Minimizing Carbon Footprint from Road Freight Transportation: A Systematic Review of Literature

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Abstract

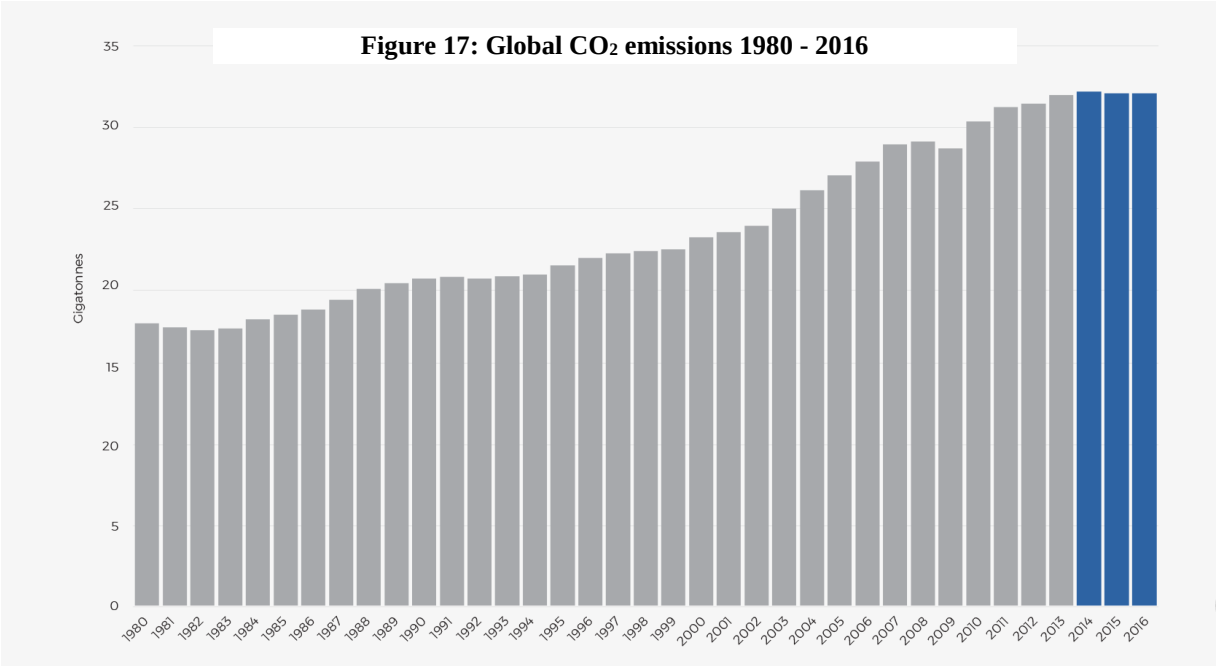
Over the years with the rapid industrialization, the percentage of Greenhouse gas (GHG) emissions has increased drastically. Among the GHGs in the atmosphere Carbon Dioxide has accounted for the highest percentage. Within the past few decades, the atmospheric Carbon concentration has shown a rapid increase thus grabbing the attention of the world population in moving towards emission minimizing strategies. Transportation is accounted as one of the highest contributors of Carbon emission across different regions of the globe. Globalization has allowed the businesses to function as a single unit thus lengthening the supply chains and making it a strong contributor to the increasing Carbon footprint by means of transportation via different modes such as land, sea, air and pipeline. Inland freight transportation is mainly carried out either as road or rail transportation and when considering the breakdown due to agility and flexibility required in modern supply chains, road transportation is mainly practised worldwide. The amount of Carbon footprint left from the road freight transportation varies with many factors, starting from the vehicle type and fuel type up to changes in the business strategies of the firm. Hence most of the business organizations place an increased concern on their logistics activities in order to reduce the percentage of their emissions thus practising a sustainable organizational policy. Based on the literature review, it is supposed to identify the factors that affect the rate of Carbon emission from road freight transportation and the currently available reduction measures that are practised within organizations. This study presents a conceptual framework for carbon emission reduction and factors that affect the rate of carbon emission from road freight transportation, through a comprehensive and systematic review of literature. Hence, the paper will provide an insight in the current available knowledge in the research area and will act as a guide for future research.

Keywords: Carbon Footprint, GHG Emissions, Transportation, Road Freight

INTRODUCTION

Carbon Footprint; "The Carbon Footprint is a measure of the exclusive total amount of Carbon Dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product"(Wiedmann & Minx, 2008). Carbon footprint has significantly increased over the years as seen in Figure 1 and thus this has led to major climatic changes and environmental imbalance.

Figure 17: Global CO_2 emissions 1980 - 2016



Source - (IEA, 2017)

Over the past decade the concern on the Carbon Footprint has drastically increased within the world community. Various researches have been carried out by global and regional environmental organizations as well as by academic community, in relevance to the topic, its effects on the global climate and the mitigation practices. Hence various global goals are set to be achieved within the next upcoming decades. According to recommendations from the Inter-governmental Panel on Climatic Change (IPCC), the accepted level of atmospheric Carbon Dioxide (CO_2) concentration should be limited to 450ppm or below with the globally acknowledged increase in the world temperature, limited to 2^0C,by 2100 relative to the pre-industrial levels (IPCC , 2014).The pathway for the achievement of this goal will require huge reduction in the total CO_2 emissions compared to previous emissions recorded.

