport.[2]..A better integration between road and rail through the construction of intermodal interchanges is a better way to improve the overall efficiency of the transportation system and build better economy of scale [3]. Basically, there are three types of intermodal terminals, each having their own locational and equipment requirements [4, 5]. The three types are as listed below: 1. Port terminals. They are the most substantial intermodal terminals in terms of traffic, space consumption and capital requirement. A container sea terminal provides an interface between the maritime and inland system of circulation. The growth of long distance maritime container shipping has also favored the emergence of intermediate hub terminals, some having an offshore location. The terminal is used as a buffer while containers wait to be loaded on another ship. The containerization of inland river systems has led to the development of an array of barge terminals linked with major deep sea terminals with scheduled barge services. At the maritime container terminal, barges can either use regular docking area or have their own terminal facilities if congestion is an issue. 2. Rail terminals. For inland intermodal chains rail terminals are linked with port terminals. The fundamental difference between an on-dock and a near-dock rail facility is not necessary the distance from the terminal facilities, but terminal clearance, [6]. While for an on-dock rail terminal containers can be moved directly from the dock (or the storage areas) to a railcar using the terminal’s own equipment, accessing a near-dock facility requires clearing the terminal’s gate (delays), using the local road system (congestion) and clearing the gate of the near-dock rail terminal (delays). On dock terminals tend to be designed to only handle containers on flatcars (COFC). Near-dock facilities tend to have more space available and can thus play a significant role in the maritime / rail interface, particularly if they are combined with transloading activities.3. Distribution centers. Represent a distinct category of intermodal terminals performing an array of value added functions, with transmodal operations dominantly supported by trucking. Distribution centers can perform three major functions. A transloading facility mainly transfers the contents of maritime containers into domestic containers or truckloads (or vice-versa). It is common in North America to have three 40 foot maritime containers transferred into two 53 foot domestic containers. Sometimes, shipments are palletized as part of the transloading process since many containers are floor loaded. Cross-docking is another significant function that commonly takes place in the last segment of the retail supply chain. With very limited storage, the contents of inbound loads are sorted and transloaded to their final destinations. Warehousing is a standard function still performed by a majority of distribution centers that act as buffers and points of consolidation or deconsolidation within supply chains. Figure 1.0 shows the layout of the three basic intermodal terminals and how they function.

