SUSTAINABLE TRANSPORT: INFRASTRUCTURE COSTS AND THE RELEVANCE OF EXTERNALITIES

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ABSTRACT

Long term sustainable transport, including infrastructure costs and recovery, as well as associated externalities, has become an increasing concern in recent years due to social and environmental issues. This paper considers infrastructure provision costs and the significance of the so-called 'hidden costs' which can benefit one transport mode at the expense of another and lead to inefficient transport pricing. It is important to consider the cost and value of each transport mode in terms of long-term sustainability, energy efficiency and environmental issues. Finally, consideration must be given to service quality to the user – whether in the private or in the commercial world.

Many of the costs of providing freight and passenger road and rail transport services have been externalised in the past and passed on to the public in general – including non-users of transport. This should be seen as a de-facto form of cross-subsidisation which can lead to decisions being made for infrastructure investments which may seem appropriate in the immediate short term, but which may have negative effects in the long term.

Infrastructure costs include the cost of providing railways and the public transport infrastructure of roads, both rural and urban, as well as the ways of redeeming these costs from users. Fair infrastructure charging principles must be applied which consider the following points:

- The capital cost the rail system, as well as road infrastructure development and the overall costs to the economy in general;
- The contribution to pavement wear and tear costs by various users, and
- Space occupation and other infrastructure facilities for specific users.

In addition, transport cost externalities must also be considered and they include:

- Accident costs;
- Congestion costs;
- Exhaust emission and pollution costs including Greenhouse and carbon issues;
- Noise costs;
- Traffic policing costs, and
- Energy efficiency and resource consumption.

Consideration is given to these issues and their relevance to South African conditions in this study. Background details relating to earlier studies which have appeared are included since many are not well known. Extracts from these reports support many of the conclusions drawn in this paper.

It is important to note that quantification of some external costs has been difficult and controversial in the past but more sophisticated scientific evaluation is advancing such work at a rapid rate. It is also important to appreciate the fact that internalising some of these costs may not be considered 'politically correct' or justifiable but it is important to be aware of the consequences of these costs – broadly and across society in general.

INTRODUCTION

Modern transport systems are essential to exploit agricultural, commercial and mining activities for the public good. Road improvements and railway developments in South Africa have gone hand in hand during the last 150 years. Railways were introduced to provide low cost transport over great distances and to handle high traffic volumes over developing corridors and arterial routes. After rail development, roads were at first seen merely as feeders to railways, expediting the collection and delivery of goods. As motor vehicle technology and road construction techniques improved in the early 20th century, the road became an alternative to the railway, which came under increasing competitive pressure by the 1930s, particularly in the matter of lighter traffic density rural branch lines. Railway administrators tended to view branch lines in isolation, often ignoring their value in generating main line traffic. Because of this and coupled to transport deregulation, a programme of branch line closures began in the 1980s which led to an accelerated growth in road transport, not only in urban and rural areas but for long-haul arterial traffic as well. But at what cost?

In respect of rail transport in South Africa, government funded and operated a national railway system after 1910. Reviewing railway costs since then, there is a belief that railway costs have been a financial burden on the taxpayer but this is not so. The railway has, in fact, more than paid for itself, including infrastructure provision and finance costs, as well as direct operating costs. It is important to consider that the South Africa Act of 1909, section 127, which stated that: -

> *"The railways shall be administered on business principles, due regard being had to agricultural and industrial development within the Union, and promotion by means of cheap transport, of the settlement of an agricultural and industrial population in the inland portions of all Provinces of the Union. So far as may be, the total earnings shall not be more than to be sufficient to meet the necessary outlays for working, betterment, depreciation and the payment of interest due on capital, not being capital contributed out of railway or harbour revenue."* [1]

This was the norm for the next 75 years, although political pressure was often used to promote the construction of railways to many rural communities and while some were not cost remunerative, they were, ultimately beneficial to agricultural development. But this was not unique to South Africa. Even in the USA, so called-uneconomic services were underpinned by cross-subsidisation with profitable operations – the forerunner to the "Loss-leader" concept.

After transport deregulation in the late 1980s, the railway administration was freed of its social responsibilities, including the provision of uneconomic urban passenger services. However, the elimination of the road freight "permit" system, which had restricted private competition in the past, led to a dramatic increase in road transport for general freight traffic, resulting in the loss of a significant portion of railway traffic. Government, and even the railway administration itself, did not at the time consider the long-term consequence of this trend, and road construction and improvements continued to be funded to the detriment of rail operations.

This led to a crisis and the late General Manager Spoornet (the Railway operating division of Transnet) AP (Braam) le Roux stated in the *Financial Mail* under the headline "Spoornet Death Wish" during late 1995:

"Once existing assets wear out, that's it…ours is a closing down policy"

Le Roux also stated: ***"The new government has a very important decision to make… …which is whether South Africa wants railways or not.*** *The advantages of rail are several. First, the basic technology of rail transport is cheaper. While the capital cost of an electric railway is high, operating costs are low because it uses local energy resources - Eskom and coal."*

[1] South Africa Act of 1909, section 127.