Global surveys are carried out yearly to identify the percentage wise contribution from different economic sectors for the Carbon emission thus enabling the governments and the industry in planning proper practices to mitigate the emissions from each sector. Data from International Energy Agency (IEA), 2017 report of highlights from CO_2 emissions from fuel combustion as shown in Figure 2 Electricity and Heat as the highest sector with 42% contribution and Transport as the second highest with a contribution of 24%.(IEA, 2017)

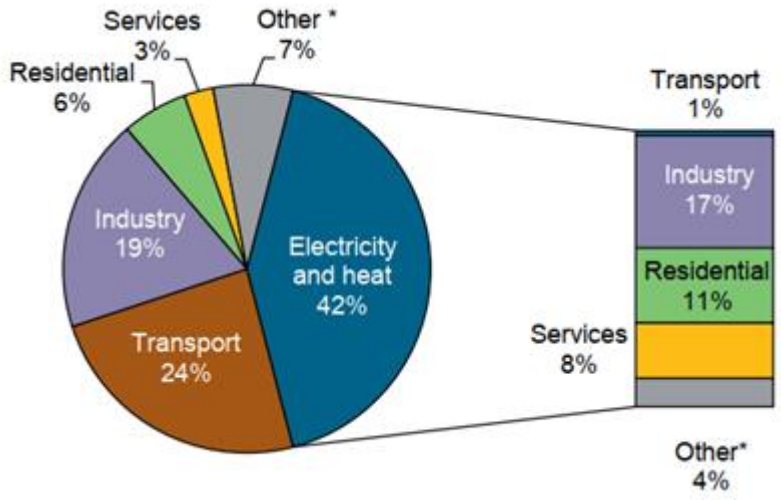


Figure 18: Economic Sector wise Global CO_2 emissions

Source - (IEA, 2017)

Despite of the various modes of transportation available such as road, rail, air, sea/ water ways and pipelines the mainly practised mode of transportation worldwide for both passenger and cargo transportation is by land. Specifically when focusing on the inland industrial cargo transportation, road ways are the most common medium used. (Ang-Olson & Schroeer, 2002)Hence business organizations are now focusing on the reduction of CO_2 emissions from their transportation activities and various researches have been carried out over the years to analyze the factors that contribute for the escalation of CO_2 emissions from road freight transportation. Many of the researches carried out have followed the qualitative approach to

find out the factors and their relative percentage effect on the emissions, while some researches have focused on forecasting the CO_2 emission amounts within the near future, thereby suggesting strategies to reduce the emission based on the factors found such as, structural considerations of the vehicles, commercial factors, operational factors, functional factors, product related factors and external factors like government policies etc. (Piecyk & McKinnon, 2010)

This study systematically analyses the available literature with the intention of ascertaining areas with knowledge gaps in factors that affect the rate of Carbon emission from road freight transportation. The findings of this study will assist in moving towards sustainability in transportation.

The paper is structured as follows; methodology of the study, review of literature, discussion of the factors identified and finally the conclusion of the study along with a guidance for future research.

METHODOLOGY

A productive literature review has the power to lay down the foundation for advancing knowledge while unveiling the unsought research areas for future studies(Webster & Watson, 2002). Hence, in developing a flourishing literature review,a prime importance should be given to the process of selecting research articles.First, articles were searched via a simple web search based on keywords related to the study area and based on the year of publication which is targeted to be between 1995 and 2017 in order to ensure the relevance of the study to current context. This resulted in a total of twenty-three articles. Then, the articles were screened based on their title and the abstract, to examine the applicability in the area of concern. This phase resulted in the rejection of eight articles. In the next step, full scripts of the remaining articles were thoroughly examined to identify the relevance and the contribution to the study area. This secondary screening process resulted in the rejection of five more articles thus leaving fifteen articles as the final sample taken for the literature review. The selection process followed is given in the Figure 3 and all the studied articles are stated in the list of references.

