QUANTIFYING THE ECONOMIC BENEFITS OF CHANGING THE GAUTENG TO DURBAN RAILWAY CORRIDOR FROM NARROW TO STANDARD GAUGE

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ABSTRACT

Railway gauge has been a topic of discussion for many years within Transnet and the Department of Transport. At the recent 2018 South African Heavy Haul Association's Technical Workshop, a statement was made regarding the future of South Africa's railway network and whether it should be upgraded from its current state, which is narrow gauge, to standard gauge. The National Rail Policy White Paper and other publications by the Department of Transport also addresses the contentious gauge issue in detail. This paper seeks to investigate various rail gauge alternatives which could be implemented along the Natal freight rail corridor. These alternatives include investigating the upgrading of the corridor's narrow gauge to standard gauge, leaving the corridor as is and constructing a brand-new standard gauge line parallel to the current narrow gauge line and lastly performing upgrades as per Transnet's plans published in the Market Demand Strategy. This paper analyses each alternative and provides recommendations on what will be required in a more detailed feasibility study of each of the alternatives. The results indicate that from the alternatives evaluated, a single standard gauge line constructed parallel to the narrow gauge line could provide the greatest benefit on the Gauteng to Durban corridor.

1 BACKGROUND

The South African railway network consists of 22,387 route-km or 30,400 track-km of which all is narrow gauge with the only exception being the 80 km Gautrain line which is standard gauge (Department of Transport, 2009). Railways' success is built upon its three genetic technologies which include bearing, guiding and coupling (van der Meulen, 2010). According to the Department of Transport (2017), South Africa can successfully operate long, heavy haul trains, however, South Africa is unable to take advantage of speed and axle load in the same way standard gauge countries are able to.

South Africa's freight trains are not able to transport double stacked containers because the lines are narrow gauge and have overhead catenary line height restrictions. If selected lines are changed to standard gauge, freight haul using rail will become more competitive when compared to road truck transport. Marsay (2005) indicated that rail has a total freight haul market share of 16 % along the Natal corridor and trucks hold the remaining 84%. The Department of Transport (2017) indicates that rail has slumped to a 90/10 split between road and rail on the Natal corridor.

2 AIM OF THE PAPER

The objective of this research is to determine the economic benefits of changing the Durban to Gauteng railway corridor from narrow to standard gauge. The paper seeks to determine whether it will be economically beneficial to change the line from narrow to standard gauge through the analysis of various scenarios.

3 SCOPE OF PAPER

The paper seeks to determine, as accurately as possible, the costs of the various alternatives using data from construction projects conducted by Transnet Freight Rail (TFR). The full project values, durations and scales are published annually by TFR. Moving block signalling with on-board signalling has been reserved for a future study.

The detailed design of the geometry of the lines will not be considered as well as the detailed design of the hump yards to allow for narrow gauge and standard gauge operations to interact. The economic benefit calculated is to TFR and not to South Africa as a whole.

4 THE FUTURE OF NARROW GAUGE RAILWAY IN SOUTH AFRICA

South Africa operated efficiently as a narrow gauge railway system between the early 1900's until 1987, following the deregulation of road transport. Road trumps rail in the mobility department because of South Africa's vast road network which covers over 750,00 km in length (National Treasury, 2009).

The Department of Transport (2017) uses numerous examples from around the world to illustrate the emerging global trend which is narrow gauge railway line conversions to standard gauge or the complete removal of narrow gauge lines. China has begun converting narrow gauge lines to standard gauge and within the African continent Kenya has completed its first standard gauge railway line along with Ethiopia, Ghana and Nigeria. The picture is clear, no countries are building their 2050 transport systems on a narrow gauge railway backbone.

Narrow gauge lacks in competitiveness against standard gauge since over 60 % of the world uses standard gauge railway lines. This has resulted in research and development being centred around standard gauge railway technology. Locomotives which are used for narrow gauge railway lines are double the cost per kilo-newton of tractive effort when compared to a standard gauge locomotive (Creamer, 2010).