"The decision that needs to be made is whether to give railways as an entity the economic space to survive. *The playing fields must be made even. For one thing, this means that roads must not be populated by monstrously big freight vehicles as in some other African countries."* [2]

Le Roux made this statement in 1995. It is only recently that government has awakened to the crisis but is it too late?

From the 1930s the state provided a national road infrastructure for public use and funded its maintenance via a dedicated fuel tax levy. This policy was abolished in 1988, after which the fuel levy became a general tax and only a small portion was used for road maintenance. The question now is whether the pricing system for the use of non-toll or toll roads is correctly applied to the various vehicle types, ranging from light private motor vehicles to heavy commercial freight carriers. The cost of appropriate infrastructure for high axle-load vehicles is an important consideration since scientific analysis has confirmed the fact that while axle-loads increase arithmetically, the effect on pavement wear increases exponentially. This fact was first quantified in the United States during the 1950s and has been refined over the years by various scientific bodies and the CSIR here in South Africa.

For the rail mode, the issue of infrastructure cost recovery is different from that of road, since in South Africa, there is only one state-owned operator who has had to maintain the infrastructure from generated revenue (with the exception of urban passenger services provided for social purposes). In the case of road transport, the multitude of operators are charged for usage but the shortfall in cost recovery coming from various vehicle types is skewed and has become an issue which must be quantified and applied across the board in a fair-priced manner. Of particular concern is the claim that light motor vehicle operators actually subsidise heavy vehicle operators by paying disproportionately high fees on toll roads. The issue of the fuel excise tax is another issue that must be addressed. Railway operators who use diesel fuel pay the same tax but do not use the roads and are put at a competitive disadvantage by so-doing. This fact, coupled with unrecovered external costs from both rail and road operators must be considered when calculating the total costs of transport in an effort to promote the most efficient investment for future growth and sustainable development in South Africa.

Environmental matters have become an important 21st Century issue and these cannot be overlooked because of short-term considerations when long-term sustainable development is necessary. For this reason various transport cost externalities which impact on society in general have been considered. Because of a serious lack of local information this study has investigated infrastructure and external transport costs in a number of countries where localised or general conditions are considered to be similar to South Africa. To achieve a representative cross-section of South African transport a group of rural branch line railways and roads in KwaZulu Natal, as well as the high density rail and road corridor route between Durban and Gauteng, have been examined and conclusions drawn that can then be used to make comparisons on other important corridors or in rural areas serving agriculture production.

This discussion paper has been completed in the hope that it will create interest and raise debate over future transport policy. Decision makers must take cognisance of the fact that much rail-friendly traffic in South Africa has been transferred to road and once this has happened it is difficult to reverse the trend, since major investments in alternative modes must be made. Industry has to make long-term plans in respect of development, expansion and related transport matters. For example, there are numerous private sidings in industrial areas which are not being utilised, while road traffic congestion in urban areas continues unabated. Can some of these private sidings be utilised as a cost-effective alternative to final road delivery?

Government has expressed its desire to see a return of traffic to rail but users should not be pressured as they were in the past. However, once the full costs of transport are understood and

[2] SA Transport magazine, January 1996: Article titled "Spoornet Death Wish."

appreciated, decisions can be made which will be in the long-term interests of South Africa. It is hoped that this study document will generate interest and raise questions which must be addressed most urgently. Only when this has been done will it be possible to develop a transport strategy that will best serve the nation.

GENERAL TRANSPORT: PRELIMINARY FINDINGS AND COMMENTS

Road transport services are fast and flexible. Operators utilise the nation's extensive road system to provide transport services to virtually every corner of South Africa. In the past, railways served major industrial and commercial development areas as well as rural communities around the country and over 2 000 stations and 3 500 private sidings were open where both freight and passenger services were catered for. In addition, the railway administration provided road transport connecting services for communities not linked to the national railway system.