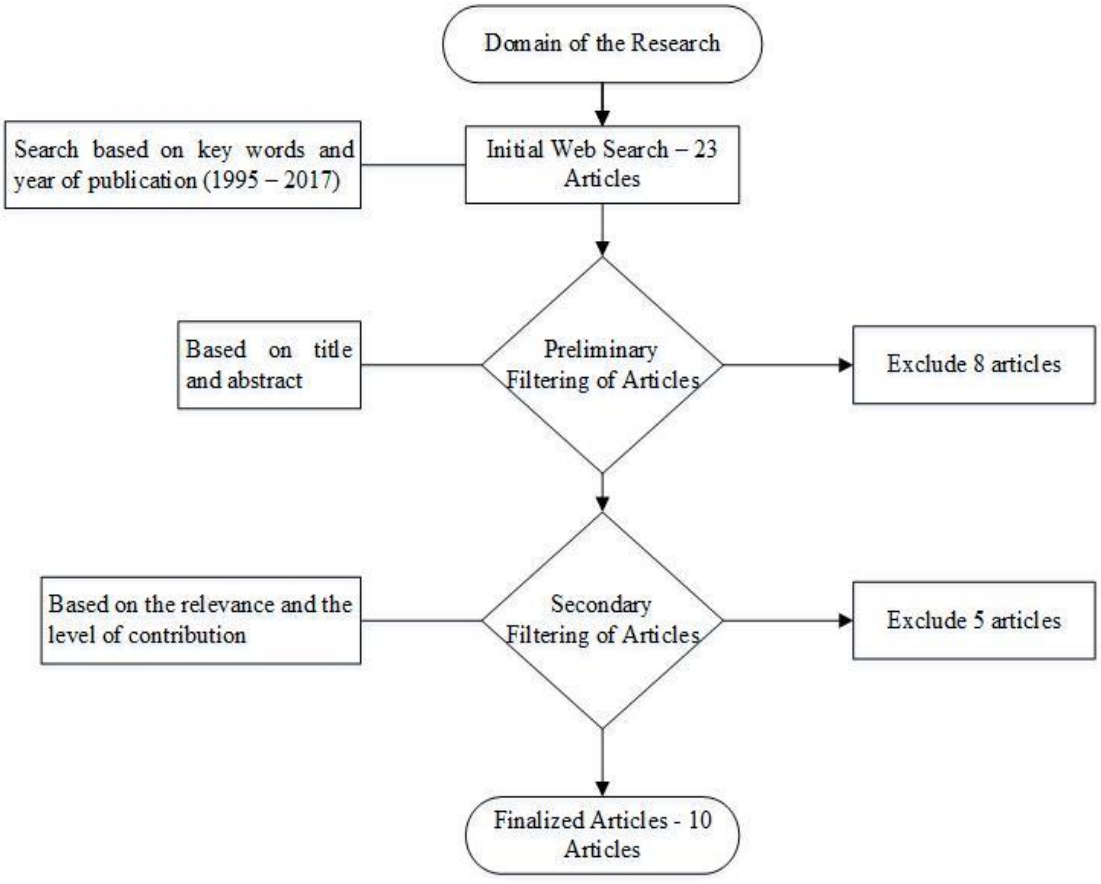


Figure 19: Screening Process

Selected pool of research papers were systematically analysed to identify the factors that affect the rate of Carbon emission from road freight transportation and based on the knowledge attained a conceptual framework was developed.

MAIN RESULTS OF THE REVIEWED STUDIES

Over the years, many researchers have contributed to literature on Carbon emission from road transportation. These researches have covered; the factors that can affect therate of Carbon emission, emission mitigating techniques and the units of measuring Carbon emission from vehicles.

An empirical assessment has been carried out byMcKinnon & Woodburn(1996) for logistical restructuring in order to reduce the growth of road freight traffic. In this research, they have identified four major factors in logistical decision making that have a direct impact on the demand for road freight transportation, thereby affecting the rate of Carbon emission from road freight transportation. First factor considered was the structure of the logistic system that prevails within the organization which in turn decides the number, location and the capacities of factories, warehouses and hubs of the organizations distribution channel. Patterns of sourcing and distribution practiced within the organization came up as the second factor with its ability of changing the total upstream and downstream transportation movements with a change in the policies practiced for sourcing and distribution. Also the process of sub-contracting intermediate stages of production such as quality assurance testing has increased the amount of transportation movements within the supply chain thus causing a higher rate of Carbon emission. Third factor identified was the way how the product flow was scheduled. This governs the number of vehicle movements that has to be done in upstream of the chain for sourcing requirements and downstream of the chain for product distribution. The final factor considered was the manner in which the transport resources i.e. vehicles, delivery routes were managed. The way in which the transportation is carried out meaning the mode of transportation, vehicles used, planning of the loads and the vehicle routing has a higher impact in the rate of Carbon emission during the transportation. When considering the authority associated over the four factors, the first two factors discussed comes from the senior managerial decisions while in the last two factors logistic manager has a higher influence in decision making.(McKinnon & Woodburn, 1996)

In the research article *'Energy Efficiency Strategies for Freight Trucking: Potential Impact on Fuel Use and Greenhouse Gas Emissions'* researchers have identified various vehicle

maintenance, driving habits and driver related factors that have an effect of energy losses during transport and thus have an impact on the rate of Carbon emission. The primarily identified factor is the availability of improved aero dynamics of the vehicle which is proved to have a very high impact on the truck fuel efficiency. Improving aero dynamics has been practiced since 1970s and currently many of the major truck manufactures offer aero dynamic models that come with sloped hood and a streamlined front along with a set of add-on devices.

Another factor identified during this research is the use of wide based tyres instead of the dual tyresused in the truck's drive and the axle. Usage of wide based tyresreduces the rolling resistance and the tare weight thus increasing the fuel efficiency. Though researches has proved the fuel efficiency of using wide based tyres, drivers shows a less interest due to the lack of redundancy offered by the usage of wide based tyresinstead of dual tyreswhich are mounted on the axle hence it do not prevent a truck from driving to a required destination even with a one flat tyre whereas the wide based tyresleaves a concern about getting immobilized.

Maintaining the tyre inflation amount at a proper rate as suited for the vehicle is also identified as a factor that can affect the fuel efficiency via its ability to reduce the rolling resistance. In nowadays Automated Tyre Inflation (ATI) systems are used for achieving the accurate tyre inflation level. Another factor identified from this research is the tare weight of the vehicle. Tare weight is the empty weight of the vehicle and this can be reduce by using lightweight materials for the body of the vehicle and by eliminating unnecessary components of the vehicle. Usage of low- friction lubricants i.e. lubricants with low viscosity also helps in the process of increasing the fuel efficiency by reducing the friction losses in the engine. Low viscosity lubricants are mainly synthetic and are seen less commonly used in truck fleets due to the concern about the possibility of engine wear. Reduced engine idling time also has a direct impact on maintaining the fuel efficiency and hence in order to maintain optimal engine idling time as required by the truck to heat or cool the cab or to run the necessary electrical appliances, automated engine idling systems can be used. The efficiency of the optimization of engine idling time with the usage of automated idling system depends on the environment where the truck is operating in.