4.1 Potential future of the core network

Should the National Rail Policy (Department of Transport, 2017) which was compiled by the Department of Transport be passed as a bill and be made law by the National Assembly, the core railway network may change drastically in the years to come.

Figure 1 displays what the future may look like for the South African core railway network as presented by van der Meulen (2010). This network consists of 5,200 km of track of which 744 km are high speed rail (in excess of 270 km/h), 2,691 km are freight orienated and 900 km are passenger orientated.

The Sishen-Saldanha line would remain narrow guage and so would the Beit Bridge-Durban line, however, the rest of the railway lines in the core network would change to standard gauge.

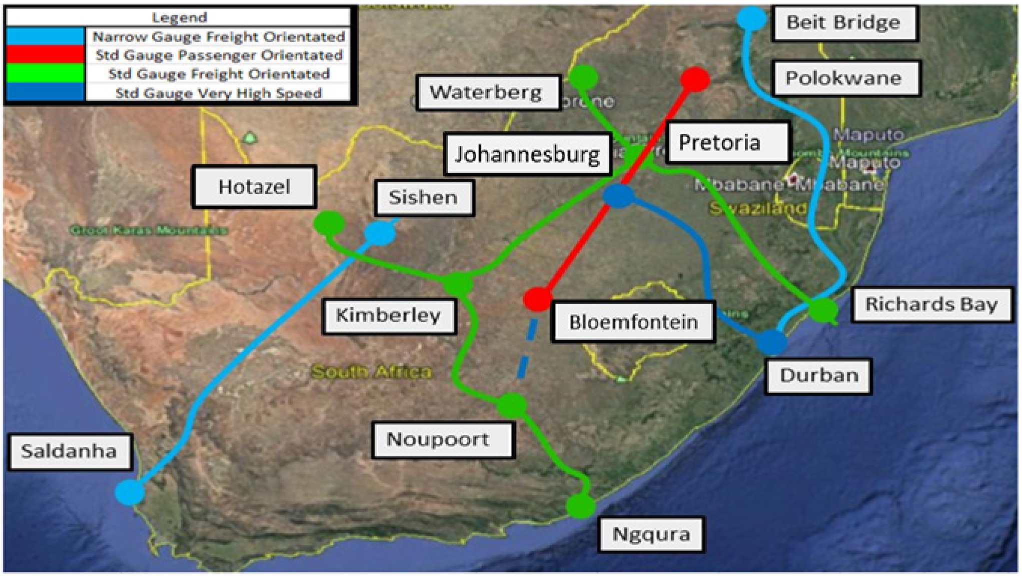

Figure 1: An essential South African railway network (adapted from van der Meulen (2010)

4.2 The Natal corridor

The Natal corridor is a double line railway which runs from Booth (Durban) to Reitvallei (Johannesburg) and is 695 km in length. The line has an axle loading of 20 tonnes, operates using 3kV DC electrification, which is an old system of electrification and uses Centralised Traffic Control (CTC). This line transports 21.6 million tonnes per annum of freight to the port and 4.7 million tonnes per annum from the port in Durban (Transnet, 2017). The cumulative amount of freight transported is expected to grow to 50.5 million tonnes per annum in 2030 and 73.4 million tonnes per annum in 2045. The line is able to operate up to 75 wagon trains and a 150-wagon compilation yard in Durban still needs to be identified (Transnet, 2012).

The current demand theoretically requires 33 trains per day to transport the freight and by 2044 a least 184 trains per day will need to run to meet the demand. This is however not possible (Transnet, 2012). Currently, sections of the line operate at a speed of 50 km/h due to steep gradients, tight curves and worsening perway condition. Transnet (2012) is of the opinion that the only feasible long-term solution is if longer trains are run on the line as opposed to the Department of Transport (2017) who argues that double stacked container trains are the future of container freight rail transport.