As private road transport services expanded and transport deregulation came about, the rail mode lost significant volumes of general traffic, and in particular for small consignments and parcels traffic. In recent times, even bulk traffic such as domestic coal, grain, and minerals such as chrome and manganese, liquid fuels and chemicals have been lost to road. This study examines the importance of infrastructure and external costs which should be borne by the rail and road modes when judging the value of each. The preliminary results of this examination are detailed:

- Road transport of freight traffic provides services to all parts of South Africa. It has grown dramatically in recent years, taking up almost all new growth, while overall rail market share has decreased significantly;
- Rail transport of freight traffic is suitable for high volume bulk export traffic, as well as on high density corridor routes where intermodal systems can be used. It can also be used to promote agricultural and general development in rural areas;
- When externalities such as accident, congestion, exhaust emission and policing costs are considered, commercial road transport operators would incur increased costs of at least 26% to 31%. Rail costs, excluding infrastructure costs, would, however, increase by about 5%; [3]
- The current deteriorating condition of roads is due to the fact that government is not spending as much on road maintenance as it should, considering particularly the fact that South Africa allows the heaviest heavy road freight vehicles in the world which have unlimited access to all the country's roads. Railways have been forced to reduce track maintenance budgets, with resulting deterioration of infrastructure. This has compromised the competitive equality between the modes;
- Government, as sole shareholder in Transnet and its business unit Transnet Freight Rail (TFR – formerly Spoornet) has stipulated in the past that it must be run on business principles and not as a national transport undertaking with social obligations. Because of this, large volumes of general traffic have been diverted to road;
- This has led to a greater dependence on imported petroleum products for transport requirements with resulting balance of payment problems. In contrast, most of the South African mainline rail network uses electric energy for transport purposes;
- Rail should be more attractive to users in terms of costs but government must appreciate the cumulative effect of years of under-investment in their asset and take cognisance of the extent of road externalities and the under recovery of road provision costs from road freight operators which have made rail less competitive, and
- By employing modern Intermodal systems, rail can provide improved long-distance service levels and road can be used for the shorter haul or for other specialised services. This should be a 'win-win' outcome for both.

[3] Jorgensen, A, "The Relevance of External Transport Costs," paper for Africa Rail 2009.

ROAD INFRASTRUCTURE PROVISION AND MAINTENANCE COSTS

Most public roads have been financed by government in the interests of development and the spin-offs that accrue through business development and the resulting increased tax revenues that are expected to follow. In an effort to more directly recover these costs, the charging of annual license fees and raising excise taxes on fuel purchased by motor vehicle operators was done at first. More recently, many roads have been tolled – a highly controversial matter. The main ways of funding road infrastructure and sustainable maintenance are as follows:

- Charging Annual License Fees;
- Charging a fuel levy;
- Weight-distance charges for various heavy vehicles;
- Tolling roads;
- GPS Tracking systems;
- Charging for the infrastructure standard of various routes, and
- Congestion charging in urban areas.

Motor Vehicle license fees have been charged since the earliest times and are based on the mass and type of particular vehicle and not its use in terms of kilometres driven or routes followed. It can only be considered as an "entry" fee for road vehicle ownership and not a road user charge.

The fuel levy was first introduced in South Africa with the introduction of the "National Roads Act of 1935. Thereafter, the building of roads, financed mainly by an allocation of the duty on motor fuel, proceeded steadily as a matter of national importance. At first the levy was 3d per gallon (17% of the pump price) and this was increased to 6d a gallon in 1950. Unfortunately, the dedicated road levy was absorbed by the National Treasury in 1988 and ceased to be dedicated from this time on and the funds raised are now paid into the exchequer and apportioned out for a variety of social uses. As such, less than 20% of the former dedicated fund now sees its way back to road construction and maintenance. Even in the United States, during 1990, Congress siphoned off 2.5 cents on each gallon of gas for deficit reduction. In 1993 a further 4.3 cents gasoline tax was introduced to be used for further deficit reduction. So, South Africa was not unique in diverting fuel taxes from road costs.

The fuel levy is, however, an inappropriate mechanism for allocating fair user charges as related to road provision and maintenance costs. This is because heavy road freight vehicles have a much higher wear effect on pavements than light motor vehicles per kilometre driven. It has been stated that a single 7 to 8 axle road freight combination is equivalent to between 50 000 and 100 000 light vehicles for pavement wear and tear. While the exact amount is open to argument, the fact is that as individual axle-loads increase arithmetically, the wear effect on pavements increases exponentially. This has been described scientifically in terms of E80 or ESA units but this is a simplification which requires more careful scrutiny as certain tyre types and inflation pressures have a further detrimental effect on pavement wear. [4]

In terms of actual fuel consumption, a typical light motor vehicle travels 10 to 14 kilometres for each litre of fuel used, while a typical Interlink road-rig travels 2 to 3 km/litre. At the current price (1 May 2013) Diesel costs R 11.41 on the Reef and R 11.15 at the coast. The fuel levy portion is R 1.975 per litre. Assuming an average of 2.5 kilometres of travel per litre of fuel used, this is an average contribution of R 0.79 per kilometre of travel. In comparison, the light motor vehicle operator paying R 12.24 a litre for 93 octane petrol makes a contribution of R 1.125 to the fuel levy. At an average of 12 kilometres travel for each litre of fuel used, this is R 0.09375 per kilometre of travel. The heavy vehicle thus pays six-times the amount of the light vehicle operator, yet his 56 ton rig is responsible for 98% of the wear and tear on the pavement. It can be concluded that the fuel price levy is unfair to the light vehicle operator and acts in effect as a subsidy to the heavy vehicle operator.