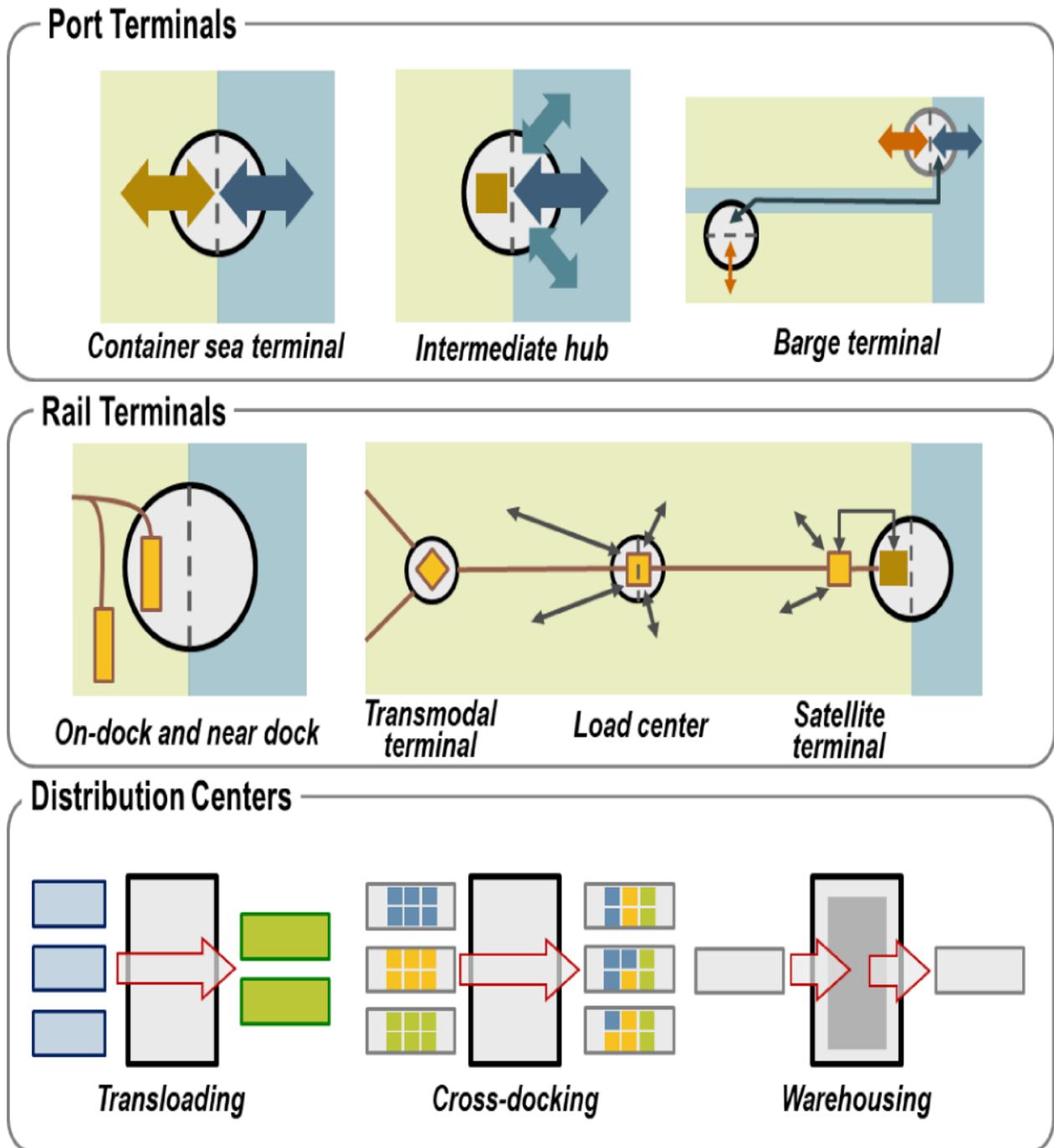


Figure 1. Basic types of intermodal terminals [7]

## 2 FACTORS THAT DETERMINE THE POINT FOR INTERMODAL INTERCHANGE

### *Transportation Mode Option*

Transport modes are designed to either carry passengers or freight, but most modes can carry a combination of both,[8]. For instance, an automobile has a capacity to carry some freight while a passenger plane has a belly hold that is used for luggage and cargo. Each mode is characterized by a set of technical, operational and commercial characteristics. Technical characteristics relate to attributes such as speed, capacity and motive technology while operational characteristics involve the context in which modes operated, including speed limits, safety conditions or operating hours, [9]. The demand for transport and the ownership of modes are dominant commercial characteristics.[1]

Mode option determines the frequency and volume of freight and passengers using the mode [10] . Intermodal interchange is located where such volume of freight and passenger is obtainable [11].

*Round the clock (24/7) accessibility.* Intermodal terminals should have 24/7 accessibility, which provides carriers maximum flexibility, particularly in the times they can pick up loads and bring them into ramps (at origins), or pick up at ramps and deliver to customers (at destinations), [12]. In contrast, a terminal that is accessible only eight hours per day, five days a week for example, results in a higher cost to serve because all the work needs to be concentrated in a tighter window of time. Terminals with fewer operating hours can still offer excellent service, but the cost of providing that excellence is higher.

*Density.* If intermodal rail terminals have or enable higher volumes, they can also enable higher service levels. "Typically, terminals with high density levels offer more service options, including more sources of backup assistance," [13]. While building consistent, repeatable processes is always the cornerstone of service excellence, having a backup supply has merit. Even just-in-time operations typically keep some level of safety stock. But lower density levels do not automatically result in low service or high cost, [14]. For example, terminals closer to shipping or receiving point can provide lower dray costs versus denser long dray coverage from a larger ramp. Or a smaller location may enable a more customized solution, versus the standard options available at a larger location. There are always tradeoffs, but in general, density enables low-cost, high-service options.

### **3 METHODOLOGY**

The combination of desktop and detailed comparative study was used to obtain data for the study. The desktop was done through the review of relevant literatures and journals. Data for volume of truck traffic on Nigeria's trunk-A- road was obtained from the values on the map in figure 2. The total number of trucks needed to carry both petrol and other freights was estimated based on the standard axle load of a five (5) axle truck which is 46 tons. The equivalent number of 60 and 100 car train needed to carry both petrol and other freights was also estimated based on the standard 60 and 100 car train capacity which is 4,400 ton and 12,500 ton respectively. The concept of load carrying capacity which leads to the advantage of economy of scale was critically considered. The comparison between truck axel load and modern train load carrying capacity, number of truck versus number of 60 and 100 car train needed to carry petrol, cement and other freights in Nigeria was analysed. The data were analysed and presented using descriptive statistics (bar charts, frequency tables).