There are many different views on the topic of the railway gauge within South Africa. According to the literature, further investigation is required into the costs of the various options available. Marsay (2005) is adamant that road should carry the country's freight industry into 2030 and beyond, however both the Department of Transport (2017) and the Department of Environmental Affairs (2015) are of the opinion that a shift to rail is the solution to meeting the freight market demand in the future and the key to reducing greenhouse gas emissions.

5 METHODOLOGY

This paper evaluates the current Natal corridor operations through the evaluation of data available for the corridor. The data includes the number of trains per day, the volume of freight moved along the corridor, the influence of passenger trains on freight train movements and the turnaround times associated with the operations. This information was used to set up a base year cost analysis and enabled the other scenarios to be evaluated against this base year case. The evaluation was done for the period between 2015 and 2045.

5.1 Alternative options selection

Table 1 displays the narrow gauge options which were analysed.

Table 1: Advantages and disadvantage of alternative narrow-gauge options

No.	Alternative options	Intervention	Advantages	Disadvantages
1	Leave the line as a narrow gauge line while performing minimal upgrades.	• Maintain the track as per the schedule. • Perform upgrades when required due to imminent failures.	• Narrow gauge railway system will be retained. • No gauge complications. • Less new rolling stock needed. • Transnet's long-term plans will not be altered.	• The line will remain as a narrow gauge system. • Long travel times and inevitable growth in freight demand may result in rail falling even further behind with respect to freight haul market share.
2	Perform line upgrades as per the MDS.	• Perform immediate interventions such as geometry corrections for increased speed. • Upgrade the line to increase axle loading.	• Speeds of 80km/h will be achievable. • Gauge remains the same. • New rolling stock required. • Line upgrades to be performed.	• Delays during the line's upgrade • Remains a narrow gauge railway line. • Cost of the upgrades will be very high especially if geometry upgrades are to be performed.

Table 2: Advantages and disadvantage of alternative standard-gauge options

No.	Alternative options	Intervention	Advantages	Disadvantages
3	Build a new Standard Gauge railway single line adjacent to the current narrow gauge line.	• Construct standard gauge railway line. • New rolling stock and land will be required.	• A ringfenced operation. • Can haul double stacked containers at 100 km/h. • Less freight on the roads and an increased rail market share. • Current operations will not be disturbed during line construction.	• The construction costs and land acquisition costs will be high. • New rolling stock will be costly. • Extra handling costs at the yards.
4	Upgrade the current lines to standard gauge lines.	• Perform gauge upgrades on current line. • Convert one line at a time from narrow to standard gauge.	• The line would eventually become fully standard gauge. • Double stacked containers. • Increased line speed. • Increased axle loading.	• New OHTE and wider cuts required. • Viaducts need to be adapted. • New land needs to be acquired. • New rolling stock to be purchased. • Extra handling costs at yards. • High construction costs. • Delays during the upgrade.

Table 2 displays the standard gauge alternatives which were evaluated. The two options vary in the sense that the first is to keep the narrow gauge line as is and to construct a new standard gauge line. However, the other alternative is to systematically upgrade the current narrow gauge line to standard gauge.

5.2 Economic evaluation and cost identification

To ensure the options are evaluated as accurately as possible, all costs should be accounted for which include the following:

- Total construction costs including track superstructure, track substructure, OHTE, bridges, cuttings, fills, tunnels, switches, yard upgrades and additional communication infrastructure for a standard gauge railway line,
- The operational costs of running the various alternatives, and
- The new rolling stock costs including wagons, locomotives and maintenance vehicles.

Table 3 displays the infrastructure costs per kilometre that were used in determining the cost of the various alternatives. The cost of constructing a railway bridge was obtained from a study conducted on numerous bridge construction projects. The study determined an average cost/m to construct a bridge (Hadi et al., 2016). The determination of the average cost per kilometre to construct a tunnel was obtained from various tunnelling projects which were compared to determine the cost per m of a tunnelling project as a function of the bore diameter (Rostami et al., 2013).

