

# The Decarbonisation of Transport Logistics: A South African Case Study

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## Abstract

South Africa is currently one of the “dirtiest” economies in the world in terms of carbon emissions. The South African economy is heavily dependent on energy-intensive industries, such as mining and primary minerals beneficiation, which in turn rely on fossil fuels as a source of energy. Sustainability is still a relatively new concept in South Africa, but awareness is growing, and there are several on-going initiatives aimed at reducing the country’s total energy consumption. The objective of this paper is to apply the TIMBER framework to assess current transport decarbonisation activities in South Africa. The article discusses a limited field survey of ten important logistics experts in South Africa to establish whether the findings of the researchers are similar to the perceptions within the logistics sector of major industries in South Africa. This paper concludes by providing possible solutions for reducing carbon emissions in South Africa’s logistics industry.

**Keywords:** carbon emissions; decarbonisation; sustainability; TIMBER; transport logistics

## Introduction

South Africa is ranked 13th globally in terms of carbon dioxide (CO<sub>2</sub>) emissions contributions (U.S. Energy Information Administration 2013). South Africa is one of the top ten carbon-intensive economies in the world, with a Gross Domestic Product (GDP) larger than \$200 billion, and with a carbon intensity



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of 0.972 metric tons of CO<sub>2</sub> per \$1000 of GDP in 2011 (compared to leading countries such as Germany at 0.290 tCO<sub>2</sub> per \$1000 of GDP, or China at 0.804 tCO<sub>2</sub> per \$1000 of GDP) (U.S. Energy Information Administration 2013). During the 2009 Copenhagen climate change negotiations, South Africa pledged to reduce domestic greenhouse gas (GHG) emissions by 34 per cent by 2020 and by 42 per cent by 2025 (National Treasury 2010).

The logistics sector is a major contributor to carbon emissions in South Africa. The transport sector (freight and passenger) was responsible for 9.3 per cent of South Africa's total cumulative GHG emissions between 2000 and 2010, with road transport (freight and passenger) contributing 92 per cent of transport sector emissions (Department of Environmental Affairs 2013). Transport decarbonisation will, therefore, be an important contributor to national decarbonisation efforts.

There are two main reasons that may lead companies to decarbonise their logistics. Firstly, companies may strive to reduce their carbon footprint and impact on the environment. Secondly, decarbonising logistics may ultimately reduce the transportation costs, which in effect will reduce the price the customer pays, thus making the transportation market more appealing.

McKinnon, Piecyk and Validi (2014) identified external factors that have an impact on company-level efforts to cut freight logistics-related carbon emissions and classified these into six categories using the acronym TIMBER—technology, infrastructure, market changes, behaviour, energy and regulation. This paper applies the TIMBER framework to assess transport decarbonisation activities in South Africa. The next section provides the methodology followed to conduct the research, followed by a section on South Africa's road and rail freight transport market to provide context for decarbonisation initiatives. Next, various initiatives that are taking place in South Africa under the classifications of technology, infrastructure, market changes, behaviour, energy and regulation are discussed. The article discusses a limited field survey of ten important logistics experts in South Africa to establish whether the findings of the researchers are similar to the perceptions within the logistics sector of major industries in South Africa. This article concludes by providing possible solutions for reducing carbon emissions in South Africa's logistics industry.

## **Methodology**

The research approach was primarily qualitative through desk-top research because aggregate data for the TIMBER factors are not readily available. Secondary research and a small sample of face-to-face interviews were used to collect examples of decarbonisation for expansion in future research.

Data, except where otherwise indicated, are outputs from the following models:

- **Logistics Cost Model (LCM):** The LCM consists of bottom-up aggregation of logistics related costs for commodity-level tonnage produced and imported, comprising transport; storage and port-handling costs; management and administration costs; and inventory carrying costs (Havenga 2010). The model was recently expanded to include detailed externality cost modelling per mode pertaining to accidents, congestion, emissions, noise, policing and land use value (Havenga 2015).
- **Freight Demand Model (FDM):** The FDM is a demand-side model based on the national input-output table to model supply and demand of commodities according to geographical areas and translating

this into modal share through gravity modelling, currently for 83 commodity groupings in 372 geographical areas with a 30-year forecast at 5-year intervals for three scenarios (Havenga 2013).

In addition, interviews were conducted with representatives of the seven biggest logistics service providers in South Africa. These experts were all senior level executives from South Africa's top ten logistics service provider companies. The results of these interviews were compared with the deductions that the researchers made, based on the TIMBER framework, to inform a high level observation as to whether or not a significant connection in focus and priority exists between practice and theory.

To provide context for the decarbonisation initiatives, the macro structure of South Africa's competitive (road and rail) freight transport market is summarised below.

### **Freight Transport Market in South Africa**

Logistics costs as a percentage of GDP edged upwards from 11 per cent to 11.8 per cent between 2011 and 2016 in South Africa (Havenga et al. 2016) but is down from 13.6 per cent in 2003. The decrease in logistics costs as a percentage of GDP is the direct result of more efficient distribution in the last mile (de Villiers 2017). The increase in the diesel price over the years has prompted a drive towards more efficient supply chain management (Russell, Coyle, Ruamsook and Thomchick 2014). This has resulted in a reduction in the number of tonne-kilometres spent on last mile distribution (Stellenbosch University 2015). Since 2013, it is estimated that the logistics costs as percentage of GDP rose to 11.2 per cent in 2014 and continued to rise to 11.8 per cent in 2016 (given specific industry assumptions) (Havenga et al. 2016).