Researchers were also able to identify two human factors i.e. driving speed and driver training and monitoring as to affect the rate of fuel efficiency. When considering the driving speed fuel economy can be improved with the reduction of speed, and according to data, the fuel economy drops drastically with the increase of speed more than 55mph. Hence, various mechanisms

such as engine speed governors, initiating driver trainings for speed maintenance and usage of technical support such as electronic engine monitoring can be implemented for this process. Also providing drivers with proper training on acceleration practice, shifting techniques, route choice etc. also have a positive impact on increasing the fuel efficiency and follow up monitoring can be done with the usage of data coming from electronic engine monitors to assess the practices of the driver in relation to the afore mentioned areas. (Ang-Olson & Schroeer, 2002)

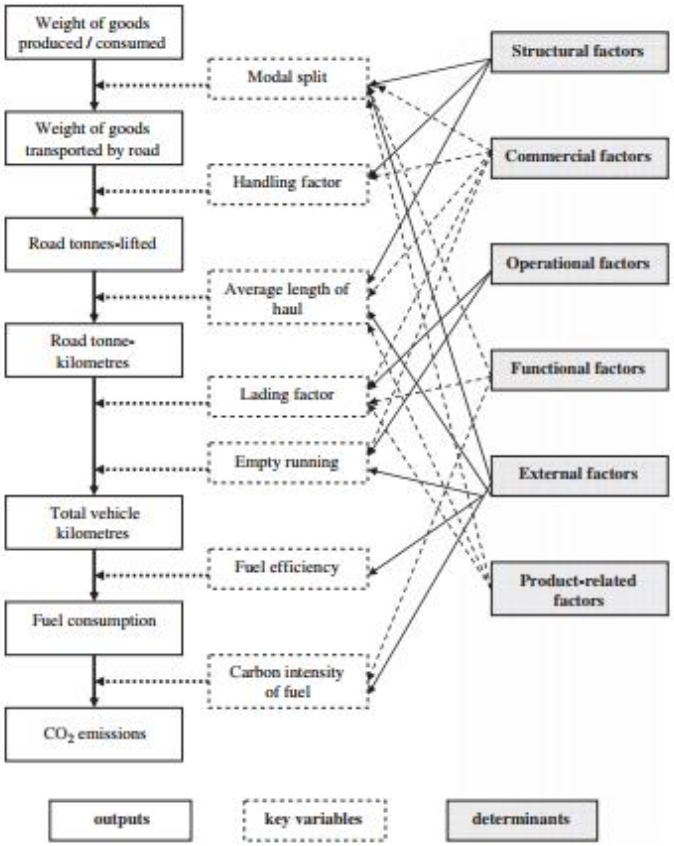


Figure 20: Relationship between logistical variables, determinants and environmental impacts

Source - (Piecyk & McKinnon, 2010)

A research has been carried out in 2010 to forecast the Carbon footprint in 2020 by analyzing the responses of around 370 specialists from across the world based on an online Delphi survey. This research allowed the researchers to identify six factors coming from logistical decision making, product characteristics and external factors that have a direct impact on the rate of Carbon emission from road freight transportation. Based on the identified factors and their relevant influencing areas an analytical framework as depicted in Figure 4 has been developed

to illustrate the interdependencies. This model has been proposed as an extended version of the initial model proposed by McKinnon and Woodburn in 1996. (Piecyk & McKinnon, 2010)

The first four factors stated in the above model i.e. Structural factor, Commercial factor, Operational factor and Functional factor links in with the four logistical decision making factors proposed by(McKinnon & Woodburn, 1996). In this research, the researchers have explored these factors considering the current trends in the world. When considering the structural factors, in relation to present scenario, some of the mainly followed practices are the centralization of economic activities, shifting to hub and spoke networks and the availability of primary consolidation centers in the distribution network. These trends can create different impacts to the Carbon emission percentages from road transportation depending on the type of business, for example within the retail industry, due to decrease in the size of storage, the number of deliveries increases resultingin an increased Carbon output. New trends anticipated in the commercial factors are the increase in the online trading and the increased amounts of product returns that are either for recycling or reuse. Organizations moving into global sourcing strategies prominent and has a direct impact on the discussed topic. In relation to operation factors with the usage practices such as Just In Time (JIT) manufacturing and reduced order lead times more frequent deliveries are required. Hence these have a direct impact on Carbon emission in transportation but can be reduced depending on the way the processes are being managed. When considering the final factor mentioned in the earlier model i.e. functional factor, with the use of new technologies such as the usage of double-deck/high cube vehicles, application of telematics and Computerized Vehicle Routing and scheduling Systems (CVRS), usage of online freight exchange and load matching services etc. will result in a savings in the fuel consumption thus leading to lesser emission of CO_2 to atmosphere.

Product related factors refer to the physical structure of the product which is developed following the store-ready approach and thus results in less space efficiency during transportation. Therefore logistical consideration should also be placed into the initial stage of product development process. When considering the external factors referred in this article, main one is the frequent rise of oil price which urge the need of practicing strategies for managing oil efficiency which in return will reduce the amount of CO_2 emissions during transportation due to high fuel efficiency. Also the article refers the government environmental policies placed for maintaining the vehicles, the availability of proper road infrastructure with less congestion, government tax policies on infrastructure usage etc. as to having an indirect

impact in regulating the logistic practices of an organization thus minimizing the Carbon emission from transportation. (Piecyk & McKinnon, 2010; Laursone, et al., 2011)

Factors that affect the rate of Carbon emission from road freight transportation can be grouped into four major categories as vehicle, driver, environmental conditions and traffic conditions. Out of which, driver related factors and some of the vehicle related factors such astyre pressure, transmission type etc. are not taken into consideration for most of the freight transportation vehicle emission models due to their unquantifiability. Rate of fuel usage is found to be high in lower speeds due to inefficiencies in the usage of fuel and tends to increase again after a certain speed limit due to aerodynamic drag. Also it is found that rate of Carbon emission is low for smaller vehicles as the rate of fuel usage is low due to smaller engines.(Demir , et al., 2011)

