CALCULATION OF FREIGHT EXTERNALITY COSTS FOR SOUTH AFRICA

STEFAAN SWARTS*
DAVID KING
ZANE SIMPSON
JAN HAVENGA
LEILA GOEDHALS-GERBER
**stefaan@sun.ac.za*
Stellenbosch University, South Africa

ABSTRACT

The purpose of this study is to quantify the marginal external costs associated with freight transport in South Africa. Six cost elements are included as externality cost items, namely, costs related to accidents, emissions, roadway land availability, policing, noise and congestion. Inputs in the calculations were a gravity-oriented freight flow model, a road transport cost model, actual transport costs for other modes, a warehousing cost survey, an inventory delay calculation and various national sources of information such as accident statistics and government budgets. Estimation techniques resulted in advances for externality cost measurement in South Africa. The quantification of the cost elements will be used to update the South African Freight Demand Model. The results show that the cost of transportation would have been 20% more if external factors were taken into account. The marginal rates of externalities can be used to develop scenarios based on alternative choices for South Africa's freight transport infrastructure configuration.

INTRODUCTION

When goods or services are traded, a voluntary exchange occurs between a firm and a consumer. During the production and consumption of these goods or services, both costs and benefits are involuntarily imposed on and received by others. If these external costs are not being accounted for, producers acting within a competitive environment will overproduce because of the understatement of the costs. When a product or service results in external benefits, third parties have access to these benefits without having to pay for them, and as such the producers will under-produce their product in a free market as they do not receive any remuneration for the benefits they provide. Both cases are inefficient from a social benefit perspective and distort the market (Pretty, Brett, Gee, Hine, Mason, Morison, Raven, Rayment, Van der Bijl, 2000). To avoid the inefficient allocation of resources within an economy these external costs need to be quantified and allocated to the appropriate parties. Appropriate externality cost allocation will inflate the real cost of carbon-intensive transport (McKinnon, 1999). This will incentivise businesses to make more sustainable logistics decisions, such as modal shifts, local sourcing and even relaxation of JIT scheduling. In addition, if appropriate internalisation costs are passed on to the end-consumer, it could direct purchasing behaviour to more environmentally friendly options, which will in turn influence supply chain decisions (Piecyk & McKinnon, 2007).

In 2010 the logistics costs (excluding externality costs) for South Africa amounted to 12.7% of the GDP (Simpson & Havenga, 2011). This is higher than first-world figures (efficient economies) of around 9.5% (Roberts, 2003). According to standard economic theory it is highly likely that this 12.7% is being spent inefficiently, because the external costs are not accounted for (Tinch, 1999).

The purpose of this study is to quantify the total external costs associated with freight transport in South Africa. The results presented here are the initial outputs of the first ever study where an estimation technique for each externality cost component has been developed. Externality costs are defined as costs related to accidents, emissions, roadway land availability, policing, noise and congestion.

RESEARCH APPROACH

The discussion section of this paper contains, in turn, literature reviews for each of the externality cost drivers, a discussion of the methodology employed to calculate the external cost and the outcome of the quantification. The impact on transport costs when externalities are included will subsequently be depicted.

DISCUSSION

Accidents

Maibach *et al*. (2008) propose that accident related externalities can be quantified according to bottom-up or top-down approaches.

The bottom-up method uses the correlation between traffic levels and accidents, and risk value assumptions. According to Maibach *et al*. (2008), the bottom-up approach only considers parts of total accident costs and therefore leads to lower values than the top-down approach.

The top-down approach is based on national accident statistics and insurance systems with a focus on total material damages, administrative costs, medical costs, production losses and societal valuation of risks. It is a combination of the gross output approach of finding the net present value of the future earnings lost, with an added portion for grief, pain and suffering as well as direct accident cost. Therefore the external portions of these costs are considered to be losses in production and value of human life.

Regardless of the approach, a crucial part of quantifying the external costs associated with accidents is the assumptions made on individual and collective risk behaviour as well as the allocation of insurance premiums. The potential differences between willingness to pay (WTP) to reduce own risk and the risk of others affect the portion of external cost (Maibach *et al.*, 2008).