[4] Department of Transport (South Africa) September 1992: Pamphlet title: "Damage caused by heavy vehicles, Road Structures."

Weight-distance charges for road use have been introduced in a number of countries such as New Zealand, Sweden and in some American States. In the case of New Zealand, vehicles over 3.5 tons in mass are exempted from paying fuel taxes but are required to pay road user charges in 1 000 km licence fee units, depending on the size and configuration of each heavy vehicle. At the current Rand-New Zealand Dollar exchange rate, a 56-ton heavy vehicle pays about R 4.00 per kilometre to use the roads. This is a reasonably fair arrangement but it does not take into consideration specific routes with differing road pavement standards. It does however, obviate the motivation to toll just certain roads and has been accepted by the road transport industry in New Zealand since its introduction in 1977.[5]

A study undertaken for the SA Automobile Association in 1995 by Africon Consultants [6] revealed that there was an under-recovery of R 2.04 per vehicle kilometre driven by 7 axle Interlink combinations while the light vehicle operator was over charged by R 0.07 per kilometre. The report stated that "the under recovery of road costs from heavy freight vehicles is a source of disequilibrium in the transport market in South Africa and is an inequitable burden on other road users and the tax payer; the light vehicle motorist being particularly disadvantaged." Since the publication of this report and considering inflation and other relevant factors, the under-recovery is over R 5.00 per kilometre and if externalities are considered, the figure is approaching R 6.00 per kilometre.

Tolling roads would appear to be a fair way of recovering road infrastructure costs but unless all roads are tolled, (see weight-distance charging) it is grossly unfair to the majority of road users. The matter of tolling the Gauteng main road system is a case in point. Another case was the plan to toll the N2 highway from Durban to East London and to construct a new 100 km "greenfields" section through Pondoland. While the proposed toll road would reduce the distance by some 80 kilometres, speed traffic flows and enhance safety when compared to the original N2 route from Port Edward to Mthatha and East London. But was the road a necessity? It would have by-passed a number of towns on the existing R61 and N2 and have been of little value to many of the local population. What was really needed were a number of local by-pass roads to avoid congested town centres. But the main issue, and that objected to by most people was the plan to toll the road at a point opposite the old Durban airport in the Isipingo area. It was alleged that local commuters would have to fund the "greenfields" section in another province and this was not popular. The plan has been temporarily shelved but will, no doubt, be raised again in the future.

The other issue regarding toll roads is the price differential between light and heavy vehicles. On the N3 route from Gauteng to Durban, motorists pass through five toll plazas and are charged R 184.50 while heavy vehicle operators pay R 676.00. As only 489 kilometres of the 573 kilometres are tolled, the light vehicle operator pays R 0.377 per kilometre while the heavy vehicle pays R 1.382 per kilometre – or only about 3½ times as much as the light vehicle operator. The 1995 Automobile Association report commented on toll roads and stated "Toll fees appear to be unevenly biased in favour of the heavy vehicles." It went on to suggest that "One solution to the problem would be to limit the mass of heavy vehicles utilising roads under certain specifications. This practice is followed widely in other countries, very effectively, and, there is no reason why it cannot be introduced in South Africa." Effective policing could, however, be a problem.

GPS Systems have been tested in a number of countries, notably in the State of Tasmania, Australia. Motor vehicles can be tracked from point of origin to final destination, monitoring movement along each of several route alternatives. This information can be linked to appropriate user charges for the pavement standard of each section. Certain ethical issues have been raised and such a surveillance system could impinge on an individual's right to privacy.

[5] New Zealand Transport Agency, 2013. Pamphlet titled: "Road User Charges.
[6] Jordaan, J,W., for SA Automobile Association, 1995 by Africon Consultants. Paper Title: "Heavy Vehicle Overloading in South Africa."

Infrastructure Standards vary widely in South Africa as in most countries. When the National Road plan was initiated in the 1930s, pavement standards were far below today's standards. As the leading road and motor vehicle country, the United States set the standards of the time. In the case of surfaced roads, whether asphalt or concrete, American specifications were applied in South Africa. The most important was to set an 8.2 ton maximum axle-load when designing roads and highways. Careful motor vehicle counts were made to estimate the design-life of a road based on the total number of E-80 units to accrue over a 15 year period.

Early National Roads were constructed to the highest standards of the time but lane widths were narrow by comparison with today's roads. Soil mechanics had not developed to the art it is today while the pavement designs were not well developed. Even before the National Road system had been completed in the 1960s upgrading earlier routes was started. This included improving the road geometry, building wider and stronger bridges and, ultimately, introducing multi-lane divide throughways (expressways) on major routes.