Table 1. Volume of heavy vehicle traffic (Trucks) flow on Nigeria’s trunk A roads

S/N	Trunk Location	ZONE	Number of trucks/Day
1	Lagos-Shagamu	South	5000
2	Shagamu-Illorin	South	2800
3	Illorin-Jebba	South	2200
4	Jebba-Abuja	South	2070
5	Shagamu-Benin City	South	3100
6	Benin City-Lokoja	South	1000
7	Lokoja-Abuja	South	900
8	Benin City-Enugu	South	4000
9	Port-Harcourt-Enugu	South	2200
10	Port-Hacourt-Benin City	South	350
11	Enugu-Makurdi	South	920
12	Makurdi-Akwanga	South	400
13	Akwanga=Abuja	South	250
14	Port-Hacort-Calabar	South	1000
15	Enugu-Mfum	South	1000
16	Abua-Kaduna	North	800
17	Kaduna-Zaria	North	900
18	Zaria-Sokoto	North	420
19	Sokoto-Illia	North	100
20	Zaria-Kano	North	480
21	Kano-Katsina	North	630
22	Kano-Potiskum	North	200
23	Potisum-Maiduguri	North	920
24	Maiduguru-Nigala	North	1000
25	Akwanga-Jos	North	220
26	Jos-Bauchi	North	380
27	Bauchi-Yola	North	370
28	Total-South	27190	
	North	6420	

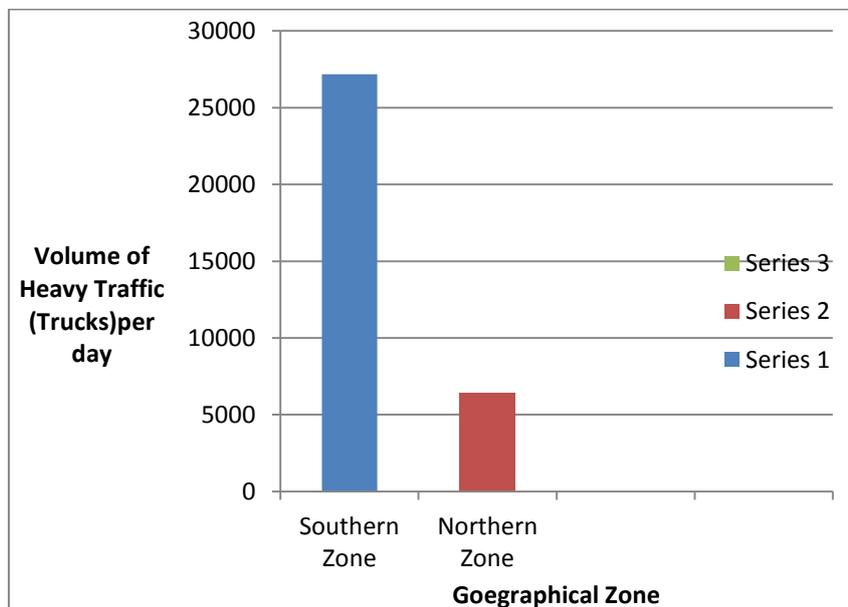


Figure 3. Bar Chart representations of the Volume of Heavy Traffic (Trucks) per day in southern and northern zones in Nigeria

#### 4.2 Volume of petrol and number of trucks needed for daily supply in Nigeria.

In the past four years, between 2016 and 2019 the volume of petrol used daily in Nigeria rose to 51 million liters per day while the daily refining capacity was 445,000 barrels (70,700cubic meter)

per day [16]. In Nigeria, transportation of all freight including petrol is done using trucks making it very cumbersome and highly risky. The capacity of trucks depends on their varying axel loading. The more the number of axel, the more the tonnage the truck can carry. Almost 100% of trucks transporting petrol in Nigeria are in the class of truck and drawbar trailer with five (5) axels, [17]. The total estimate of trucks needed to transport the daily petrol volume in Nigeria based on standard 5 axle load is 1109 trucks. From the estimate, it is seen that one thousand one hundred and nine (1109), five axels trucks are needed to supply petrol in Nigeria daily. This number of trucks carry 51 million liter of petrol daily, which translate to 51 thousand tons of lifted freight daily apart from the truck weight. All of this freight is coming from the southern region to be distributed all over the country. This freight and truck load is repeated daily over the same road causing unimaginable damage to the road and loss of lives and properties not to mention delay.