Currently, estimates of South African accident externality costs differ widely. Jorgensen (2009) notes that in the March 2000 report, 'A quantitative analysis of the full costs associated with motor vehicle use in South Africa,' a conservative estimate in 1998 of the external accident cost for all vehicles in South Africa, was valued at R5.04 billion. Due to a lack of South African crash statistics, Jorgensen estimated the external accident costs via extrapolation methods from the European Union, Canada and Australia at 6c/tonne-km. February (2011) estimated the external accident cost attributed by road freight at R11.02 billion, based on an average costs per accident and 2006 data from the South African Department of Transport (DoT).

Methodology

Due to the risk of underestimating external freight transportation costs when using the bottom-up approach, the top-down approach, also used by February (2011), is recommended. For the purposes of quantifying road freight externality cost, the methodology below used in a 2003 DoT study conducted by CSIR Transportek (DoT, 2004) to calculate total road accident externality cost, was adjusted to reflect freight vehicle accidents only. The following data inputs are required:

- fatal accident statistics
- vehicle counts of different vehicles involved in fatal accidents
- costs of accidents classified by severities (casualty outcomes for the accidents) and urban/rural (additional costs)
- costs for towing, car hire, insurance administration, assessors, legal, accident administration and time delay per accident for each vehicle type
- total tonne-kilometres for road freight

The calculations were done with 2010 total road accident fatalities. The unit casualty cost (value of statistical life) tables and the vehicle cost tables from the DoT study (DoT, 2004) were conservatively adjusted according to consumer price index (CPI) inflation without taking into account changes in income levels. A cost calculation table for a single road fatality was generated from the actual data of 2002. After a total estimate has been calculated, the final sum less the total amount outstanding and paid out by the Road Accident Fund (RAF), which is funded from the fuel levy and is not an externality, is portioned according to how many light delivery vehicles and trucks were involved in fatal accidents. Additional costs per vehicle and per accident are then added for accidents involving light delivery vehicles and trucks. To obtain a rate per tonne-km the total cost is divided by total road tonne-kilometres.

Calculations

Due to a lack of detail of recent road accident statistics (only fatal accidents) the number of severe and slightly injured road users were estimated through the most recent figures, 2004, in relation to the road fatalities. The application of the calculation resulted in the estimated external cost of the loss of a life for the different age categories for urban and rural accidents.

The sum of the cost values added up to R59.9 billion. From this, the sum of R21.3 billion (R11.4 billion RAF payments added to the R9.9 billion outstanding claims, which is accounted for in the fuel levy) was subtracted. From the remainder only 5.1% and 19.5% was attributed to truck and LDV-related accidents, respectively, resulting in a total of R9.53 billion of road freight external accident costs attributed to loss of output.

To estimate the costs additional to that of the loss of output, the values as per Table 1 were used to cost each accident and vehicle involved in an accident. The estimated number of slight and serious accidents for trucks were 6 800 and 2 922 respectively, and 26 178 and 11 248 for light delivery vehicles. The ratio of 1:1.28 vehicles per fatality was used to estimate the number of vehicles involved in the different types of accidents. These costs added up to R1.71 billion.

Table 1: Additional external costs incurred per vehicle and per accident, 2004 values adjusted to 2010 for CPI inflation (rand per vehicle)

Vehicle type	Per vehicle						Per accident		
	Towing	Car hire	Insurance admin	Assessors	Legal	Total	Accident admin	Time delay	Total
LDV	2 460	4 101	2 296	492	377	9 727	9 513	8 201	17 714
Truck	3 280	4 101	2 296	820	377	10 875	9 513	8 201	17 714
Articulated truck	11 482	4 101	2 296	492	377	18 748	21 323	8 201	29 524

Source: DoT (Department of Transport). 2004.
The estimation of unit costs of road traffic accidents in South Africa

In 2010 accident externality costs related to road freight transport, therefore, cost the South African economy an estimated R11.24 billion at a rate of 4.92367c/tonne-km. Transnet reported R436 million in cost of losses for 2010 or an external rail accident cost of 0.38704c/tonne-km.