(Demir, et al., 2014) carried out a literature review on green road freight transportation in which the researchers were able to identify five major categories of factors that affect the rate of fuel consumption in vehicles that in turn affect the rate of Carbon emission as given in Figure 5. Among the numerous factors that affect the fuel consumption, speed is considered the most important as it can affect inertia, rolling resistance, air resistance and road slope. Optimum driving speed can assist in gaining high fuel efficiency but this optimum value varies depending on the geographical area due to the speed limits permitted by government and due to traffic density. Congestions contribute to the increase in fuel consumption due to the low non-optimal speeds practiced. A positive gradient of the road will increase the fuel consumption while a negative gradient will decrease the fuel consumption. With higher payload on vehicle the demand for engine power increases thus increasing the fuel consumption and also payload can affect the inertia forces, rolling resistance and road slope force thus again impacting the fuel consumption. Empty running results in a cost for the organization and also impacts the rate of Carbon emission. This is mainly seen in inbound transportation and majorly identified reason for cause is the lack of information integration among different stakeholders. *Green freight corridor* is a new concept developed in order to minimize the impact of environmental factors on the fuel consumption.

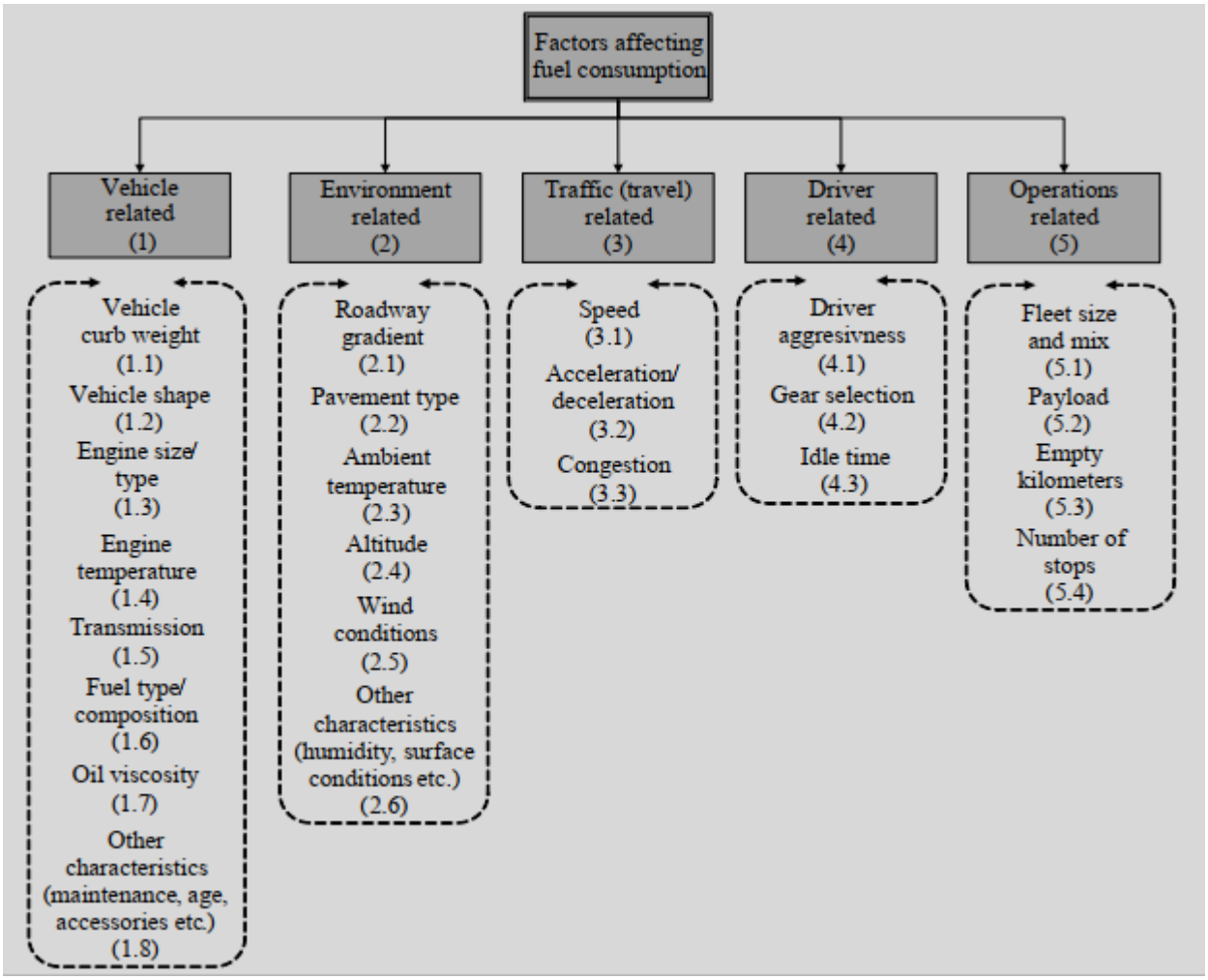


Figure 21:Factors affecting fuel consumption

Source - (Demir, et al., 2014)