Logistics costs as a percentage of transportable GDP (primary and secondary sectoral GDP) have risen progressively since 2010, peaking at 46.7 per cent in 2013 (Havenga, Simpson, de Bod and Viljoen 2014). In South Africa, transport costs contribute 62 per cent of logistics costs (Havenga and Simpson 2013), compared to the global average of 39 per cent (Rodrigue, Comtois, and Slack 2009). Transport externalities totalling R40 billion added an additional 15 per cent to already high transport costs, of which approximately 40 per cent are due to accidents and 30 per cent to emissions (Havenga, Goedhals-Gerber, de Bod and Simpson 2015; Swarts, King, Simpson, Havenga and Goedhals-Gerber, 2012). In 2013, 88 per cent of the country's total freight tonnage, or 70 per cent of tonne-kilometres (tonne-km), was on road (Havenga and Simpson 2013). Of greater concern, however, is the fact that 86 per cent of corridor (long-distance) tonne-kilometres were on road. While road freight delivery has significant advantages over other modes of transport, the high number of freight vehicles on the road contributes to overloading and subsequent significant deterioration of the road network, traffic congestion and higher levels of carbon emissions (Freight Transport, n.d.). Due to the high percentage of freight being transported by road transport, almost 40 per cent of South Africa's freight transport costs in 2013 were attributable to diesel costs; such costs are a volatile exogenous cost driver (Havenga and Simpson 2013).

### **Classification of the External Factors**

The level of carbon emissions from a company's logistics operation are influenced by external factors. They are classified into six categories by McKinnon, Piecyk and Validi (2014), using the acronym TIMBER, as discussed in Table 1.

**Table 1:** The six categories of the acronym TIMBER

Technology	Technology includes advances in transport, warehousing and materials handling technology.
Infrastructure	Infrastructure is predominantly made up of transport infrastructure, comprising networks and terminals and covering all the main transport modes, but can also include energy and communication infrastructures.
Market	Market includes changes in the structure of the logistics services market, the way logistics services are traded and the nature of the demand for these services.
Behaviour	Behaviour applies to industry and employee levels and, at the latter, includes driver training and certification programmes
Energy	Energy comprises the nature of electricity generation, the availability of alternative fuels and the carbon intensity of the range of fuels used.
Regulation	Regulation is at multi-national, national and local levels. This can include construction and use regulations on trucks, regulatory controls on the road haulage industry, and restrictions on vehicle access at particular times of day. It can also be extended to cover fiscal policy measures.