However, many Provincial and District roads continued to be surfaced with shallow pavements but based on the expected usage. No one anticipated the phenomenal increase in heavy vehicle usage which developed after transport deregulation in the late 1980s and this undermined the earlier calculations of pavement design life. Of particular concern has been the rapid pavement deterioration and safety of operations on many of these routes. Pavement wear and the incidence of potholes has led to increased operating and accident costs for operators, and, ultimately, to the provincial authorities to redress the conditions.

In addition, additional overtaking lanes have had to be provided to reduce vehicle congestion on many routes. Concrete overlays have been provided in many places such as Town Hill, north of Pietermaritzburg, to cope with heavy vehicle wear and tear on the infrastructure but who pays for this expenditure? Another issue that must be considered is the additional cost of providing a road infrastructure of high axle-load road freight vehicles. It has been estimated that the cost of providing a single direction lane for motor vehicles having a 3.5 tons maximum mass is R 150 000 per kilometre but increasing this to 8.2 tons to accommodate heavy vehicles, will cost an additional R 250 000 per kilometre. There appears to be no mechanism to charging the additional amount to the road freight operators – indeed, it is spread over all users. Since government sanctioned an axle-load increase to 9 tons – a 10% increase, the life of asphalt pavements will decrease by between 25 and 50%. One day the chickens will come home to roost.

The South African Automobile Association has issued repeated warnings about this state of affairs and in 2000 it released a report, researched by Jeffares & Green which stated that between 1988 and 1999 the condition of roads in South Africa had deteriorated dramatically[7]. In 1988 about 75% of National and Provincial roads were in good to very good condition but by 1999 this percentage dropped to 33%. At the other end of the scale, the percentage of roads in poor or very poor condition increased from 5% in 1988 to 33% in 1999. There were three major consequences flowing from this fact:

- The cost to restore the road network to an acceptable level will, it is estimated, to be seven times that if adequate maintenance has been done earlier, and
- The backlog of funding had by 1999 increased to an estimated R 65 billion (SABITA).

Motorists would have to pay almost twice as much in vehicle operating, tire and safety costs to travel on a road in poor condition compared to one in good condition. This applied to all forms of commercial and industrial transport, as well as public transport and emergency vehicles. The above conditions were allowed to occur despite:

- Numerous and continual warnings by transport professionals, government officials and the business community;

[7] Automobile Association of South Africa, "Road Conditions and Funding: A 20 Year Review of National and Provincial Roads in South Africa," October 2008

- Pronouncements regarding the problem by Ministers of Transport and some politicians;
- The fact that the current fuel levy paid by motorists it two to three times in excess of that required to pay for much needed maintenance, and
- The potential availability of other revenue paid by the motoring public such as licenses, transport taxes, VAT, levies and import duties.

It was also noted that toll roads, which were often cited as a solution to the problem could only be sensibly applied to less than 5% of the rural road network and, combined, tolls could bring in a net total income equivalent to a tax on fuel of between one and two cents a litre. To have maintained the road network in 1998 it was estimated that an amount of 35c/l of the approximately 96c/l fuel tax would have been required.

That was in 1998 and it is now 2013. What has changed? In a *Mail & Guardian* Critical Thinking Forum, held in Johannesburg on 23 April 2013 and reported in the newspaper on 26 April 2013, the hotly debated topic of how South Africa can fund its future road infrastructure was discussed. Nazir Alli, Chief Executive SANRAL stated that the backlog of road maintenance now stood at R 149 billion and was continuing to increase. He stated that South Africa needed about R 340 billion to maintain and grow its road infrastructure. Alli also stated that South Africa has the tenth largest road network in the world. It included 606 000 route kilometres of which 153 000 was surfaced and 3 128 km were tolled. Government currently funded 84% of the national road network from the fiscus but only 16% from toll roads. [8]

Also in attendance was Dr Iraj Aberdian of Pan-African Capital Holdings and Patrick Craven of Cosatu. There was a general debate over the issue of taxation. Dr Abertian stated that "taxation is inefficient." It might be justified at any moment in time but does not provide the long-term consistency that is required. Craven did not believe that public-private partnerships were the solution either (Note: toll roads are public-privates sector partnerships). Craven stated: "This enshrines the idea that the roads are a commodity or a business opportunity. Infrastructure development is not an opportunity for people to make money. It is a public service. If we raise money to fund it, it needs to be done in the fairest way possible. In the end it comes down to taxation."