In a report prepared for UNDP,(Arsalan, 2015) has concluded various best practices that can be implemented in order to reduce the rate of Carbon emission. Usage of clean and low Carbon fuels like B20 biodiesel fuel can improve the fuel efficiency and thus can reduce the rate of Carbon emission. Also these fuels are harvested from sustainable resources instead of the case in petroleum fuels that are harvested from finite fossil-fuel resources and these clean fuels will lead nations to be more energy independent. A major factor that affects the rate of Carbon emission from road freight transportation is the vehicle structure in terms of aerodynamic drag, tyre rolling resistance, weight of the auxiliary components of truck such as air conditioning compressor, hydraulic pump, fans etc., condition of the vehicle air conditioning system etc. It is also found out that vehicle idling has a positive impact on increase of the rate of Carbon emission. When considering operations and management relevant factors that can affect the rate of Carbon emission are truck loading efficiency, use of technologies to track traffic

congestions, use of *telematics* to optimize transportation networks, use of modal splits for transportation of freight etc. With proper use of technology and supply chain integration, these operation and management related factors can be used in order to achieve low Carbon emission levels. Driving habits also have a direct impact on the rate of Carbon emission. Hence, proper training and driver monitoring systems can be incorporated to manage these.

A research was carried out by (Lu, et al., 2007)to analyze the impact of changes in emission coefficient, vehicle fuel intensity, vehicle ownership, population intensity and economic growth on the rate of Carbon emissions from highways in Germany, Japan, South Korea and Taiwan during 1990-2002. Researchers have incorporated the *Divisia index* approach in carrying out the research. Overall research outcomes showcased that with the development of highways the rate of Carbon emission has increased drastically. This happens due to high aerodynamic drag that is resulted in driving in high speeds and hence higher amount of fuel consumption is resulted leading to increased Carbon emission.

In a research carried out in 2014,(Wang, et al., 2015)have identified the direct impact of the ICT practices used in logistics operation in reducing the rate of CO_2 emissions during transportation. Hence a framework has been modeled and tested in this research to benchmark the ICT strategies practiced and to identify their relevant impact on reducing the CO_2 emission from road freight transportation. Major ICT applications that are in current practice are the telematics systems, Transport Management Systems (TMS) and supplier management systems which helps in improving energy efficiency of vehicles, in routing and scheduling of vehicles and in managing collaborative transport arrangements.

Another research has been carried out in order to assess the impact of smart phone freight application service (Apps) in the reduction of Carbon emission from road freight transportation. Research was carried out in the form of a multiple-case-study approach andanalyzed 7 of the available freight apps in Chinese market. Three types of freight apps were identified; apps to integrate demand and supply in time and space, apps to match cargo and available trucks and apps to optimize return route design. A framework has been developed as a modification to the previously available researches in order to show cases the impact of different freight applications. The identified factors that can affect the rate of Carbon emission from road freight transportation are as given in Figure 6. (Li & Yu, 2017)