*Source: McKinnon, Piecyk and Validi (2014)*

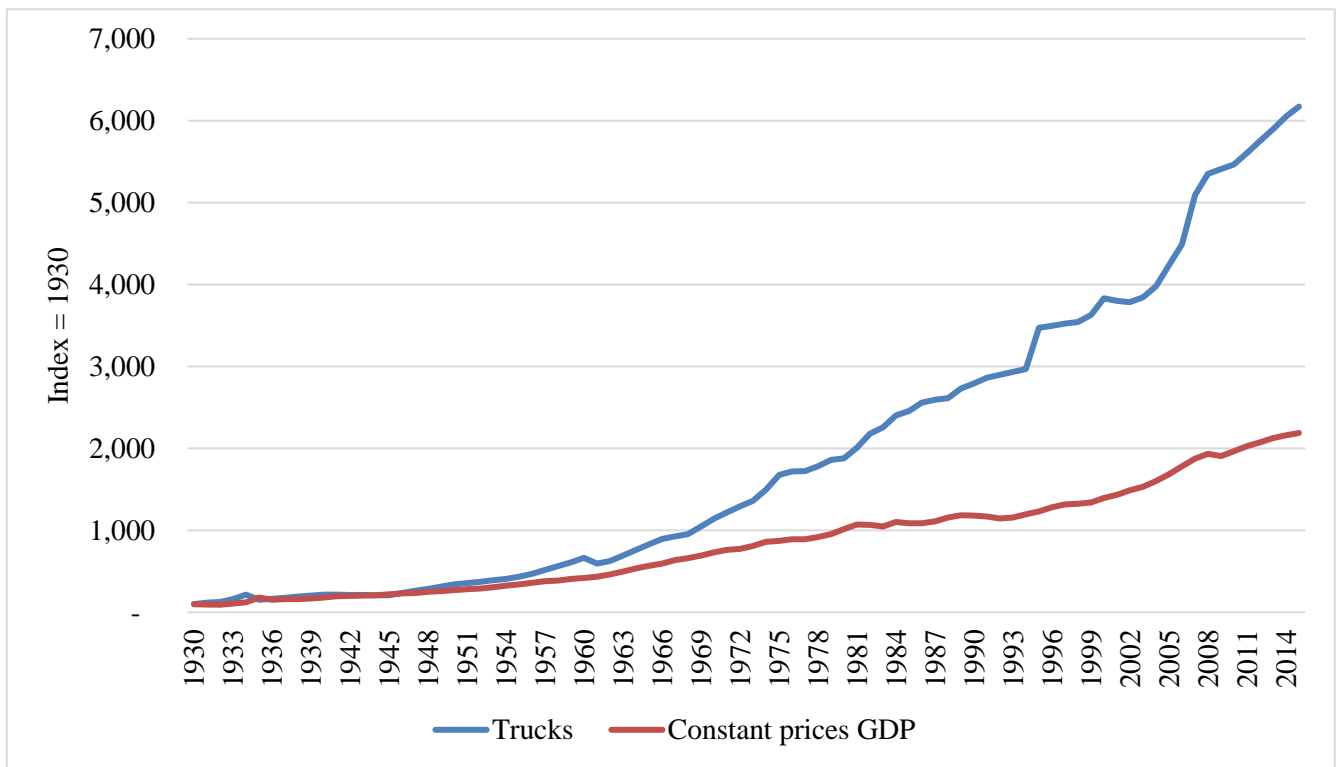
## **Review of External Factors**

### **Technology**

Technological advances affect the carbon emissions released through logistics in several ways. A major influence of technological advances is through enhancements made to the fuel efficiency of freight vehicles. In addition, technology can influence the carbon content of the fuels used. There are a number of advancements being made in terms of efficiency initiatives in an attempt to reduce the impact of logistics on the environment. Potential opportunities exist for the reduction of carbon emissions, especially if the rail freight industry starts to play a more prominent role in the inland transportation of freight.

### *Road Freight*

As of February 2016, there were approximately 11.8 million vehicles registered on South Africa's National Traffic Information System. Approximately 65 per cent of the total registered vehicles were passenger vehicles (motor cars, minibuses and buses), while approximately 26 per cent were freight vehicles comprising Light Duty Vehicles (LDVs) and trucks (eNaTis 2016). Gauteng Province, the economic centre of South Africa, has the largest vehicle population with 38.95 per cent of the total national vehicle population, followed by the Western Cape (16.11%), and KwaZulu-Natal (13.51%) (eNaTis 2016). The heavy vehicle population has seen considerable growth across all sizes (eNaTis 2016). Figure 1 shows how South Africa's heavy vehicle fleet has grown faster than GDP.



**Figure 1:** Heavy vehicle growth and constant GDP for South Africa (Botha 1970; Stats SA 2017; National Traffic Information System 2017)

The increase in South Africa’s heavy vehicle fleet talks directly to South Africa’s decline in rail use, but also to opportunities for improvement as investment in rail technology picks up. According to Mathabatha (2015), companies stopped using rail transport due to unavailability, unreliability and the just-in-time needs of freight owners. His research further indicates that a return to rail is possible if railways concentrate on service delivery as well as capacity generation. Recent developments such as Barloworld’s drive to move freight from road to rail (Fin24 2017), Exxaro’s 10-year contract with the railway (Kilian 2017), and the rail collaboration with ArcelorMittal, Barloworld and Grindrod to open a new steel logistics centre (FTW Online 2016; Odendaal 2016a) show that this trend can be reversed.

Although the majority of passenger cars (90%) and light commercial vehicles (56%) are currently petrol driven, 95 per cent of heavy commercial vehicles are diesel driven (Kruger 2012). Diesel vehicles are growing in popularity for both passenger cars and light commercial vehicles, accounting for 29.5 per cent of new vehicle sales in 2013 (Automotive Industry Export Council 2014).

There is an ongoing debate around emission efficiency and environmental damage when diesel and petrol vehicles are compared. Generally, however, it is accepted that more modern diesel engines perform better even though historically petrol was more sustainable (Khan 2017). The average age of the fleet is therefore important. According to Maile (2009), the average age of vehicles in South Africa is approximately 13 years.

As of 2008, all new vehicles that are sold in South Africa must comply with at least Euro 2 emissions standards (Carolin 2010), meaning that South Africa’s fleet will consist of increasingly more modern

vehicles. Unleaded petrol was also introduced in South Africa in 1996, and leaded petrol was phased out on 1 January 2006. Petrol fuel grades available in South Africa include 95-octane at the coast (500ppm sulphur), 93-octane inland (50ppm sulphur), as well as 500ppm and 50ppm diesel. This is in line with the majority of countries from which South Africa's vehicles are sourced (South African Petroleum Industry Association 2008).

EU-level estimates point to a 3.2 per cent increase in average fuel efficiency of new vehicles between 2010 and 2020 (McKinnon, Piecyk and Validi 2014), and this effect is transferred to South Africa due to Euro 2 standards. Road freight vehicles comprise 26 per cent of total registered vehicles in South Africa, with an exponential rise (Figure 1) in the truck fleet from 20 000 vehicles in 1950 to 340 000 in 2012, a compound annual growth rate of 5 per cent (eNaTis 2012). Although sixteen per cent of the fleet was found to be unroadworthy in 2009 (Barry 2011), modernisation will continue due to new standards. However, emissions contribute approximately 30 per cent of road externality costs. Some efficiency initiatives are described below.

