The Development of a Freight Flow Segmentation Methodology to Inform Rail Reform: A South African case study

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Thesis presented in fulfilment of the requirements for the degree of Master of Commerce (Transport Economics) in the Faculty of Economic and Management Sciences at the University of Stellenbosch

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March 2013

Declaration

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ABSTRACT

Global rail reform is an important topic, especially seen against a backdrop of a worldwide requirement to facilitate modal shift back to rail. This modal shift is required because of growing environmental issues and rising freight cost concerns.

Appropriate rail reform is also required to create an environment for South Africa's freight railway to sustainably achieve modal shift to reverse this trend. This research is based on an idealised design approach that postulates an ideal virtual railway for South Africa, based on Transport Economic and market segmentation principles.

It is accepted that major investment will be required to realise this ideal railway, but the exact role, positioning, institutional and organisational structures of the railway system require clarification. The established approach to provide this clarification in a typical business is, first and foremost, to understand the market that needs to be served through appropriate market segmentation. In this regard, the research presents:

- an overview of South Africa's surface freight transport industry, including the specific challenges faced by the industry and the historical evolution of the industry;
- a benchmarking exercise of South Africa's rail system against global rail systems;
- a summary of global rail reform case references;
- the need for transport economic regulation;
- an analysis of current total surface freight flows (road and rail) across the geography of the country's transport corridors, culminating in a freight flow market segmentation for South Africa informed by rail's economic fundamentals;
- the resultant effect of this analysis on the framing of an idealised network design; and
- a rail reform proposal based on the idealised design.

The research 'imagines' that the country has no existing railway system and analyse the manner in which specific freight (commodities and cargo types) actually flows from origin to destination by all modes of transport within the country's freight logistics industry. The result of the freight market segmentation exercise informs the crafting of an ideal network. Using this ideal network as a starting point, the most appropriate rail reform option is considered against the background of benchmarking the current system.

UITTREKSEL

Die wêreldwye beweging vir ‘n modale verskuiwing terug na spoor is ‘n belangrike faktor wanneer spoorhervorming ter sake kom. Dit word as gevolg van die toenemende klem wat op omgewingskwessies gelê word en stygende vervoerkostes, vereis.

Toepaslike spoorhervorming is ook in Suid-Afrika belangrik sodat‘n omgewing waarin Suid – Afrika se vragvervoer volhoubaar modale verskuiwing kan bereik, geskep kan word om sodoende ‘n modale verskuiwing te bewerkstellig. Die navorsing in hierdie tesis word op ‘n geïdealiseerde ontwerp benadering gegrond wat die ideale spoorweg vir Suid – Afrika postuleer. Vervoerekonomiese en marksegmenteringsbeginsels vorm die grondslag van die ontwerp.

Beduidende investering sal benodig word om hierdie ideale spoorweg te laat realiseer, maar die presiese rol, posisionering, en institusionele en organisatoriese strukture van die spoorwegsisteem is nog onduidelik. Die gevestigde navorsingsgefundeerde benadering om hierdie vraagstuk te benader is om eerstens markvraag deur middel van marksegmentering, te bepaal. In hierdie opsig bied die navorsing:

- ‘n oorsig van Suid–Afrika se landvragvervoerbedryf, insluitend die spesifieke uitdagings en historiese evolusie van die bedryf;
- ‘n nomrstellingsoefening van Suid–Afrika se spoorsisteem teen globale spoorsisteme;
- ‘n opsomming van globale spoorhervorminggevallestudies;
- die behoefte aan vervoerekonomiese regulering;
- ‘n analise van die huidige landvragvloeivolumes (pad en spoor) regoor die land se vervoerkorridors wat in ‘n vragvloeimarksegmentering vir Suid–Afrika uitloop,
- die gevolglike effek van die analise op die ontwerp van ‘n geïdealiseerde network; en
- ‘n spoorhervormingvoorstel gegrond op die geïdealiseerde ontwerp.