#### 4.3 Tonnage analysis of other freights and number of trucks carrying them

The total number of trucks used on daily bases in Nigeria is approximately 33,610 (Table 2). Out of this total, only 1109 trucks are used for the supply of the daily petrol needed in Nigeria. The remaining 32501 are used for the transportation of other freights. These other freights consist of the various basic needs and consumables including vehicles, spare parts, meat, and clothes furniture e t c. Most of these freights originate from the south because of the location of the company’s manufacturing them. This brings in the estimated load of about 1495046 tons to bear on the road together with the petrol load. From other freights, the daily tonnage applied on Nigerian road is 1,495,046tons. This shows that, lifting other freights apart from petrol causes more damage to the road than lifting petrol alone. So if the transportation of petrol alone is considered for intermodalism, the problem of road deterioration, loss of lives and properties, delay and so on wouldn’t have been solved. So the transportation of petrol which most people see as the main cause of road transportation problems in Nigeria especially road deterioration, is not necessarily so. But one very important aspect of tanker trucks that causes so much distress when it happens is the nature of accidents prevalent with tanker trucks. Whenever there is an accident, the entire or part of the road is always blocked leading to a temporary diversion that consume more time of delivery. Also, sometimes the truck may explode spilling fuel that causes severe damage to the road and fire that burn down properties and even kill people. All refineries and jetties in Nigeria are located in the south making every part of the nation to go down south for fuel supply. This brings about heavy traffic congestion because of the number of trucks going to the same place. With intermodal interchange between road and rail, petrol could be lifted in few tanker trains for onward delivery to trucks.

Table 2 Total tonnages, number of trucks and estimated load from Dangote and Ashaka Cement factories in Nigeria (Using standard axle load factor).

Factory	Capacity(Mta)	Number of Trucks	Estimated Load on Road( Tons)
Dangote	29.5Mta	4658	214268
Ashaka	10.5Mta	900	41400
Total	40.0Mta	5558	255668

Table 3. Estimated numbers of 60 and 100 cars train needed to carry petrol, Dangote and Ashaka cement and other freights in Nigeria (Using standard train car loading factor).

S/N	Freight Type	Tonnage	Truck Capacity(Tons)	Number of Trucks	Train Capacity(Tons) (60 and 100 Cars)	Number of Trains(60 and 100 cars)
1	Petrol	51000	46	1109	4,400 12.500	12 4
2	Other freights	1495046	46	32501	4,400 12.500	340 120
3	Cement	316222	46 and 59	5558	4,400 12,500	72 25

From results in Table 3, it is obvious that freight from other source apart from petrol and cement contributes more in road congestion and road damage on Nigerian roads. This freight from other source contains basic daily needs like beef, grains, beverages, consumables, wears, timber, steel, water, bitumen, gas. Freight from other source is about 350% more in tonnage than freight from both cement from Dangote and Ashaka, and petrol put together. From Table 3, the number of delivery trucks for other freight is about 500% more than that for delivering both cement from Dangote and Ashaka, and petrol. Table 3, shows the number of 60 and 100 cars freight train needed to carry other freights, petrol and cement in Nigeria. From the low number of train needed to transport freights in Nigeria, the need for intermodalism interchange between rail and road in Nigeria is paramount. From data obtained, it was discovered that the tonnage of freight from other commodities by far outweigh the tonnage of freight from both petrol and cement which was thought to be the culprit for road deterioration in Nigeria. Also, most of this commodities and even petrol originates from the south, making prices of commodities higher in the north and road congestion and deterioration worst in the south. It was also estimated based on the capacity of both truck and train the number of 60 and 100 car train needed to lift all commodities in Nigeria. It was discovered that fewer number of trains are needed as compared to the number of trucks in lifting freight. From the view point of the importance of economy of scale, it was discovered from the study that the availability of different types of freight in Nigeria, coupled with the disparity in prices of commodity across the country, there is an immediate need for an intermodal interchange between road and rail. Repeated axle loading from thousands of trucks daily on Nigeria's road leads to incessant deterioration and rehabilitation that consumes lots of money that could have been used for developing other sectors. The introduction of intermodal interchange as seen from the study can bring about sustainability of the entire transport system in the country.