Some South African logistics companies are experimenting with aerodynamic developments to improve the fuel economy of their road freight fleets. One example is Barloworld's "Green Trailer," which makes use of aerodynamic panels to reduce drag and increase fuel economy. In a test, the Green Trailer, travelling at a constant speed of between 70 and 80 km/h, resulted in an 11 per cent fuel saving or a reduction of 66.8 tons of CO<sub>2</sub> emissions over a ten-month period (Henderson 2014).

Smart trucks—extra heavy vehicles mainly used off-road in, for example, the timber and forestry industry—provide improved stability, reduced trips, increased productivity, reduced carbon emissions, and significantly reduced road wear. Smart trucks are generally longer, can carry heavier loads than other trucks and are therefore limited to travelling on certain roads. There are currently 60 smart trucks in operation in South Africa, with 30 more in the process of being designed and approved (Henderson 2014).

Imperial Logistics introduced the "extra distance" campaign: the difference between the number of kilometres vehicles actually run and the kilometres required under optimal planning conditions. Initial indications are that eliminating extra distance in their Gauteng and Cape Town fleet could lead to cost reductions of R29 million (De Swardt 2014).

ECO2Fleet is a web-based fleet management data collection and reporting service that measures carbon emissions and provides emissions reporting data to internationally accepted standards for a fleet of trucks (Standard Bank 2014). Almost 500 companies (comprising 40 000 vehicles) currently subscribe to this product. One customer reports that, by using this data, average fuel consumption per vehicle across their group's 900 vehicles fell to below the 10 litres/100km average for the first time, an improvement of up to 30 per cent for some vehicle classes (Arrive Alive 2014).

## *Rail Freight*

The introduction of new-generation locomotives with regenerative braking capabilities on the ring-fenced coal and iron ore export lines (Transnet 2012) culminated in a reduction of total energy consumption by 3.4 per cent in 2012–2013 (Munshi 2014). More specifically, locomotives used in South Africa's 78-million-ton coal export system (over a distance of 561 kilometres) regenerate 27 per cent of the energy required for a round-trip. Locomotives on the 54-million-ton iron ore export system (over a distance of 882 kilometres) regenerate 38 per cent of the energy required for a round-trip (Munshi 2014) when expressed as a percentage of tons transported regeneration is 13 percent for the coal line and 34 percent for the iron ore line (Cameron and Meyer 2014). These coal and iron ore export railways constitute 13 per cent of the network, but about 64 percent of tons shipped and two thirds of tonne-km of the railways' current freight task. The objective is to deploy these new technologies in the general freight business. Intermodal heavy haul is possible in South Africa, although new investments in bearing, guiding and coupling might be required (Van der Meulen 2006). However, the railways have already illustrated success with heavy haul operations on a current general freight line (Creamer 2013).

The greatest opportunity for rail is possibly in the long-distance transport of fast-moving consumer goods (FMCG), where it currently only has a market share of 2 per cent of targetable traffic (Havenga, Simpson and de Bod 2012). In the Supply Chain Foresight Study (2011), 89 per cent of respondents in the retail and FMCG industry indicated that less than 10 per cent of freight transport is on rail, although 69 per cent of respondents indicated that it could be more than 10 per cent. New intermodal technologies are, however, required. There have been talks of introducing Swop Body technology in South Africa, such as the Roadrailer (Railways Africa 2013) and Roadrunner, which will enable penetration of this market. Transnet signed agreements with two local private firms to test the Roadrailer technology during 2015 (Ash 2015). They have since piloted the use of Roadrailers to try reduce rail transports' loss of haulage to the road sector, enter new markets, and to improve turnaround times (ParlyReportSA 2017). The pilot for this project is now underway (ParlyreportSA 2017).

## **Infrastructure**

Improvements made to infrastructure can assist efforts to cut carbon emissions in three ways: namely by reducing traffic congestion, overcoming the effects of overloading, and promoting a shift to lower carbon modes, such as rail transport.

## *Congestion*

South Africa's transport task is currently to move 848 million tons over 379 billion ton-kilometres (Stellenbosch University 2016) (this figure relates to movements from initial points of supply to final points of demand, which does not include the split between line-haul and redistribution, meaning shipments will be much higher). The large majority of this freight (87.5%) moves via road transport and the remaining 12.5 per cent moves by means of rail transport (Department of Environmental Affairs 2014).

Freight vehicle fuel consumption rises quickly when speeds drop below 40 km/h, with the optimum range between 40 and 70 km/h. Fuel consumption approximately doubles with an average of one stop per km and trebles when the vehicle stops twice per km (Kuehne Logistics University 2014). Consequently, fuel

consumption and resulting emissions rise quickly under conditions of congestion, a problem that South Africa faces both in metropolitan areas and long-distance corridors (Natmap 2050 2009).

This is problematic for South Africa, as the country faces high levels of congestion on its roads and is the result of a national over-reliance on the road freight industry. Many roads are insufficient for the growing number of vehicles as not all roads have double lanes or an additional truck lane (Engelbrecht 2013). This, therefore, contributes to the slow average speed of South African trucks in both metropolitan areas and on some of the major corridors and impacts on the emissions generated by road transport. In South Africa, congestion adds R4 billion (or 10%) to total externality costs. Across six major metros, South Africa had a congestion level of 24 per cent in 2017; i.e. a 24 per cent increase in overall travel times when compared to a free flow situation (TomTom Maps 2017).