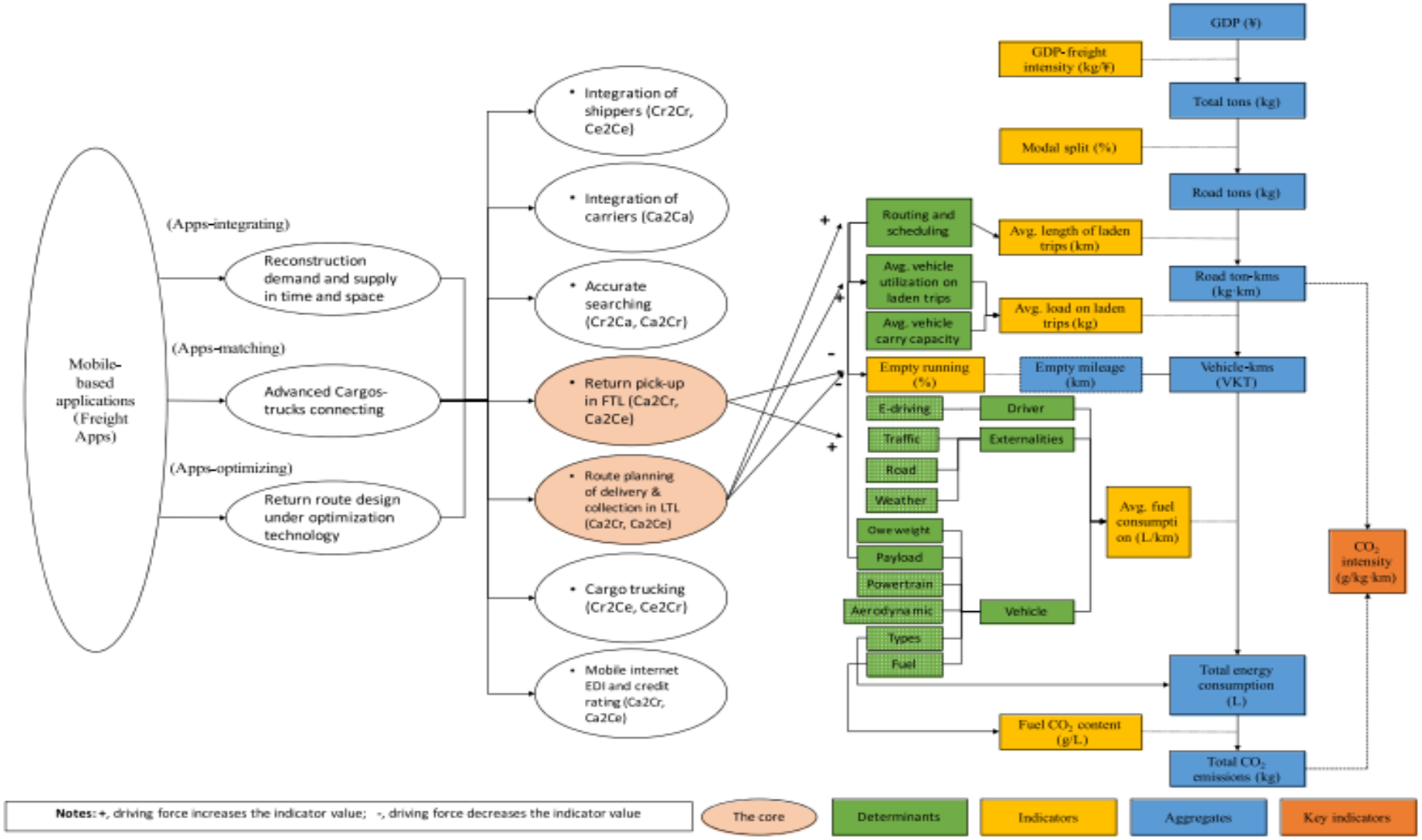


Figure 22 - Framework for analyzing freight apps for CO_2 reduction

Source - (Demir, et al., 2014)

DISCUSSION

Following section analyses the identified factors affecting the rate of Carbon emission from road transportation.

Factors that Affect the Rate of Carbon Emission from Road Freight Transportation

Table 1, depicts the major categories of factors that have been identified in the reviewed studies as to having an effecton the rate of Carbon emission from road transportation.

Table 51- Major categories of factors that affect Carbon emission

Study	Structural	Commercial	Operational	Functional	Product-related	External	Vehicle Structure	Human Resource	Technology/ ICT	Environmental	Traffic
(McKinnon & Woodburn, 1996)	*	*	*	*							
(Ang-Olson & Schroeer, 2002)							*	*			
(Piecyk & McKinnon, 2010)	*	*	*	*	*	*					
(Laursone, et al., 2011)	*	*	*	*	*	*					
(Demir , et al., 2011)							*	*		*	
(Demir, et al., 2014)			*				*	*		*	*
(Arsalan, 2015)			*			*		*	*		
(Lu, et al., 2007)										*	
(Wang, et al., 2015)									*		
(Li & Yu, 2017)									*		

Structural factors focus on the overall structure of the supply chain and its impact on the rate of Carbon emission. Decisions made on the structural factors of the supply chain have been conducted at higher levels of the organization and includes decisions such as the level of centralization and decentralization of the supply chain processes. These decisions in turn decide the number, capacity and the location of the

factories, warehouses, hubs etc. (McKinnon & Woodburn, 1996). Nowadays most of the supply chains expand overseas. Thusit is predicted to have a growth in the usage of hub-and-spoke networks and also in port and airport centric logistics. These two factors affect the rate of Carbon emission oppositely and the overall outcome of these two activities moderates the carbon emission rate.(Piecyk & McKinnon, 2010; Laursone, et al., 2011) Fewer freight miles can be achieved by fully optimizing the vehicle in transportation and by practicing switching between different modes of transportation (model splits). (Laursone, et al., 2011)

Commercial factors focus on the sourcing and distribution strategies of the organization and thus impact the number and the nature of links in upstream and downstream supply chain. With the globalization of the world, supply chains have lengthened and most of the organizations are moving towards sources of cheap raw materials and labour and this results in relocating the sourcing, production and inventory handling to countries outside of the mainland. Currently, most of the non-core activities such as valued-addition and quality testing are outsourced leading to additional linkages to supply chain and resulting in more transportation and more Carbon emissions. Today online retailing industry is blooming due to its availability of providing fast service and high customer satisfaction with doorstep delivery. This industry requires frequent small scale transportation and leads to a higher rate of Carbon emission.

Operational factors emphasize on the operational strategies of an organization. These strategies can have an indirect impact on the rate of Carbon emission from freight transportation. Implementation of JIT practices have led to the requirement of minimum storage facilities and frequent deliveries. Also organizations are focusing on shortening the order lead times which allows the reduction in inventory and increase in transportation.(Piecyk & McKinnon, 2010)Operational activities related to transportation such as delivery time, selected vehicle mix, number of stops made during a trip, payload and vehicle empty running should be carefully analysed before taking any decisions in order to reduce the impact on the rate of Carbon emission. (Demir, et al., 2014)

Functional factors are affected by the decisions made at managerial level of an organization. (McKinnon & Woodburn, 1996) Technology has been developed to facilitate faster and optimized vehicle scheduling to match demand and supply and telematics; to monitor the delivery journey. Another major strategy that can be

implemented is the back loading where you utilize the remaining space within a vehicle to carry the returned products of company's own or from its customer or a third party. This will reduce the amount of empty running or altogether the use of separate vehicle for return handling.

When focusing on the *product-related factors* it mainly concerns the availability of efficient packaging in order to get maximum space utilizations in transportation. Currently customers demand more and more store-ready packaging and hence it is predicted on the inability of full vehicle utilization thus causing smaller amount of products per journey and higher amount of journeys causing more emissions to environment. In order to mitigate these effects considerations should be taken early on the product development stages and hence requires proper integration throughout the supply chain.

External factors are affected from the immediate macro environment of the organization and are mostly out of control by the organization. These are majorly decisions taken by government in the areas of fuel prices, regulations and policies on transportation vehicles, roads, pricings etc.(Piecyk & McKinnon, 2010)Higher fuel prices can force the organizations to move towards modal splits in transportation or to move towards more clean alternative fuels. Governments can impose pricing for the usage of road structure for freight transportation thus redirecting the traffic to less consumed hours of the day and to less optimized roads. Differential pricing schemes depending on the hours of the day and on the road structures used will redirect and reduce the traffic congestions in busy hours.(Arsalan, 2015)

Vehicle structure has a high and direct influence towards the emission minimization. Starting from the vehicle engine type that decide the fuel efficiency up to add-ons that can minimize the Carbon emission, *vehicle structure related factors* identified from the review of literature are stated in Table 2.