The issue that was not discussed was the matter of tolling secondary and rural roads. It is clear that toll plazas cannot be placed on every route but it would be possible to declare certain roads as being "commercial routes." For example, the R612, running from Bulwer and Ixopo to the coast at Umzinto in KZN, is used to move over 2 000 tons of pulpwood a day (some 55 truck loads and empty returns) and large volumes of sugar cane during the cutting season (March to October). This provincial road is narrow and winding, with steep gradients and there are few places for safe overtaking, while the pavement surface is in poor condition. Surely, tolling such a road would make sense, or applying the New Zealand road-distance tax as an alternative. There are many other such roads where similar principles could be applied.

Congestion charging in urban areas has been applied in many cities, particularly in London. The efficient use of road infrastructure in urban areas is a high priority as in most cases urban road space cannot be increased. Some towns and cities provide loading zones or bays for commercial traffic in order to improve working conditions for transport operators and also to address the negative impacts that can be caused by delivery operations such as double parking. Limiting entry of large long-haul road vehicles to the city centres is another alternative as they often create congestion on narrow roads. The use of smaller vehicles operating from out of town warehouses is an alternative.

HEAVY VEHICLE OVERLOADING ISSUES

During the mid-1990s some 16% of heavy vehicles that were stopped at weighbridges were found to be overloaded, yet it was estimated that they were responsible for over 80% of the damage to road infrastructure – both pavements and bridges. During 1997 (annual CSIR Transportek Report No. CR-97/016), 58 904 vehicles were weighed and 19 342 were found to be overloaded – 33% of

[8] Mail & Guardian: "Critical Thinking Forum," held in Johannesburg on 23 April 2013, published on 26 April 2013

the total. Unfortunately only 13 840 vehicles were charged – just 22%. Kwa-Zulu Natal had the lowest number of offenders – 28% but in the Eastern Cape the figure was 81% and in Gauteng – 91%.[9] Since this time, the overloading problem has declined somewhat because of the installation of additional weighbridges and greater traffic police enforcement. Another factor has been the increase in permissible axle-load from 8.2 tons to 9.0 tons and the relaxing of the bridge formula which affected multiple axle combinations. But the fact is that in terms of road design, the granting of a higher axle-load has meant that overloading has been legalised.

The damage resulting from higher axle-loads on paved roads was first quantified in a series of experiments known as the AASHO Road Test, carried out in the United States between 1956 and 1960. The outcome of the testing led to the development of the load equivalency formula which compares the damaging effect of any axle-load with the standard axle-load of 8 200 kg (an E80 unit). The result of the tests showed that an axle carrying twice the legal load, 16.4 tons, had 16 times the damaging effect of a legal axle. Even if an axle-load is 25% over the legal limit, it causes 2.5 times the damage of a legal axle. From the formula, it can be seen that the structural damage caused by light motor vehicles was negligible. Nevertheless, it was estimated that a legally-loaded two axle truck was equivalent to 100 000 light vehicles. Consider now a seven or eight axle Interlink road freight vehicle having a maximum axle-load of 9 000 kg.

Road structural layers are designed to carry a given number of standard axles or E80s.The fact is that most paved roads are designed to provide the structural strength for heavy vehicles. For more important routes which carry heavier traffic, a thicker structure with stronger materials is provided. A typical rural road having a relative cost of, say, one unit compares to a typical National two-lane road which costs 2 units, or twice as much per lane kilometre. A high standard Freeway may cost 3 or more units per kilometre – and this is just for the pavement and does not include the route design with cuttings, fills and embankments. A rural road may be designed for 100 000 E80s while a freeway for 10 million E80s but the relative cost per E80 unit is 33 times greater for the rural road than the freeway. This is the reason that high axle-load vehicles can lead to rapid pavement degradation on rural roads. The fact that many heavy vehicle operators deliberately by-pass toll road sections to use older alternative of often parallel routes leads to increased damages and, ultimately, cost to the taxpayer. A good case example is on the N3, where many south-bound heavy vehicles exit from a point north of Mooirivier and use the R 103 through Nottingham Road to Howick to avoid the toll plaza. In so doing, they create congestion on the old narrow road and are a safety risk to other road users and pedestrians alike.

It was stated in a report released in 2001 that heavy vehicle overloading was costing the country R 650 million a year. Since then, many responsible road-freight operators have fitted on-board electronic mass metres to their vehicles, and many industries, particularly in the forestry sector, will not allow overloaded vehicles of off-load at their pulpwood mills. Nevertheless, these efforts, while most laudable, are quite small when considering the total road freight traffic around the country. Now that government has thrown its weight behind upgrading the national railway system it is time to consider the position of the country's roads. Increased haulage of bulk commodities such as minerals, coal and forestry products will take the pressure of the roads and lead to improvements in the goal of sustainable transport. The following section considers the cost of moving significant volumes to heavy freight traffic on road when this traffic is better suited to rail transport at a greater return in energy efficiency and reduced external costs.