## **5 CONCLUSIONS**

From the research, it was discovered that fewer cargo train can solve the problem of traffic congestion and freight lifting in Nigeria if the needed points of intermodal interchange are put in place between rail and road. For intermodal transport to be effective as seen from the study, freight must be generated and available at all times, security must be provided round the clock and transportation infrastructures must be in good conditions. In the case of Nigeria, it is seen from the study that freight is readily available, security can be provided but the condition of infrastructures is not in good shape, also the road and rail are not connected by an intermodal interchange for easy transfer of freight. With the advent of the standard gauge railway construction going on in Nigeria, it is very possible for an intermodal connection between rail and road to be implemented to meet up with the required standards for intermodalism. Private sectors like Dangote factories and others who use much number of trucks to transport there products, should be integrated into the transport system planning and implementation committees for better synergy between government and private sectors.

## **REFERENCES**

1. Rodrigue, J.P. (2015). Transportation Modes, Modal Competition and Modal Shift. *Journal of Transport Geography*, vol. 7, pp. 255-259.
2. Agbo-Paul, A. (2017). Abuja-Kaduna Road: The Bad, The Ugly. Leadership Newspaper, pp. 1-3.
3. Weisbrod, G. and Fitzroy, S. (2011). Traffic Congestion Effects on Supply Chain; Accounting for Behavioral Element in Planning and Economic Impact Models. *Publishing House Intech Open Limited, 5 Princes Gate Court London. SW72QJ. UNITED KINGDOM*, pp. 1-264.
4. U.S Department of Transportation (2006). Annual Conditions and Performance Report, Bureau of Transportation Statistics, Washington DC 20590 368-4200, pp. 368-4,200.
5. Jean-Paul, R. (2006). Intermodal Transportation and Integrated Transport Systems: Space, Networks and Flow. Paper presented at the "Flowpolis". *The form of Nodal Space Conference, Las Palmas de Gran Canaria, Spain*, pp. 1-14.

6. Edge, G. (1998). A Century of Petroleum Transport. Roundoak Publishing, ISBN 978-1-8715-6527-0, pp. 1-197.
7. US DOT (2015). The Geography of Transportation Systems, The Spatial Organization of Transportation and Mobility. *Journal of Geographical Sciences*, vol. 26, no. 8, pp. 1067-1080.
8. Laetitia, D. (2007). Good Transport in Large European Cities: Difficult to Organize, Difficult to Modernize. *Journal of Transportation Research Part A: Policy and Policy and Practice*, vol. 41, Issue 3, pp. 280-331.
9. Eng-Larsson, F. and Kohn, C. (2012). Modal Shift for Greener Logistics the Shipper's Perspective. *International Journal of Physical Distribution & Logistics Management*, vol. 42, no. 1, pp. 36-59.
10. Clay, K., Jha, A., Muller, N. and Walsh, R. (2017). The External Costs of Transporting Petroleum Products by Pipelines and Rail: Evidence From Shipments of Crude Oil from North Dakota *The Energy Journal, International Association for Energy Economics*, vol. 1, pp. 397-415.
11. Crainic, T.G., Nicoletta, R. and Giovanni, S. (2004). The-Day-Before Planning for Advanced Freight Transportation Systems in Congested Urban Areas. *Journal of Transportation Research C: Emerging Technologies*, vol. 12, no. 2, pp. 119-137.
12. U.S Department of Transportation (2002). Federal Highway Administration, Office of Freight Analysis Frame Work. *Bureau of Transportation Statistics Washington, DC 20590 800*, pp. 853-1351
13. Bertini, R.L. and Show, A. (2002). Generating Performance Measures from Portland's Archived Traffic Management System Data. *Journal of the Transportation Research Board*, vol. 1, pp 101-111.
14. European Commission (2006). Sustainable Urban Transport Planning. <https://ec.europa>urban> mobility. *Action*, 106p.
15. Olumide, I. (2014). Railway: The return of the economic live wire. *Vanguard News 2 march*, 2014, 6p.
16. Petroleum Product Pricing Regulatory Agency (2019). Abuja Petroleum Support Fund (PSF) Policy and Procedure Manual, pp. 1-258.
17. Oladayo, K. (2015). Overseeing the resurrection of Nigerian railways. *News Agency of Nigeria*, pp. 4-7.