Table 3: Infrastructure costs per kilometre (Transnet (2017), Rostami et al. (2013) and Hadi et al. (2016))

	Cost (R/km)	
	Narrow Gauge	**Standard Gauge**
Single Track	18,218,961.09	20,715,633.53
Double Track	36,437,922.18	41,431,267.07
Bridge Single Track	20,040,857.20	22,787,196.89
Bridge Double Track	40,081,714.39	45,574,393.77
Tunnel Single Track	472,150,000.00	512,620,000.00
Tunnel Double Track	944,300,000.00	1,073,704,074.07

Table 4 displays the prices of narrow and standard gauge locomotives. These values were used in the cost calculations for new rolling stock.

Table 4: Prices of electric and diesel narrow and standard-gauge locomotives (Cremer (2014) and Railway Gazette International (2018))

Locomotive Type	Electric (R million/unit)	Diesel (R million/unit)
Narrow-Gauge	41.0	32.0
Standard-Gauge	25.8	20.2

Table 5 displays the prices of two wagons types commonly used on the Natal corridor. Narrow and standard gauge wagon prices are similar and are more dependent on the wagons purpose than the gauge the wagon will run on.

Table 5: Wagon prices (Transnet (2018) and Railway Gazette International (2018))

	Container CR (R million/unit)	Tanker (R million/unit)
Wagons	1.2	2.5

5.3 Revenue calculation

Revenue is generated through the transportation of commodities on the railway corridor for clients. To determine the benefits of possibly implementing the various alternatives, a method of comparison was established. The alternatives were compared to the base case and the difference in the number of tonnes transported per year is then equal to the benefit. The base case is the current status quo of the Durban-Gauteng corridor.

The rate to transport one tonne of a commodity was obtained from TFR and these rates were used to determine the revenue generated per year by the railway line. TFR generates on average R171.85 per tonne of freight transported, however this value changes depending on the type of freight transported as well as the waiting time of the freight in the yard before collection (Transnet, 2017). The revenue generated per year for future years was determined by using the present worth formula (Remer & Nieto, 1995). An expected annual growth rate of 3.1% was used (Transnet, 2017).

5.4 Operating cost determination

The operating costs are variable and dependant on the line density, line utilisation and tonnes moved on the line. Harris (1977) developed a relationship between operational cost and density on a line which showed that the greater the density, the lower the operating costs. This relationship was used to determine operating costs as line utilisation increased with time due to increased demand. Figure 2 displays the relationship used to calculate the operational costs per track kilometer. The density is calculated by dividing the tonne kilometers by the route kilometers.

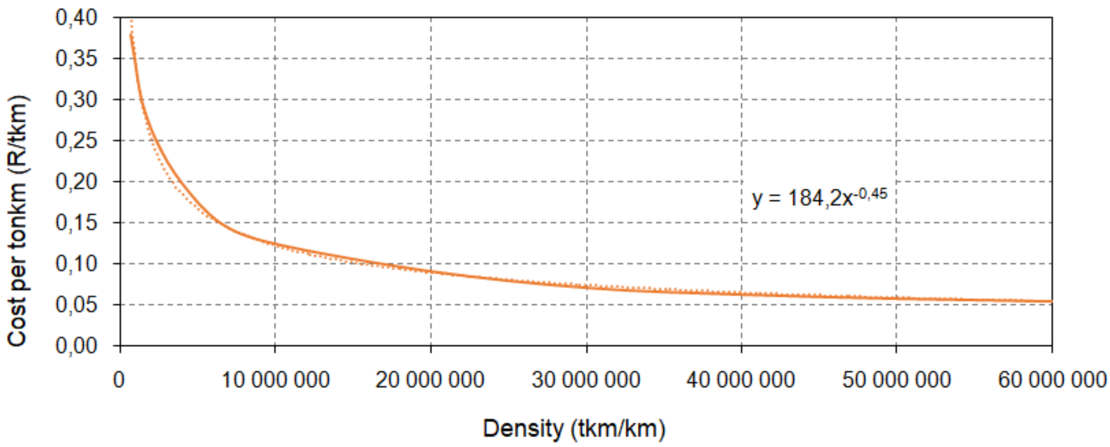

Figure 2: Intermodal density change on the Harris curve due to density-driven savings (adapted from Harris (1977))