Emissions

Emissions form a large portion of external transport costs. Particle matter (PM) such as NO_X, SO_2, O_3 and VOC (volatile organic compounds) are the main components. Air pollution from transport emissions adds to health costs, building and material damages, and crop losses, and has a negative impact on biodiversity and ecosystems (Van Essen, 2008).

An advanced and detailed quantification process, the Impact Pathway Approach, is discussed in a European Commission (2005) paper and is proposed as a best practice methodology. Ricci and Friedrich (1999), Navrud *et al*. (2006) and Maibach *et al*. (2008) propose an Impact Pathway Approach and state that it is widely accepted and acknowledged. Ricci and Friedrich (1999) define it as a detailed bottom-up approach to solve the problem of technological diversity in transport equipment. The complete chain of causal relationships, through emissions, diffusion, chemical conversion in the environment and impact on the various receptors (humans, crops etc.) and, finally, the monetary valuation of such an impact are followed.

Although a bottom-up approach is regarded as the ideal way, it is highly data-intensive. Alternatives to the bottom-up approach are a top-down approach or a marginal abatement approach. The top-down approach as proposed by Salvatore and Romano (2002) approximates emission levels through means of proxy variables (road length and population) and multivariate regression. Based on these values emissions are estimated at urban, highway and provincial levels. Marginal abatement cost curves (MAC) are important tools to give countries a set of options to follow in order to reduce their emissions footprint. It is an important tool for understanding emissions trading and shaping policy discussions. Based on a MAC, the cost of a tonne of an emission factor can be established, given the target level emissions a country wants to achieve (Morris, Paltsev & Reilly, 2008).

Methodology

Due to the lack of available data inputs required for the bottom-up method as well as the lack of emissions simulation models and receptor sites for South Africa, the Impact Pathway Approach could not be implemented for this study and the top-down approach was used. The newly developed method used in this study is based on the offset cost of emissions from the European Union, (Van Essen, Davidson & Brouwer, 2008) converted through PPP-adjusted GDP per capita and empirical data sourced from the Freight Demand Model (FDM) for South Africa as applied in the Logistics Cost Model (Havenga, 2010) used in tandem with vehicle data from the Road Freight Association (2011). The following data inputs are required:

- diesel emission breakdown
- offset cost for different emission types
- estimated breakdown of vehicle fleet
- average vehicle payload per trip
- tonne-km per different mixes of vehicles used
- load factors for each type of commodity hauled
- emissions per kWh generated by Eskom (South Africa's electricity public utility)
- total tonne-kilometres for road and rail freight

For road transport, for each different type of vehicle, the average transport distance was calculated from the 2010 FDM by dividing the tonne-kilometres by the tonnage and the load factor. By then dividing the total tonnes hauled by the average payload for the given vehicle composition, a total kilometres per annum (KMPA) was calculated. From the KMPA the litres of diesel consumed by road freight were obtained by multiplying each KMPA with the respective vehicle composition mileage (litres per kilometre.) The total litres were then cost-based on the emissions breakdown per litre of diesel multiplied by the total litres and the cost per tonne of emissions.

Because only an estimated 8.5% of freight is transported via diesel in South Africa, the calculation for rail emissions is initially split into two parts, electrical and diesel. The diesel is then calculated on the total amount of litres consumed as with road. The electrical part is calculated on the total amount of kWh consumed by the electrical rail infrastructure and multiplied by a CO_2 equivalent emissions factor (Letete, Mondli & Marquard, 2012) per kWh generated and then costs are calculated.

Calculations

In 2010 road freight transport consumed an estimated 3.768 billion litres of diesel. The total offset cost for all road emissions amounted to R10.61 billion (Table 2), which is equivalent to 4.64538c/tonne-km. Diesel rail emissions cost for 2010 was an estimated R337 million resulting in a figure of 3.528c/tonne-km. The bulk of rail tonnes, moved via electrified railways, had an emission offset cost of R538 million, or 0.5225c/tonne-km, which drove down the total rail cost of emissions to 0.7779c/tonne-km (Table 3).