Hierdie navorsing gebruik ‘n virtuele benadering naamlik dat die land geen bestaande spoorwegsisteem het nie en analiseer die vraag na vervoer op die fynste moontlike vlak. Die resultaat van die vragsegmenteringoefening word gebruik om die ideale netwerk te bou. Deur die gebruik van die ideale netwerk as ‘n uitgangspunt word die mees geskikte spoorhervormingopsie oorweeg met normstelling van die huidige sisteem as ‘n vergelykende agtergrond.

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1. Introduction

The revival of South Africa's freight rail system has been urged in key research projects and national policy frameworks for almost two decades[1]. The driving factors for this revival is that, at 12.7%[2], South Africa's 2009 freight logistics cost as a percentage of GDP is 35% higher than first-world figures of around 10%[3], and at 53.2%, freight transport's contribution to total freight logistics costs[10] is significantly higher than the world average of 39%[4].

The key driver of South Africa's above average logistics costs is that the bulk of dense long-distance surface freight is transported by road. This poses not only a substantial exogenous risk to the country's growth aspirations due to the volatility of oil prices (the key input cost driver of road transport), but also increases externality costs and uncertainty regarding future offset charges. The modal imbalance is the culmination of a number of historical events. Political agendas in the latter part of the 20th century limited rail infrastructure investment, impacting on rail's service quality. This was exacerbated by the deregulation of the freight transport industry in the early 1990s without concomitant economic regulation, resulting in a rapid growth in road transport service providers, further reducing rail density and rail's ability to invest. Road freight transport growth was further fuelled by the unforeseen growth in demand for freight logistics services, attributable to the rising middle class in the new democracy, driven by unchecked demand in a trade-liberated, just-in-time world[5].

Worldwide, freight railways also experienced a decline in rail transport whilst highways were developed and markets were liberalised. This was the key driver for various forms of rail reform worldwide, which have, in many cases, successfully turned the tide for rail over the past 15 years. More recently, the drive for environmentally friendly transport solutions, growth in transport demand, oil supply risks and the implementation of intermodal (road-rail) transport logistics solutions have started to mark a clear trend for the revival of rail. In South Africa this is not the case yet (Figure 1).

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[1] Havenga, 2012

[2] Simpson and Havenga, 2011

[3] Bowersox & Closs, 1996; United Nations, 2002; Wilson, 2008

[4] Rodrigue *et al.*, 2009

[5] Havenga, 2012

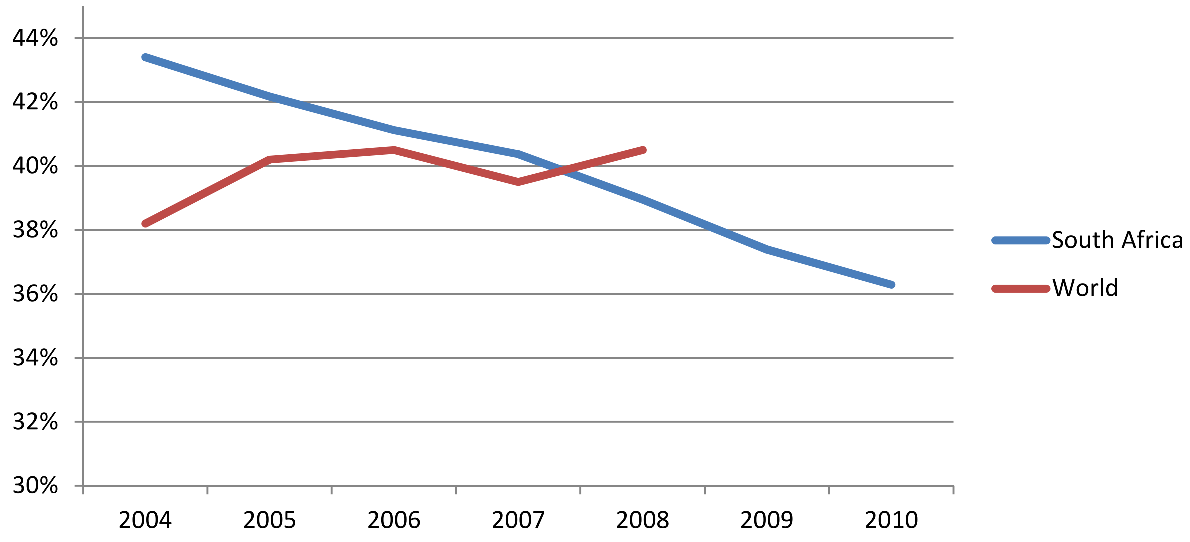

Figure 1: Rail market share South Africa vs. world tonkm[6]