### *Overloading and Road Quality*

Fifteen to twenty per cent of heavy vehicles on South Africa's roads are overloaded, accounting for 60 per cent of damage to road surfaces (CSIR 2009). Almost a third of provincial roads in South Africa are in a poor to very poor condition (SAPA 2012) and almost 40 per cent of national roads (Kannemeyer 2013). The quality of the roads inter alia impacts the speeds at which vehicles can travel, causes accidents, and damages goods and vehicles. A 2010 wheat transport case study calculated an incremental revenue loss of R1.34 per tonne per trip, or R2.5 million annually for South Africa, due to vibrations when wheat is transported on bad roads (Steyn, Bean, Pretorius and van der Walt 2011).

### *Promoting a Shift from Road to Rail*

Given South Africa's freight transport market structure described earlier, the main avenue to address congestion and overloading challenges is modal shift. Eighty-six per cent of corridor tonne-kilometres are on road, of which 48 per cent are on the two main corridors Johannesburg-Durban and Johannesburg-Cape Town. Road corridor freight contributes 45 per cent of freight emissions (WWF South Africa 2013). Dense, long-distance corridors are ideal intermodal candidates. Havenga, Simposon and de Bod (2012) estimate that building three intermodal terminals to connect the three major industrial hubs—Gauteng, Durban and Cape Town—through an intermodal solution could reduce transport costs for the identified 22.9 million tons of intermodal freight flows on the two main corridors by 64 per cent (including externalities), resulting in 1.2 million tons CO<sub>2</sub> savings. Initially, targetable freight is identified as palletisable fast-moving consumer goods.

The delivery of domestic intermodal solutions has been included in the annual shareholder compact between the national Department of Public Enterprises (DPE) (the shareholder) and the national rail operator. Transnet responded by delivering a strategy to the DPE by the end of 2015 (Transnet 2016). The memorandums of understanding between two of South Africa's largest logistics service providers—Imperial Logistics and Barloworld Logistics—and Transnet support this goal (Diza, 2013; Finweek, 2013). Transnet signed agreements with two local private firms to test swop body technology during 2015 (Ash, 2015).

Incentives can be used to encourage a modal shift for certain commodity classes, for example, incentivising a shift in the transport of high cube containers from road transport to rail transport (which is possible



technologically even with South Africa's narrow gauge) in order to reduce the occurrence of overloading on the country's roads. There are, however, currently no incentives from government to shift from road to rail.

## **Market**

South Africa's logistical systems, transport networks and freight markets are in their infancy when compared to many of the world's leading developed countries. However, amongst developing countries, and compared to BRICS counterparts, according to the annual Logistics Performance Index of 2016, South Africa is ranked 20th in the world with a score of 3.78 points. In addition, South Africa's ranking is 89.3 per cent of the highest performing country in the index, Germany (The World Bank 2016). South Africa's ranking, given the country's classification as a developing nation, is a testament to the country's ability to keep abreast with the world's logistical leaders.

A higher degree of freight consolidation will result in greater opportunities for rationalising freight movement, raising load factors and reducing empty running (Kuehne Logistics University 2014). Competition within the road freight transport industry in South Africa is high due to the well-developed nature of the industry. There are an estimated 4 000 operators in the transport for reward market (which is estimated at 60 per cent of total road freight, the balance provided by in-house transport), with the seven largest firms (the "big 7") handling 40 per cent of this outsourced freight (Department of Transport 2005). This is negated through collaboration between service providers and freight owners to exploit inter alia back-haul or cyclical opportunities. However, South Africa needs to develop viable domestic intermodal transport alternatives and must shift its focus towards the development of renewable energy sources and technology to reduce the country's emissions and reliance on fossil fuels.

### *Collaboration of Transport*

As the world becomes more environmentally aware, transport companies are trying to stay ahead by developing new and more efficient ways of transportation. Collaboration is starting to emerge as companies are beginning to develop close ties with suppliers. Profit gains and shared logistics seem to be an attraction to the 46 per cent of businesses who have started to collaborate (Kumar 2013).

Smart trucks, a concept driven by the CSIR, are a transport initiative that are said to increase the transport efficiency of the vehicles thus producing less CO<sub>2</sub> emissions. Smart truck tests show an increase of 14 per cent in fuel efficiencies as well as reduced road wear while allowing larger loads to be transported which, in turn, entails fewer trips thus allowing companies to have a competitive advantage within their market (Nordengen 2013).

In the current South African logistics market, there needs to be a shift towards a dual transport system for in-house transport (de Swardt 2014). A dual transport system incorporates two companies that work together to form a transport shuttle service. This shuttle consists of two legs; the first leg transports one company's product on the outbound journey and the second leg transports the second company's product on the return journey. Potential benefits of using this system include reduced transport costs, improved safety due to fewer drivers on the road, reduced CO<sub>2</sub> emissions, and a sustainable transport shuttle service

(de Swardt 2014). Where transport is outsourced, return loads are more easily found and this has been a mainstay of large South African road freight operators.