Table 2: Emissions per litre of diesel and PPP-adjusted GDP/capita transferred abatement cost of emissions per tonne

	NO_x	PM metro	PM rural	HC	CO	CO_2	SO_2
g/l	26.5	1.194	1.194	0.7	4	2 688.9	12.559
2010 rand cost per tonne	18 692	413 278	121 726	5 470	5 470	225	36472
Total emissions road ('000 tonnes)	161.73	0.198	7.091	4.272	24.41	16 411.01	76.65
Rail diesel emissions ('000 tonnes)	5.17	0.001	0.231	0.13	0.78	524.6	2.45
Total rail diesel cost (millions)	96.64	0.54	28.21	0.75	4.27	118.04	89.37
Total road cost (millions)	3 023.193	82.088	863.216	23.373	113.56	3 692.4	2 795.733

Table 3: Rail emissions calculation

Eskom emissions per CO_2 equivalent (Kg/kWh)	1.015
Tonnes CO_2	2 393 541.54
Cost of electric CO_2 (rand millions)	538
Diesel and electric combined cost (rand millions)	876
Rail tonne-km (millions)	112 649
Cost per tonne-km (c/tonne-km)	0.7779

Roadway land

Road users do not pay rent or property tax when using roadway land and it is therefore considered to be a sunk cost (Victoria Transport Policy Institute, 2012a). To avoid under-pricing of space-intensive modes, roadway land should be priced and taxed at the same rate as competing uses. If economical neutrality is not reached, transport will be under-priced relative to other goods. Basic access, as discussed below, should be excluded. It would furthermore seem as if charging for congestion as well as land use would lead to a double count but these two charges are not mutually exclusive for social infrastructure that is written off over a long time. The one refers to an annual loss and the other to a permanent loss.

The Victorian Transport Policy Institute (2012a) defines roadway land value as the rent that road users would pay for roadway land, or at a minimum, the equivalent of property taxes. It reflects the cost of land used for road right-of-way and other public facilities dedicated for automobile use. Newman and Kenworthy (1989) observed a positive relationship between annual car kilometres per capita and metres of roadway per capita – as per-capita travel increases so must the amount of land devoted to roads. Not all the costs should have to be recovered by road users. It is acknowledged that 25% of roadway land costs (Victorian Transport Policy Institute, 2012a) are to be attributed to basic public access. The valuation of road- and railway land can be based on the total land surface area being used by the infrastructure, cost at property prices, and discounted annually.

Methodology

South Africa has a vast road network spanning many different urban and rural areas. In addition, transportation is not limited to a single province or area. It is therefore proposed that roadway land cost be calculated as a national average. Other than property prices and a discount rate, the following data inputs are required:

- total kilometres of road and rail
- width requirement for each type of road and rail track
- national total vehicle mileage

Once the average width requirements of a certain type of road are added, multiplying it by the length of road gives the surface area. Costing the surface area at an average price for land gives the total sunk cost of the road network. This total sunk cost can be transferred to road users through discounting it annually.

Calculations

Based on a sample of 100 vacant land prices from all over South Africa, the average cost per hectare was estimated at R24 563. The surface area used for the road network was calculated at 31 997.13 square kilometres. The total value of roadway land was estimated at R78.6 billion. Given a 10% discount rate, based on the 2010 interest rate, less 25% attributed to public access, the annual cost of roadway land was R5.89 billion. The total estimated vehicle kilometres travelled for 2010 (127 billion km) was extrapolated from South Africa's vehicle database, as maintained by the DoT, time series data. Road freight attributed 49.5km billion vehicle kilometres, which resulted in a cost of R2.29 billion or 4.629c per vehicle kilometre. Using total road tonne-km, this translates into a roadway cost for trucks and light duty vehicles of 1.00315c/tonne-km.

Policing

In contrast to road-related transport, rail freight transportation has no external portion of policing cost.

The Victoria Transport Policy Institute (2012) carried out a comprehensive literature review on how to quantify the costs associated with traffic services. They propose that for each public service, be it fire and rescue, traffic police, courts or jailing, the budgets for each of these services be proportionally allocated to the traffic related incidence.