Appropriate rail reform is required to create an environment for South Africa's freight railway to sustainably reverse this trend. Any proposed rail reform programme must however also support South Africa's socio-economic objectives. The potential contributions of the 'ideal' railway in supporting these objectives, are summarized in Table 1.

Table 1: Potential contributions of an 'ideal' railway to South Africa's socio-economic objectives

Ideal	Objective	Contribution of the ideal railway
Economic growth	• Investor friendly environment • Small business support • Access and growth inducements for rural economies • Successful BBBEE • State intervention to build large industries / businesses	• Low cost of transport • Logistics integration • Global competitiveness • Capacity creation • Access to markets for rural economies
Equitable distribution	• Lower unemployment through state capital projects and grants to small business • Tax grants • Strong public service	• Easy access for rural railways • Mobility of second economy • Job and skills creation
Sustainability	• Continuous measurement for improvement • Regulation • Incentives for environmentally friendly operations	• Modal shift • Reduction in cost of environmental impact / cost of externalities

It is accepted that major investment will be required to realise this ideal railway, but the exact role, positioning, institutional and organisational structures of the railway system require

[6] South Africa: Havenga and Pienaar (2012), updated results; World: Datamonitor (2009), UIC (2010)

clarification. The established approach to provide this clarification in a typical business is, first and foremost, to understand the market that needs to be served through appropriate market segmentation. The purpose of this research is to illustrate that this approach is also pertinent for the country's freight transport system where the 'business' is the need to position inventory in the supply chain (from the point of extraction to the point of consumption) for different industries, given the characteristics of the commodities and ancillary needs in question. The result of the freight market segmentation process will then inform the rail reform requirements.

2. Approach

The overarching approach of this dissertation is quantitative, based on economic modelling. This approach, that can be tested over time for intrinsic and extrinsic congruity, has been shown to be more appropriate than traditional survey approaches in addressing the freight transport industry's challenges[7]. In addition, it ensures that analysis is applied to South Africa's unique country- and freight transport market situation by considering the industry in its own specific economic context[8].

In this regard, the research presents:

- An overview of South Africa's surface freight transport industry, including the specific challenges faced by the industry and the historical evolution of the industry;
- A benchmarking exercise of South Africa's rail system against global rail systems;
- A summary of global rail reform case references;
- The need for transport economic regulation;
- An analysis of current total surface freight flows (road and rail) across the geography of the country's transport corridors, culminating in a freight flow market segmentation for South Africa informed by rail's economic fundamentals;

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[7] Havenga, 2007

[8] Since the1980s, railways in Europe, North and South America as well as Australia and New Zealand have undergone significant restructuring and rail reform. One cannot simply assess the failure or success of these reforms, nor merely consider the pros and cons of their outcomes, and apply them to the South African situation. Rather one can derive the basic principles and original intent behind these reforms and the lessons learnt by referring to these "case studies".

- The resultant effect of this analysis on the framing of an idealised network design; and
- A rail reform proposal based on the idealised design.

Historically there has been a great temptation to analyse and describe the current state and challenges of the existing freight rail network and operations, and to propose reforms and approaches to improve on what is known about the system.

An alternative approach will be taken in this research – to 'imagine' that the country has no existing railway system and to analyse the manner in which specific freight (commodities and cargo types) actually flows from origin to destination by all modes of transport within the country's freight logistics industry. Rail's economic fundamentals will be superimposed on the total flow result to identify market segments that exploit those rail fundaments, testing the assumption, especially in the developing world, that rail is only appropriate for low value bulk transport. The results of the freight market segmentation exercise will inform the crafting of an ideal network. Using this ideal network as a starting point, the most appropriate rail reform option could be considered against the background of benchmarking the current system. Reform can then be used as a tool to shape the *status quo* into what is required based on the idealised design.