### *Intermodal Transport*

South Africa has a large geography and a small market, opposite to the structure of European markets. Large distances immediately create concern regarding the level of carbon emissions spent by vehicles and other transportation that serves those routes. With road transport being responsible for the majority of land freight transport in South Africa (and road transport having some of the highest carbon emissions of all modes), the impact of the road transportation market on the environment becomes questionable. The development of a domestic intermodal transport solution could contribute to significant carbon footprint improvements for freight transportation and logistics companies in South Africa.

According to Behrends (2012, n.p.), intermodal transport is “the combination of two or more transport modes in one transport chain.” Not only is the intermodal shift a possible solution to high carbon emissions and sustainability of transportation in South Africa, but companies in the private sector have also noted that “deliberate and proactive cooperation” could be a solution to capture opportunities in international trade (GAIN and Frontier Advisory 2013). This could also see further motivation for the shift to intermodal transportation and cooperation, particularly between road and rail.

Where freight transportation is along routes less than 200 kilometres long, road is a better suited mode than rail in terms of energy costs, speed, and flexibility (Van Essen and Martino 2011). However, over longer distances, rail freight transport is more fuel efficient and releases far less carbon emissions than that of road transport (Havenga and Simpson 2013; International Energy Agency 2009).

Road transport will always play a pivotal role in the delivery of freight solutions for both short and long haul. With freight that is targetable by domestic intermodal solutions, a focus shift for that specific freight from being the primary transporter of freight to focusing mainly on providing a last mile role, is possible. Litman (2014) confirms that “mileage reduction” is one of the best strategies to employ when aiming to reduce carbon emissions from transport.

Intermodal collaboration could, however, cause greater harm to the environment if it is not implemented properly. OECD (2012) mentions how drayage (the use of trucks to move freight to railheads) is a major source of inefficiency and environmental problems at ports. A solution to these problems includes obtaining additional space in the port itself or adjacent to it. So, if road and rail are to collaborate, operators must ensure that there is sufficient space to receive and handle freight to guarantee sustainable practices and an improved carbon footprint. Road freight transport operators will always be a contributor of carbon emissions in South Africa but with shortened distances travelled, together with efficient practices at the railhead, the road transport market may contribute fewer carbon emissions under an intermodal transport system.

### **Behaviour**

Aggressive driving (rapid acceleration and braking) is known to waste energy, while improved driving behaviour can reduce fuel consumption by up to 33 per cent (US DEEE & RE and EPA 2008). Other

behavioural changes that reduce fuel consumption include (approximate reductions are given in brackets, where known) (Vanderschuren, Jobanputra and Lane 2008):

- the reduction of unnecessary idling
- the use of overdrive gears
- the reduced use of accessories (2.2%)
- closing sunroofs (where applicable) (4%)
- turning off air conditioning (10%)
- closing front windows (5%, 10% more at 120km/h) and
- turning off rear-window heaters (3–5%).

The Road Transport Management System (RTMS) was initiated in 2003 in an attempt to self-regulate South Africa's road freight transport sector after failure to implement the regulated Road Transport Quality System (Collings 2009; Furter 2014). The successes brought about through RTMS adherence, listed below, point to the inter-relation of the six TIMBER factors. RTMS certified organisations reported a reduction in the number crashes of between 40 per cent and 66 per cent over a 5-year period, translating into a decrease in the cost of crashes from 5 per cent of revenue to 1.3 per cent of revenue over a 5-year period for one road haulier. Overloading in the forestry sector was reduced from 18 per cent to 6 per cent in the decade leading up to December 2010, while the sugar industry reduced overloading from more than 30 per cent prior to 2007 to approximately 7 per cent in 2011. The City of Cape Town Electricity Support Services improved fuel consumption from 5.9 km/litre in 2007/08 to 8.3 km/litre in 2010/11. These results are indicative of what can be achieved; however, substantial efforts are required to raise awareness to increase certification and compliance (Nordengen and Naidoo 2014).

In addition, fleet vehicle tracking systems have been introduced by companies to monitor the whereabouts of their vehicles and to enhance goods flows. The vehicle tracking systems have resulted in numerous benefits for companies due to better awareness of driver behaviour (resulting in lower speeds), improved route choices, and a reduction in private use of company vehicles. The combined effect is a reduction in fuel consumption of between 15 per cent and 25 per cent (Vanderschuren 2006).

Replacing vehicles in a shorter time frame due to scrappage policies also has the potential to improve fuel efficiency. Larger truck operators in South Africa are adopting a much better replacement regime than a few decades ago, but older vehicles tend to remain in the fleet. Nonetheless, in general it is reported that truck fleets are getting younger (Lamprecht 2015). Possible schemes that can be used are centred around the replacement of older, less efficient vehicles with either new vehicles or with newer vehicles based on a cash incentive to purchase. Incentives can be determined by using a sliding scale subject to the age of the vehicle. The success or failure of such schemes is linked to how many vehicle owners choose to replace their vehicles, the age at which they replace their vehicles (US DEEE & RE and EPA 2008), and the strict enforcement of vehicle emission standards (US DEEE & RE and EPA 2008). Practice in Italy eludes to the fact that scrappage policies, especially short-term programmes, may be linked to the earlier retirement of older vehicles, but may not alter the overall composition of the country's vehicle stock (IEA 2001). If this is the case, the fuel and resultant environmental benefits of such programmes are limited (Vanderschuren, Jobanputra and Lane 2008). In South Africa, the proposed carbon

tax might lead to transport fleet operators reducing their replacement cycles, having a similar effect to scrappage policies (Engelbrecht 2013).