Methodology

Based on the assumption that more people require relatively more policing, approximations of the per capita cost of policing could be calculated based on population and budget density. Based on the relationship between metro police budget allocated per person as a function of population density, the national average cost of policing can be estimated and transferred to road freight through the total proportion of registered vehicles attributable to trucks and light delivery vehicles. The following data inputs are required:

- municipal populations, surface size and Metro Police budgets
- national population and surface size
- proportion of registered vehicles attributable to trucks and light delivery vehicles

Calculations

Based on the data from Table 4 the relationship between money density per square kilometre and population density per square kilometre was used to calculate the money density per square kilometre for the country as a whole.

Table 4: Data used for calculating policing cost per population density

2010/2011	Metro-policing budget	Surface area (square km)	Population	Budget per person	Population density per square km
JMPD	1 500 000 000	1 644.96	4 031 432	372.07	2 450
Ekurhuleni	603 776 503	1975	2 824 597	213.75	1 430
City of Cape Town	297 907 000	2455	2 998 802	99.34	1 221

An exponential model of the form $y = ae^{bx}$ was fitted through a linear regression model, fixing the intercept based on a preliminary curve fitting in Microsoft Excel. The fitted relationship found and used was: Budget per person = $42.752e^{0.0009(\text{population density})}$, as can be seen from Table 5.

Table 5: Regression results for estimating policing cost through population density

Coefficients:				
	Estimate	Std. Error	t value	**Pr(>|t|)**
PopDen	9.05E-04	9.47E-05	9.557	0.0108

Residual standard error: 0.2924 on 2 degrees of freedom, Multiple R-squared: 0.998, Adjusted R-squared: 0.997, F-statistic: 991.5 on 1 and 2 DF, p-value: 0.001007.

The total cost of (traffic) policing was estimated at R2.2 billion. This cost was then transferred to road freight through the total proportion of registered vehicles attributable to trucks and light delivery vehicles which totalled R589 million. The effective cost was 0.25814c/tonne-km.

Noise

Due to the logarithmic nature of sound, a doubling of traffic volume will increase noise levels by 3dB. This relationship causes the marginal costs to rely on and be very sensitive to current traffic flows (World Bank, 1997).

Maibach *et al*. (2008) discuss both a bottom-up and a top-down approach. The bottom-up approach commences with the traffic flow at a particular route. Once this reference scenario has been set up with the appropriate speed and density distributions of cars along the route, a marginal scenario is created which is the same as the reference, but with one additional vehicle. The damage costs (based on WTP) are determined by the difference between the reference and marginal scenario. The top-down approach uses willingness to pay or accept compensation for additional health or more silence, scaled to a national level. The key differences are that the bottom-up approach attempts to quantify the marginal noise costs of smaller or heavily used (noisy) roads while in contrast the top-down approach uses the total national impact aggregated by total distance driven to give average cost implications.

The following factors are highlighted by Maibach *et al.* (2008):

- There are different opinions regarding the threshold for annoying sound, such as 50dB(A), 55dB(A) or even 60dB(A). The threshold impact has a substantial effect on the marginal noise cost as research has shown that changing the threshold from 50 dB(A) to 55 dB(A) reduces the impact of noise pollution of cars by nearly 50%.
- Rail noise is experienced as less annoying and is therefore usually given a 5 dB(A) 'discount'.

Methodology

Due to the total lack of receptor sites (locations for noise readings) in South Africa, the literature-proposed methodology could not be employed and an extrapolation method was used. Caution needs to be taken before extrapolating noise costs from one country to another because the negative impact of noise will vary from one country to another based on the vehicle fleet composition and population densities of different receptor areas. The method used within this study was to identify possible country relationships at a national level based on density-based statistics and to extrapolate the costs through them. The following data inputs are required:

- noise cost as a percentage of GDP
- GDP/capita for the countries under scrutiny
- national population counts
- national surface sizes

Once noise cost has been estimated as a percentage of GDP, the noise cost of rail and road freight can be allocated.

Calculations

Based on the assumption that the more densely populated an area is, the more cost will be incurred due to noise, exponential relationships based on data from Table 6 were compared between people per square mile, GDP per capita per square mile and percentage noise cost of GDP.