3. South Africa's freight transport industry challenges

This section provides a description of the South African surface transport market, an overview of its challenges and the implications of these challenges and developments for the logistics industry and for rail in particular.

Industry overview and key challenges

The South African freight transport market plays a significant role in the country's economy. This is evidenced by the fact that the GDP value of freight transported in South Africa is R2.3 trillion. The GDP, however, only measures added value, i.e. if the raw material for the production of a widget is transported to a plant and the subsequent manufactured widget is transported from the plant, the original value of the raw materials is not included in the "GDP value" of the second shipment; only the value that was added in the production process is added. If the full value of all shipments is added together, the estimated value of the country's cargo is R3.8 trillion.[9]

A total of 350 billion ton kilometres moving over an average transport distance (ATD) of 409 km and at a logistics cost of R180 billion were delivered. In addition, externality costs (comprising the costs of accidents, carbon emissions, congestion, noise pollution and policing) of R28 billion were incurred.

As mentioned in the introduction, at 12.7%[10], South Africa's 2009 freight logistics cost as a percentage of GDP is 35% higher than first-world figures of around 10%[11], and at 53.2%, freight transport's contribution to total freight logistics costs[10] is significantly higher than the world average of 39%[12].

In most first world countries (which remain some of South Africa's most important trading partners), the cost of logistics relative to the GDP have been managed downwards substantially over the last two decades. In the USA this percentage in this time was reduced by more than a third (from 15% to 8.5% relative to GDP (Wilson, 2012)). Many of these savings were possible because logisticians could (on a firm and industry level) reduce inventory levels, the periods for which inventory is kept, and reduce empty back-haul of freight. There is also an inverse relationship between inventory and transport, i.e. reducing backhaul requires stockpiling and consolidation, which increases inventory charges, yet reducing inventory levels requires expedited and smaller shipments, which increases transport charges. Changing customer service requirements, especially the recent trend of favouring inventory management with a resultant move away from mass shipments, has contributed to the decline of rail.

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[9] Data sourced from the Freight Demand Model (FDM) for South Africa. The methodology was developed between 1995 and 2007, described in Havenga (2007) and published in Havenga (2010), Simpson and Havenga (2010) Havenga, Pienaar and Simpson (2011) and Havenga and Pienaar (2012). It is currently accepted as the only reliable Freight Transport Demand database in South Africa and used for the planning of all large national logistics infrastructure projects, such as the development of rail and port facilities. The FDM is currently updated every year by the candidate and Dr Jan Havenga. Raw data for this thesis is from this source unless otherwise stated

[10] Simpson and Havenga, 2011

[11] Bowersox & Closs, 1996; United Nations, 2002; Wilson, 2008

[12] Rodrigue *et al.* 2009

Spatial challenges

South Africa can be described as being spatially challenged in logistics terms due to the agglomeration of major industries in Gauteng, in the centre of the country (that resulted mainly from development around the inland mining deposits), leading to increased logistics costs when competing in the global market due to distance to ports. South Africa therefore requires more ton kilometres per unit of output than the rest of the world (Figure 2). This points to a need for South Africa to have a freight system that is more efficient than the international norm.