## **Energy**

Approximately 88 per cent of South Africa's total energy is supplied by fossil fuels (Department of Energy 2010). The three largest consumers of primary energy in South Africa are industry (40.8%), transport (27.2%), and residential areas (20%) (Department of Energy 2010). Given the structure of South Africa's freight transport market, the consumption of diesel is paramount. The biggest impact will, however, be through modal shift to less carbon-intensive rail transport. According to the Association of American Railroads (2011), rail transport is on average four times more fuel efficient than road transport.

## **Regulation**

### *Carbon Tax*

A new carbon tax, set to be implemented in the future (Odendaal 2016b), is one of the South African government's initiatives to transition the country towards a low-carbon economy. During Phase 1, Scope 1 emissions (activities under the ownership or control of an entity) above the 60 per cent threshold will be taxed at R120 per tCO<sub>2</sub> increasing by 10 per cent a year during the first five years (National Treasury 2013). Potential benefits of the carbon tax are that it could fast track a shift to a more efficient, well-maintained truck fleet, but more importantly that it could support a modal shift (Kaack, Vaishnav, Morgan, Azevedo, Rai 2018).

### *New Vehicle Emissions Tax*

Effective 1 September 2010, CO<sub>2</sub> tax must be paid on all new motor vehicles sold in South Africa. The objective of the tax is to influence the composition of South Africa's vehicle fleet towards a more efficient and environmentally friendly fleet. Purchasers of new passenger and light commercial vehicles emitting more than 120 g/km of CO<sub>2</sub> are taxed according to the class of vehicle. Currently, light passenger vehicles are taxed at a rate of R90 per gram of CO<sub>2</sub> emitted above 120 g/km, and double cab pickups at R125 per gram of CO<sub>2</sub> emitted above 175 g/km. Commercial vehicles will also be included once CO<sub>2</sub> emissions for these vehicles are standardised (Droppa 2013).

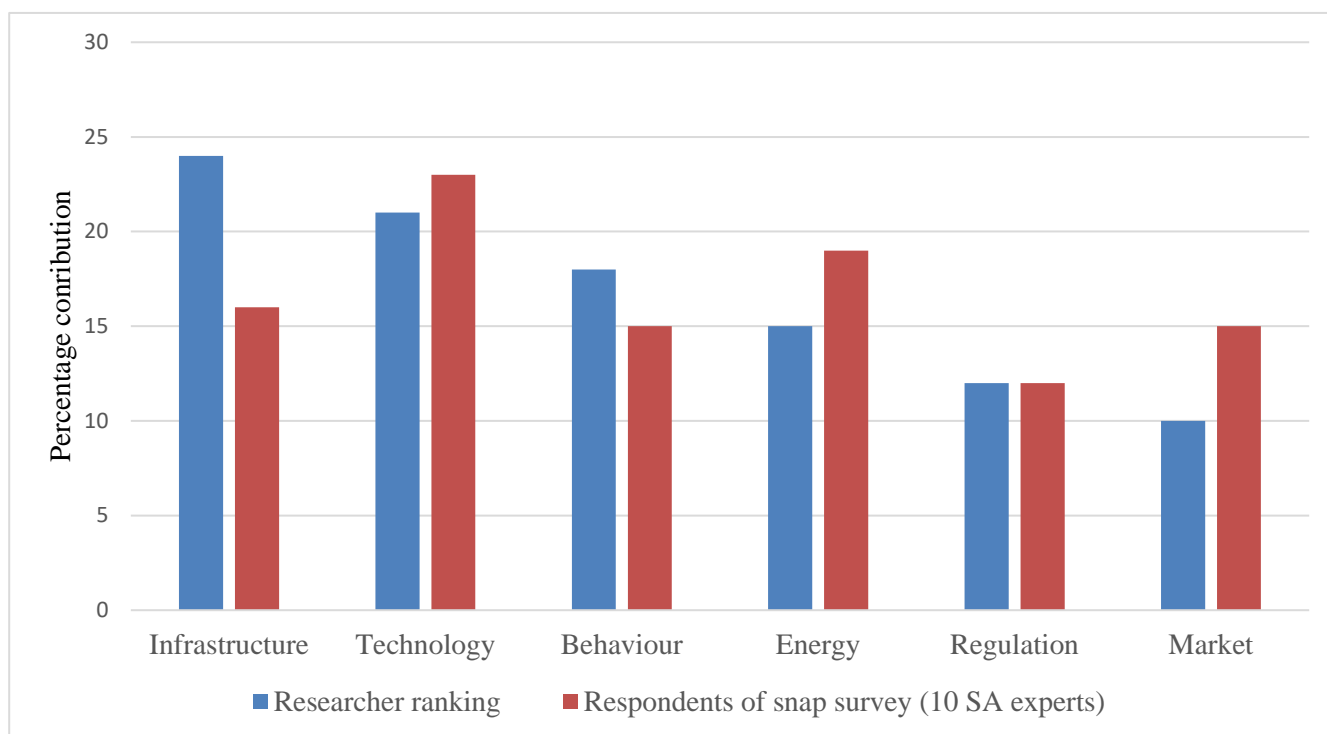
### *Externalities*

Freight transport externalities for South Africa across all modes are estimated to be approximately R40 billion (compared to the total freight bill of R260 billion), almost exclusively attributable to road transport (Havenga and Simpson 2013). In a market economy, with price the most important decision-making criterion, neglecting to account for the full ecological and social impact of economic activity causes the price signal to fail (Lewis and Conaty 2012). To allow full cost decisions between modes, it is important to measure and regulate the internalisation of these costs.