THE COST OF MOVING RAIL-FRIENDLY TRAFFIC BY ROAD

In recent years large volumes of bulk products such as grains, minerals, coal and forestry products have been moved by road due to the inability of the national carrier to handle this traffic. But it is important to consider why this has happened. As stated in the beginning of this paper, government marginalised the rail sector from the 1980s and there was little incentive for the railway management to fight what was seen to be a losing battle.

[9] CSIR Transportek Report No. CR-97/016)

But what is it costing South Africa to move former rail and rail-friendly traffic by road? The following investigation (Table 1) of certain commodities seeks to quantify this cost. TFR have been unable to move many bulk commodities because of 30 years of underinvestment, largely the fault of government, and this has resulted in large quantities of traditional (and logical) rail traffic being forced to road.

Table 1: Summary of Selected Commodities and cost per annum.

Bulk Commodities on Road			
Commodity	**Tonnage**	**Route**	**Cost**
Manganese ore	**1 600 000**	**Hotazel to Durban**	**R 368 764 279**
Chrome ore	**250 000**	**Steelpoort to Richards Bay**	**R 93 380 828**
	558 000	**Rustenburg to Richards Bay**	**R 197 944 975**
	300 000	**Rustenburg to Durban**	**R 82 870 035**
Pulpwood *	**100 000**	**Bulwer to Richards Bay**	**R 13 891 333**
TOTAL	**2 808 000**		**R 756 851 450**

* This is only a very small portion of the total traffic moved by road which is over 4 million tons, most of which should be moved by rail.

This represents the real road cost of only 2 808 000 tons of potential rail traffic. During 2010 some 647 million tons of corridor and rural traffic moved by road – equivalent to 203 billion ton kilometres. If the rail potential of this total was even only 100 million tons, then the cost to the country of the rail operator's inability to move the potential traffic exceeded R 12-bn.[10]

EXTERNAL TRANSPORT COSTS

The writer presented a paper examining external transport costs at the 28th Southern African Transport Conference. As was stated, it is necessary to study various transport routes in detail to obtain accurate statistics on each of the externalities. For example, the number and severity of accidents, places where congestion occurs, where exhaust emissions present a threat to the environment and the health of all living creatures, as well as where noise levels create an unacceptable level of discomfort. Traffic control and policing costs should be evaluated along each route, while space usage and the extent of land required by the different modes must be considered. Finally, energy efficiency and resource use must be considered for transport on different routes.

The International Union of Railways (UIC), Paris, commissioned an in-depth study on the external effects of transport which appeared in 2000. This study was updated and appeared in 2004, using the year 2000 as the base year. Information from 17 EU states, as well as Switzerland and Norway was interpreted and published in two outputs – total and average costs for the region, and by social marginal cost pricing. The updated report, completed in 2004, detailed total external costs, excluding traffic congestion, at € 650 billion or 7.3% of the total GDP in the region. Accident costs were 24% of the total, air pollution 27%, climate change 30%, noise 7%, up-and-down stream processes 7%, nature and landscape 5%. Road transport generated 83.7% of the total, air transport 14% and rail only 1.9% of the total, the balance being inland water transport. Two thirds of the costs were attributable to passenger transport, while one third was from freight transport.[11]

After reviewing various local and international research data the following add-on costs to cover present externalities were suggested in the 2009 paper. A number of different report findings were

[10] Jorgensen, A, Report for the Rail Road Association of SA, April 2013

[11] INFRAS (Zurich), IWW Karlsruhe, March 2000. Book title: "External Costs of Transport: Accident, Environmental and Congestion Costs of Transport in Western Europe"

shown which could be used as inputs in a sensitivity analysis to obtain more reliable conclusions. Each section of road and competing railway must be analysed on a route basis such as the N3 road and Natcor rail corridor, or a geographic area such as the Natal Midlands forestry area. This is currently being done but for the present, the data contained in the following two tables estimates the financial effects of external costs that are currently not directly recovered from users. Utilising the quantified external add-on cost figures, thought to reflect local conditions, the tables detail the effect of each of these. The first table deals with forestry traffic in the Natal Midlands, and the second with general traffic on the N3 corridor.

The Natal Midlands forestry traffic was for one-way short to medium haul length at an average charge out rate of 60c per tonne-km, while the N3 Corridor traffic is long haul at 50c per tonne-km, both in 2009. The opportunity of obtaining return loads (back haul) can reduce the rates by 25% or more. The charge-out rate is very sensitive to fuel costs and virtually varies from month to month even where contracts are in place (Table 2).