The operating costs for the base year were obtained from Transnet's Integrated Report from 2017 and was used to verify the operating costs calculated from Harris's (1977) relationship. Transnet Freight Rail (2017) indicates that their operating costs for the Natal corridor amounted to R 2 620 922 796.00. The Harris (1977) relationship led to the operating costs amounting to R 2 764 731 255.29 which is a difference of 5.5%.

5.6 Method of comparison

The alternatives were compared with one another by evaluating each alternative's profit generation during the period from 2015 to 2045. Profit is the difference between the revenue and the sum of the operating and capital expenditure costs. Monetary values are expressed in present worth. The line has a calculated maximum throughput volume of 43.8 million tonnes per annum if 50 wagon configurations are used and Transnet (2012) indicates that 35% of all theoretical train slots are lost to maintenance activities.

5.7 Cashflows per alternative

Figure 3 displays the annual spending per year for each of the narrow gauge alternatives against the amount of line capacity available. Alternative 1, which entails no line upgrades to increase capacity, can meet the demand up until 2026. After 2026 there is no additional line capacity available due to no capacity upgrades being performed on the line. Alternative 2 loses line capacity until a line upgrade is performed in 2035, allowing longer trains to run. Capital is spent on the line to increase capacity to meet the demand.

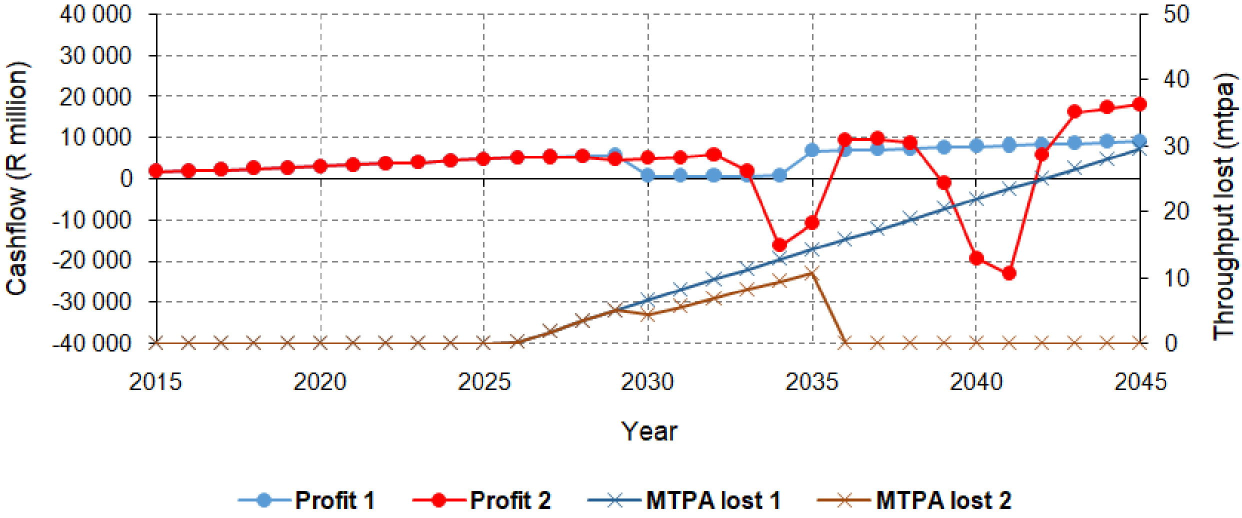

Figure 3: Present worth of annual spending for Alternatives 1 and 2

Figure 4 displays the annual income per year for the alternatives which involve standard gauge line construction. Alternatives 3 and 4 have a construction time of 10 years after which extra capacity becomes available.