Table 6: Data used for estimating noise cost as percentage of GDP

Country	Noise cost % of GDP	People per square mile	Square miles	PPP-adjusted GDP/capita	GDP per capita per square mile
France	0.24	289	210 668	34 385	0.16
Germany	0.2	609	135 236	36 225	0.27
Norway	0.23	39	118 865	56 498	0.48
Great Britain	0.5	650	93 278	37 000	0.40
USA	0.06–0.21	84	3 539 225	45 613	0.01
Japan	0.2	836	152 411	35 011	0.23

Source for noise cost % of GDP: Victorian Transport Policy Institute. 2012b. Transportation Cost and Benefit Analysis II – Noise Costs

Exponential models (of the form $y = ae^{bx}$ were fitted through a linear regression model and fixing the intercept a based on preliminary curve fitting in Excel.) The exponential relationship, Table 7, between people per square mile and percentage of GDP, estimated the noise cost of South Africa as 0.14%, while the GDP per capita per square mile-based relationship, Table 8, estimated the cost at 0.15% of GDP. The GDP per capita per square mile statistic was introduced to be another measure and control of population density.

Table 7: Regression results for estimating noise cost as percentage of GDP through population density

Coefficients:				
	Estimate	Std. Error	t value	**Pr(>ltl)**
PeoplePM^2	0.001003	0.000477	2.102	0.0895

Residual standard error: 0.6004 on 5 degrees of freedom, Multiple R-squared: 0.8986, Adjusted R-squared: 0.8783, F-statistic: 44.31 on 1 and 5 DF, p-value: 0.001154

Table 8: Regression results for estimating noise cost as percentage of GDP through GDP density

Coefficients:				
	Estimate	Std. Error	t value	**Pr(>ltl)**
cgdpM^2	1.717	0.7108	2.416	0.0605

Residual standard error: 0.5197 on 5 degrees of freedom, Multiple R-squared: 0.9086, Adjusted R-squared: 0.8904, F-statistic: 49.72 on 1 and 5 DF, p-value: 0.0008863.

Trying to estimate noise costs through GDP per capita alone could give contradicting results, for example two countries could have the same GDP per capita but one has a high population density and the other a low one. The latter should theoretically have less external noise cost than the former, assuming the same vehicle fleet composition. For the purpose of this study it was then assumed that noise cost in South Africa will be a conservative estimate 0.145% of GDP, i.e. R4.322 billion.

The total cost was split between road and rail in the same relationship as the total vehicle kilometres travelled per mode. Rail noise was found to be insignificant, i.e. 0.49% of total noise cost. The relative noise weights, obtained from Maibach *et al.* (2008), multiplied by the estimated vehicle kilometres travelled resulted in road freight accounting for 77% of the road noise cost at 1.88278c/tonne-km. Rail is therefore accountable for R21.211 million at 0.01883c/tonne-km (91.5% of rail traffic is electrified; therefore a 33% noise discount is applied).

Congestion

According to Jorgensen (2009) congestion has become a growing concern in South African urban areas. Maibach *et al*. (2008) propose a bottom-up approach which is capable of '(estimating) very detailed values'. Congestion should be calculated based on reiterative remodelling of marginal trip costs based on the demand elasticity of travel on a certain route.

Methodology

Calculating the national congestion costs which are attributable to road freight according to the generally accepted methods would be difficult due to the lack of data. A proposed, conservative approach is based on national vehicle statistics for the purposes of this study. The following data inputs are required:

- national vehicle counts
- average speed travelled and speed limit per section monitored
- distance per section monitored
- maximum vehicles per lane per hour monitored
- estimated value of time
- average daily trips and truck trips per section

The proposed methodology is based on the assumption that, on average, most people (taking into account speeding drivers and drivers who drive below the speed limit in the absence of congestion) drive at the speed limit. The difference in average speed observed and the speed limit are therefore attributable, under the assumptions, to congestion.