## Results and Discussion

Of the top three items, the most important contribution to decarbonisation must come from infrastructure. Overarchingly the demand for infrastructure can be reduced by bringing points of supply and demand together in logistics hubs and productive villages. Modal shift can lead to more efficient supply and large opportunities exist for South Africa. If this is combined with proper road maintenance programmes, road maintenance should be more effective, and congestion will decrease. Technology will play the second most important role through fuel efficient vehicles with lower emissions, but also advanced scheduling and planning that can reduce unnecessary trips. Advanced railway engineering such as regeneration capabilities will also play a role. The third item is behaviour, i.e. driver training, which can play a big role, with many of the more established companies now having well established programs.

As a final step, the output of the quantified survey generated a rank order for the various TIMBER factors in terms of the possible contributions that they can make. As a secondary observation (which was not the core part of the study), ten South African practitioners on Executive level from seven of South Africa's ten large Logistics Service Providers (LSPs) were asked to rank each TIMBER item in order from biggest to smallest in terms of how the respondent believes each item will have the biggest decarbonisation impact in the future. The respondents were just asked the one question (as this was not the study's main focus), but the answers could lead to more in-depth future studies to establish the perceptual links between reality, what is actually required to do, and what people think is important. Short interviews were used to determine whether the findings of the desk-top research conducted represented similar results to the perceptions of industry. The items were ranked according to the possible future relative contribution of the TIMBER factors to decarbonisation and then compared to the polled responses from ten experts in South Africa (see Figure 2).



**Figure 2:** Relative contribution of TIMBER factors to CO<sub>2</sub> savings 2010–2020

A fair amount of agreement exists, except for the researchers' stronger belief in infrastructure's contribution and less so for energy and market. This could be a result of the research team's exposure to current infrastructure planning in South Africa: strong evidence that South Africa cannot afford a wholesale abandonment of coal-based energy and a general belief amongst industry experts that any market intervention would probably be more effective than government-led infrastructure developments.

## **Concluding Remarks**

South Africa is currently one of the "dirtiest" economies in the world in terms of carbon emissions. The South African economy is heavily dependent on fossil fuels for energy supply, as well as energy intensive industries such as mining and primary minerals beneficiation. Sustainability is still a relatively new concept in South Africa, but awareness is growing and there are several on-going initiatives aimed at reducing the country's total energy consumption

The application of the TIMBER framework to assess transport decarbonisation activities in South Africa indicates that the external (or macro) freight transport environment still poses significant challenges to transport decarbonisation in South Africa. Decarbonisation of South Africa's freight transport industry will be facilitated by:

- Technology: adopting and implementing formal fuel efficiency and economy standards for freight vehicles; deploying rail's export line success in the general freight business.
- Infrastructure: timely road surface maintenance; promoting road-to-rail shift.
- Market: encouraging collaboration between service providers and freight owners.
- Behaviour: training and retaining skilled drivers; increasing RMTS certification and compliance.
- Energy: reducing carbon intensity of energy; road-to-rail shift.
- Regulation: implementing carbon emissions reduction policies; internalising externalities.

As one of the leading economies on the African continent, South Africa is in a good position to take the lead in reducing the carbon intensity of economic activity and to set an example for other developing countries.

A major contribution to decarbonisation in South African logistics will without a doubt be a modal shift. Modal shift is an important government policy, but also a growing objective of both freight owners and LSPs. Major opportunities exist on the two major corridors between Gauteng and Cape Town and Gauteng and Durban. Investment in rail infrastructure, swap-body technologies and market restructuring between the railway and major LSPs indicate that over a 10 to 20-year period this could be possible. Even though decarbonisation is not high on the agenda of many shippers and LSPs, blue chip shippers and the larger LSPs have at least launched initiatives to get houses in order.

Carbon taxes are somewhat controversial but are still set for implementation within the next five years. South Africa's freight regulatory management has lagged behind other government initiatives, but indications are there that capacity within the Department of Transport is being created to address the regulatory vacuum. A direct result, these changes might only be visible towards the end of the decade.

Given the relative contribution of freight transport to carbon emissions and a 10 per cent modal shift on all freight, around 80 million tons over a 600-kilometre average haul, a saving of 1 per cent on total

emissions in South Africa could be possible. Contribution from regulation, decarbonisation of energy at its source, emerging attempts from freight owners, and LSPs to decarbonise carbon activities and new technologies could add another 1 per cent. Given South Africa's carbon emissions of 417 metric tons in 2015 this would result in a total savings of just over 8 metrics tons of CO<sub>2</sub>.

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