Table 2: Estimated Total External Costs for KwaZulu Natal Forest Industry Roundwood Traffic (2006 figures). [12]

	Sector	Railway		Roads	
	Present charges	*		**	
1	Av rate per tonne-km	30c		60c	
	External Costs		% of Increase		% of Increase
2	Accidents	0.12c/t-km	6.63	6.00c/t-km	38.39
3	Congestion	***		2.50c/t-km	15.99
4	Emission	1.44c/t-km	79.56	6.39c/t-km	40.89
5	Noise	0.25c/t-km	13.81	0.43c/t-km	2.75
6	Policing	Nil		0.31c/t-km	1.98
7.	TOTAL	1.81c/-km	100.00	15.63c/t-km	100.00
	Revised Rate	31.81c/t-km		75.63c/t-km	
	Percentage increase	6.03%		26.05%	

* This is an average siding to siding charge, which excludes road short-haul from plantation to the rail loading point which can cost over R 1.20 per tonne kilometre. Loading to rail can cost an additional R 8.00 per ton.

** The charge of 60c per ton kilometre was an typical road transport charge for an average 36 ton during 2006 for forest to mill traffic from the KZN Midlands area. It includes profit for the operator.

*** There is possible congestion at some level crossings but programmes in recent years have all but eliminated such crossings on important provincial roads.

Forestry industry pulpwood or roundwood transport is generally over modest distances, usually not exceeding a lead distance of 300 km. It is also one-way traffic, with no return-leg or back-haul. The cost per kilometre, is therefore, higher than long-haul general traffic, particularly where return-leg traffic is the norm, such as on the Durban – Gauteng N3 corridor. Most forestry traffic is over district and provincial roads where no toll fees are charged. Such roads generally have shallow pavements which are far more susceptible to damage from high axle load vehicles.

A considerable investment has been made in recent years to allow large road vehicles to reach plantation loading points, whereas when rail is used smaller tractor-trailer combinations can operate over less expensive roads, although there is an extra loading cost at the railway siding (Table 3).

[12] Jorgensen, A and Sowman, R: Paper title: "Pietermaritzburg Branch Line Cluster" TMT Projects, 2008

Table 3: Estimated Total External Costs: Durban – Gauteng Corridor (2006 figures). [13]

	Sector	Railway		Roads *	
	Present charges			**	
1	Av rate per tonne-km	30c		50c	
	External Costs		% of Increase		% of Increase.
2	Accidents	0.12c/t-km	8.82	6.00c/t-km	38.30
3	Congestion	***	-	2.50c/t-km	15.99
4	Emission #	1.08c/t-km	79.41	6.39c/t-km	40.89
5	Noise #	0.16c/t-km	12.17	0.43c/t-km	2.75
6	Policing	Nil	-	0.31c/t-km	1.98
7.	TOTAL	1.36c/-km	100.00	15.63c/t-km	100.00
	Revised Rate	31.36c/t-km		65.63c/t-km	
	Percentage increase	4.5%		31.1%	

* The legal payload of a seven-axle Interlink or equivalent vehicle ranges from 36 to 40 tons, depending on the truck type and commodity hauled. For the purposes of this table, it has been assumed that a great number of trucks on the N3 route will be hauling import/export goods, much of which is containerised. Two containers can add up to 7 tons of non-payload weight to the combination, which in the case of Interlinks, averages about 20 tons unladen. The average payload, therefore, has been estimated to be 30 tons.
** The charge of 50c per ton kilometre is based on a single load with no return haul. When a return load is realised (most of the time) transport costs can be reduced considerably, depending on extra time required to secure such a load.
*** There are no level crossings over the National road on the railway line between Durban and Gauteng.
# Rail is reduced because electric traction is used throughout.

The real cost of road transport externalities (excluding infrastructure costs) are about four times that of rail when diesel traction is used in South Africa. When electricity is the source of energy, even considering power station emission costs, rail improves this even more.

GENERAL CONCLUSIONS

- When based on full cost accounting calculations for each mode, including energy resource consumption and other transport cost externalities, the rail mode has important financial and environmental advantages over road.
- Road transport is fast and flexible, a great benefit to many users who are able to reduce warehousing and other logistics costs as a result. However, operators use an infrastructure funded by government to which it is generally accepted that they do not pay adequate external costs and for provision and maintenance costs. It has also been claimed that road toll fees are skewed to the benefit of large vehicles while light motor vehicle operators significantly subsidise the large vehicles.
- The under-recovery of road costs has generally been accepted by government since good roads and efficient transport generate development and business opportunities. This, ultimately, creates income and profits that produce revenue for government via taxes. It must be pointed out that rail benefits are considerable, including the payment of taxes as well, and these must be considered in an effort to better appreciate total costs.
- The road transport industry has strived to present a good public image but the negative aspects must be factored into the total value of the mode.

RECOMMENDATIONS

- Infrastructure costing and user pay systems must be fully investigated;
- External transportation costs must be more fully investigated in the South African context;
- The cost of these externalities must be factored into the total cost of transportation – to the operator, the user, the State and society in general, and
- Only then will it be possible to make decisions regarding infrastructure investment priorities and net benefits to the country as a whole.

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