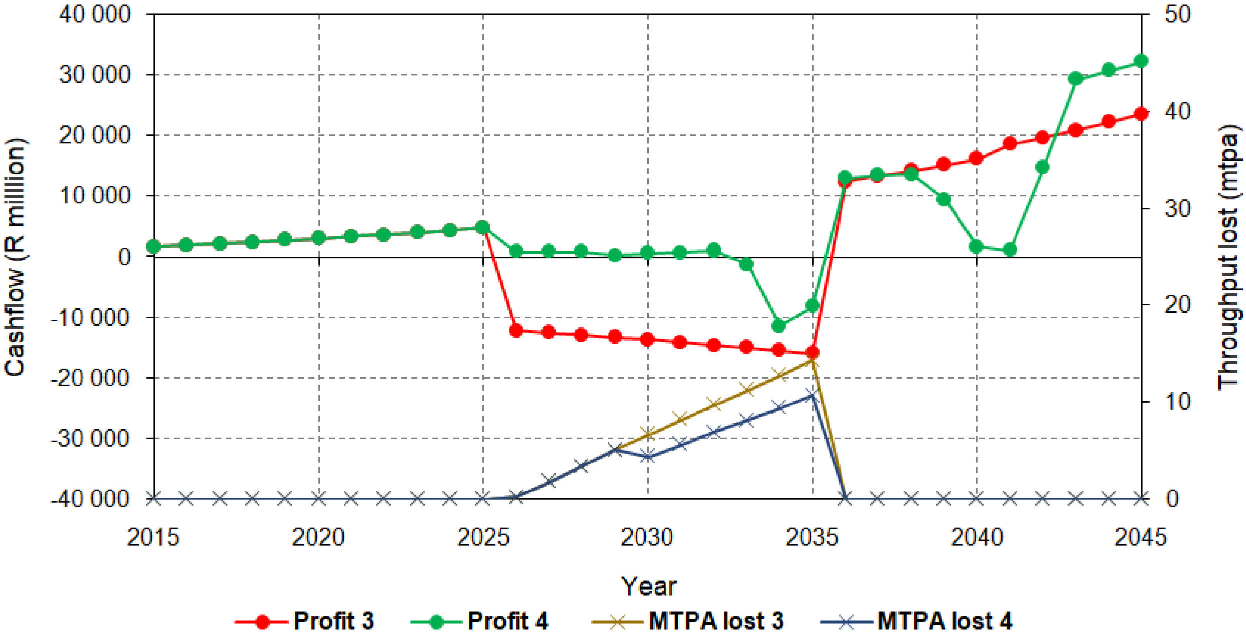

Figure 4: Present worth of annual spending for Alternatives 3 and 4

For Alternative 3, there is a high amount of capital expenditure during construction, however after construction the line can generate R 7 billion rand a year in 2036. Alternative 4 does not disturb the narrow gauge corridor's operations, however, construction is expensive because land needs to be purchased.

Figure 5 displays the cumulative spending of each of the alternatives evaluated. Alternative 3 requires a large amount of capital spending to construct, however, the project breaks even in 2042. Alternative 2 maintains profitability throughout the analysis and cumulatively generates R 150 billion. Alternative 1 remains profitable through the analysis period, however, as observed in Figure 3, the alternative does not accommodate the future demand expected on the corridor. Alternative 4, which entails constructing a new standard gauge single line, generates the most profit. By implementing this project, containers can be double stacked and almost solely transported by the standard gauge line.