Table 52-Considerable Vehicle factors

Factor	Remedies
Vehicle Type	- Hybrid trucks
Fuels	- Clean fuels (e.g.: B20 biodiesel fuel)
Aero-dynamic drag	-Use of cabin top deflector, sloping hoods, cabin side flares - Closing and covering the gap between cabin and trailer

	- Trailer or van leading and pneumatic trailing edge curvatures - Pneumatic aerodynamic drag reduction - Planer boat tail plates on tractor-trailer - Vehicle load profile improvements
Tyre rolling resistance	-Use of Automatic Tyre Inflations Systems (ATIS) - Wide based tyre - Low rolling resistance tyres - Weight (tare weight) and accessory weight reduction - Light-weight materials -Electric auxiliaries - Fuel cell operated auxiliaries
Engine idling	- Off-road truck stop electrification - Truck-board truck stop electrification - Auxiliary power units - Direct fired heaters
Air conditioning system improvements	- Alternative refrigerants
Transmission Improvement	- Low viscosity lubricants

Driving practices of the truck drivers have a huge impact on the rate of Carbon emission from vehicles despite of the technologies implemented on the vehicle. Higher frequencies in acceleration or deceleration, vehicle speed, frequency in break usage are some of the *vehicle driver related practices* that affect the rate of fuel consumption thus leading to higher Carbon emissions.(Demir, et al., 2014) These effects can be mitigated with proper training provided to vehicle drivers on timely basis and with the use of driver monitoring systems to track truck idling, speed of driving, route taken etc.

Many *technologies* have been developed in order to facilitate the monitoring of Carbon emission rates and their affecting factors. Driver monitoring systems and application, telematics and apps to integrate demand and supply in time and space, to match cargo and available trucks and to optimize return route design are some of these technologies that are currently in practice. Though developments are available in the field, the frequency of usage of these resources are still at a very low level due to unawareness of general crowd on these technologies and due to deficiencies in the knowledge of handling the devices.

When considering the environmental consideration, this is taken as two types; road infrastructure and environment. When considering impacts from road infrastructure, rate

of Carbon emission has risen due to development of highways which allows driving at high speeds that increase the aerodynamic drag and high fuel combustion leading to more carbon emissions. When considering the impacts of external environment it was found that factors such as temperature, wind speeds, road surface conditions has a direct impact on the rate of Carbon emission from vehicles. As a remedy to *environmental factors* affecting the Carbon emission rate a concept called 'green corridors' has been developed.(Demir, et al., 2014)

Traffic congestions cause driving at low speeds than the stated optimal speeds resulting in the reduction of fuel efficiency and hence lead to higher Carbon emissions. Hence freight transportation should be more focused towards less traffic hours or to less congested roads in order to avoid delays and to reduce Carbon emissions. This can be again supported with government policies regarding pricing on road usage.

CONCLUSION

Global temperature is predicted to rise over the years due to industrialization that resulted in the emission of higher percentage of CO_2 emissions to the atmosphere. Breakdown of CO_2 emissions showcase transportation as the second highest contributor. For business organization, transportation execution plays a major role in delivering the right products to the right customer at the right time and hence is a key feature that enables the sustainability of the business. Nowadays, emphasis is not only placed on cost effectiveness of the deliveries but also on decreasing the environmental footprints left behind from transportation. Various strategies are implemented by business organizations to minimize their CO_2 emissions from road freight transportation.

Review of literature elaborated how strategic decisions taken at higher managerial levels such as the product development strategies etc. can affect the rate of Carbon emission from transportation activities. Hence, when devising strategies considerations should be taken on the impact for transportation and proper integration of information across the supply chain which will assist in the process. Functional decisions taken at the floor level such as proper maintenance of trucks, driver training, proper truck utilization etc. have a higher direct impact to the rate of Carbon emissions. Vehicle manufacturers should also focus on strategies to minimize the Carbon emission early on the designing stages of vehicles and this requires the integration of sustainability concepts even within the vehicle manufacturing bodies. Finally, it can be concluded that the factors that affect the

rate of Carbon emission are influenced by numerous factors which ultimately requires the integration of different bodies i.e. business organizations, transport companies, vehicle manufacturing organizations, government and also the collaboration of vehicle drivers in moving towards the reduction of Carbon emissions.

With the higher focus gained by the study area during the recent years, many researches have been conducted, but still there are areas which lacks knowledge. One such area is the impact of ICT and technology towards the minimization of Carbon emission. Many of the ICT applications are been developed in recent years to assist in transportation and hence this area will have a higher impact on the rate of Carbon emission reduction. Another area that has lacked focus in earlier researches is the impact of driving habits of vehicle drivers towards the Carbon emission. This factor has a high qualitative aspect to it that prevent researches from analysing it due to difficulties in quantifying the impacts.

Most of the developing countries practise the use of re-conditioned vehicles for both freight and passenger transportation. Over the time with vehicle degradation the rate of Carbon emissions increases. Hence, it needs to be properly researched on correlations between vehicle age, condition and rate of Carbon emissions in order to implement policies on importing and maintaining vehicles. Also research needs to be conducted on integration of freight and passenger transportation within the existing road structures and during new road constructions in order to mitigate Carbon emissions.

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