Research by Nel and Pienaar (2009) found that the appropriate free-flow volume of traffic on South African roads is 1 600 vehicles per lane per hour. Based on this, only sections where there were more than 1 600 vehicles per lane per hour at any given time were used in the calculations, assuming that these sections would not be constrained by other factors such as road layout or junctions. The total time lost, calculated based on the average speed and distance of the section monitored, due to trucks is then allocated by calculating which portion of the average passenger car equivalent daily trips was caused by trucks.

Calculations

Based on the methodology a total of 4.39 billion minutes of extra travel time was caused by road freight, which valued at R1 a minute (Nel & Pienaar, 2009) resulted in a cost of R4.39 billion or 1.9225c/tonne-km.

Impact on total freight transport costs

South Africa's surface freight transport costs amounted to R181 billion in 2010 (Simpson & Havenga, 2011). The externality costs calculated in this paper are significant and amount to R34.7 billion (1.2% of GDP) (as depicted in Figure 1), i.e. nearly 20% of freight transport costs are not 'invoiced'.

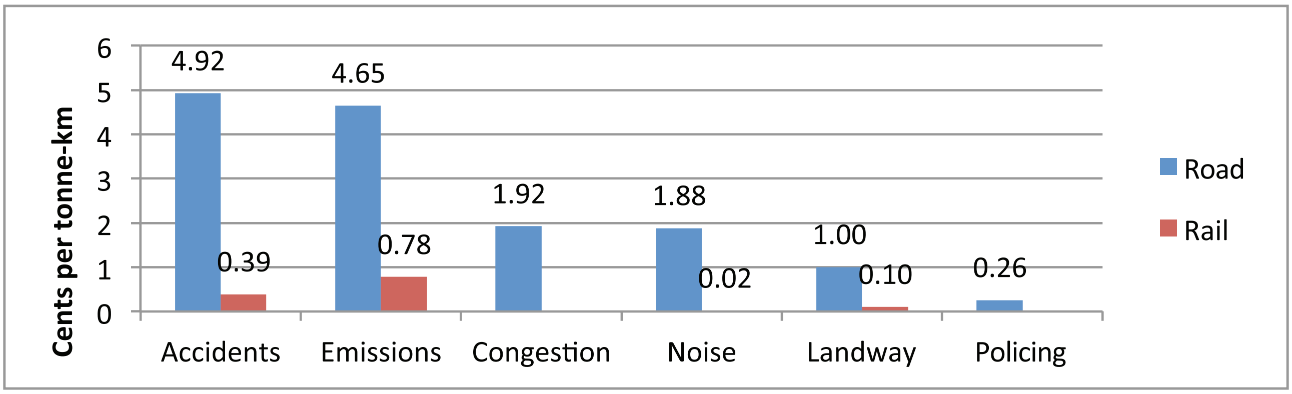

Figure 1: South Africa's surface freight transport externality costs based (2010)

CONCLUSION

The research presented in this paper is the output of an estimation for surface freight transport externalities in South Africa. Many of the models applied internationally have onerous data requirements, and adaptations were made as required to obtain an executable approach for South Africa. The initial results highlight that freight externality costs are a significant cost that has not yet been accounted for but are borne by the public at large. Maibach *et al.* (2008) comment that evidently road transport has by far the largest share in total external costs of transport. The results of this study, as depicted in Figure 1, support this claim. If externality costs were to be taken into account with the pricing of surface freight transport, road transportation would be less attractive in comparison to other modes. Marginally, road freight incurs eleven times more external costs than rail. Simpson and Havenga (2011) discuss the dependency of South African logistics cost on the predominant volatile cost of fuel and encourage a shift to relaxing JIT constraints and raising levels of inventory levels to mitigate the associated volatility. This encourages and could be achieved by a modal shift from road to rail in order to reduce the transportation cost of logistics in South Africa, which is also supported from an externality cost perspective.

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Table of acronyms

CPI	consumer price index
DoT	Department of Transport
FDM	Freight Demand Model
GDP	Gross Domestic Product
JIT	just in time
KMPA	kilometres per annum
LDV	light delivery van
MAC	marginal abatement cost curves
PM	particle matter
RAF	Road Accident Fund
VOC	volatile organic compounds
WTP	willingness to pay