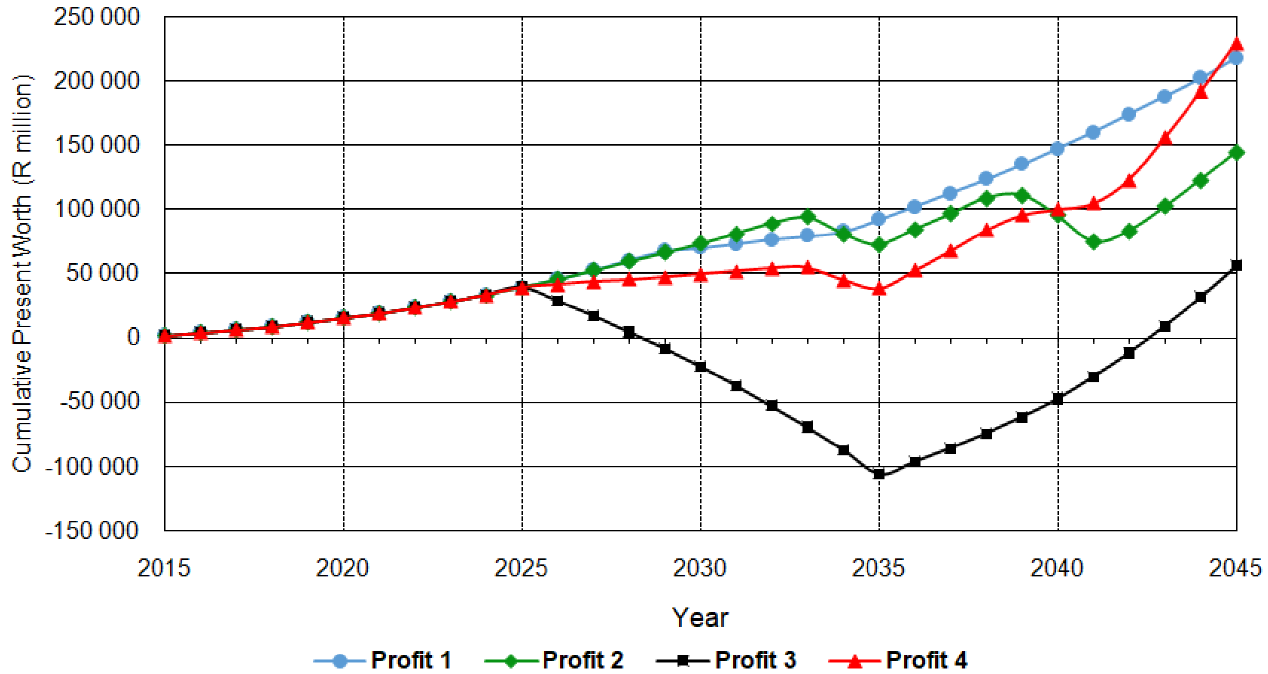

Figure 5: Cumulative present worth cashflow for each alternative

6 CONCLUSION

The railway networks within Southern Africa are positioned to handle the increase in freight demand but need to be ready for the future. The results of this paper suggest that the Durban-Gauteng corridor would benefit from a single line standard gauge railway. The addition of this line would aid in the transport of mainly double-stacked containers as well as various other commodities. Transnet Freight Rail (TFR) will be able to run the narrow gauge line as per the plans set out in the market demand strategy. Additional line capacity will be available on the narrow gauge line and the standard gauge line will be available to transport any additional freight.

7 RECOMMENDATIONS

The cost model used to evaluate the various alternatives, was limited by the information made available. If more information on the various corridors becomes available in the future, the model could be calibrated and would deliver improved line capacity and usage results. The results of this research should be a stepping stone towards a feasibility study which could be conducted in more detail to evaluate the benefits of constructing a standard gauge freight haul line between Durban and Gauteng.

The added benefits of a standard gauge railway line should be evaluated such as the potential for a high-speed rail link as postulated by Van der Meulen (2010). The future benefits of running electric trains versus the costs to use diesel operated trucks to transport freight over long distances will make railway projects more attractive economically and environmentally. This aspect should therefore be considered in a future study. The effects of the large-scale infrastructure projects on the country's Gross Domestic Product (GDP) should be studied because this will add value to the project through job creation in the construction sector.

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