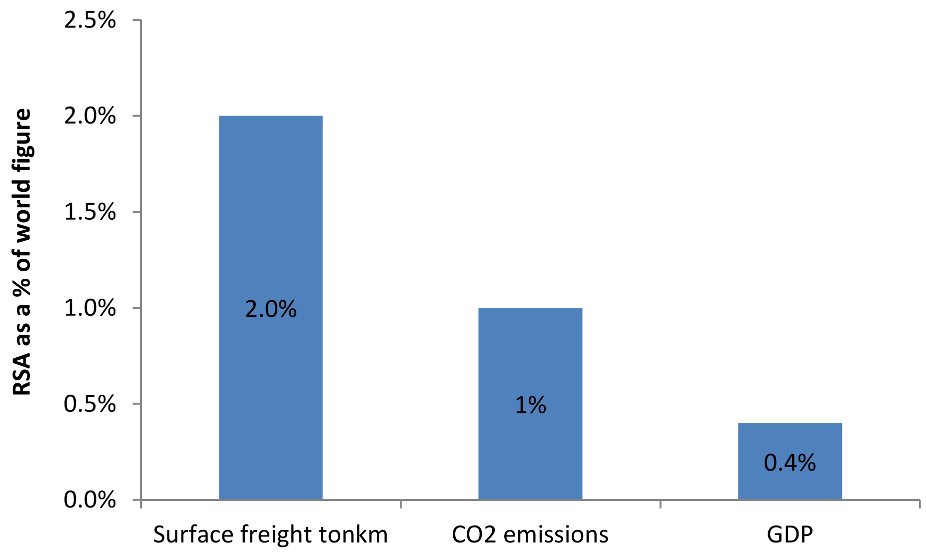

Figure 2: Disproportionate consumption of freight transport in the South African economy[13]

In considering how this spatial challenge should be addressed various considerations are necessary. Modal imbalance adds cost, which is the driver of the current debate when the achievement of efficiency and effectiveness is concerned. As is however often the case in this regard not all costs are considered and not all costs are accounted for, leading to imbalances in the system. Part of the problem exacerbated by the modal imbalance, is the risk of fuel cost challenges, imbalances in infrastructure cost accounting and the cost of externalities.

[13] Havenga, 2010

Modal imbalance

Rail freight transports a 23% share of the 856 million tons or accounts for 32% of the effort (expressed in ton kilometres) to convey this freight. Rail provides this service to the country at only 11% of the total cost of moving this freight (Figure 3).

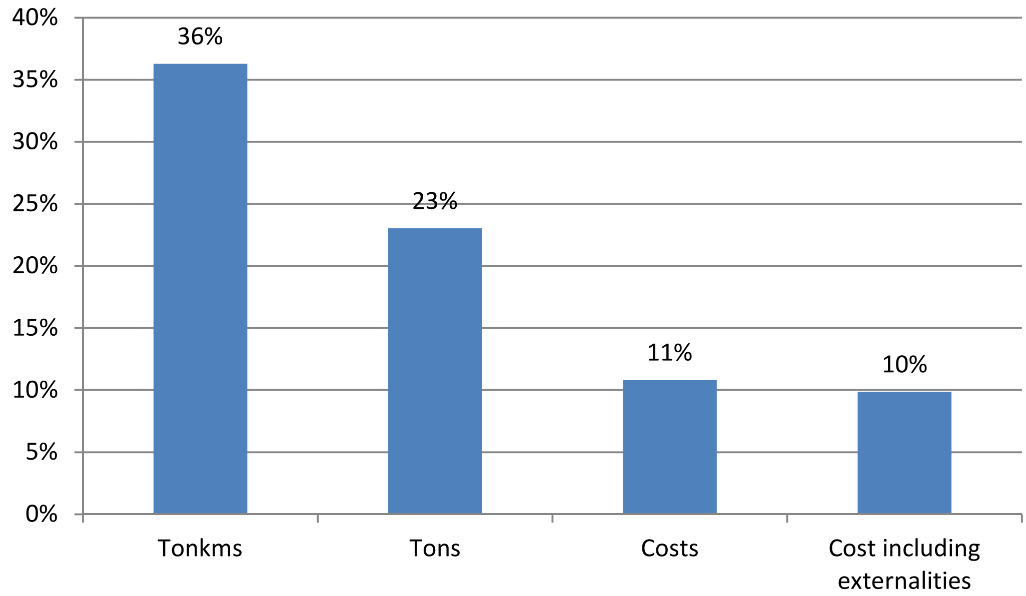

Figure 3: Rail market share and cost for 2010

This is exacerbated by the fact that the majority of corridor freight is transported by road. In 2008, sixty-six % of the country's total surface freight transport costs (road and rail) were spent on corridors, while 95% of the corridor transport costs were attributable to road transport. In addition, almost all growth over the already dense corridors also occurred in the road transport mode (Havenga, 2012). This compares extremely poorly with the USA's rail corridor market share trend, as illustrated in Figure 4.

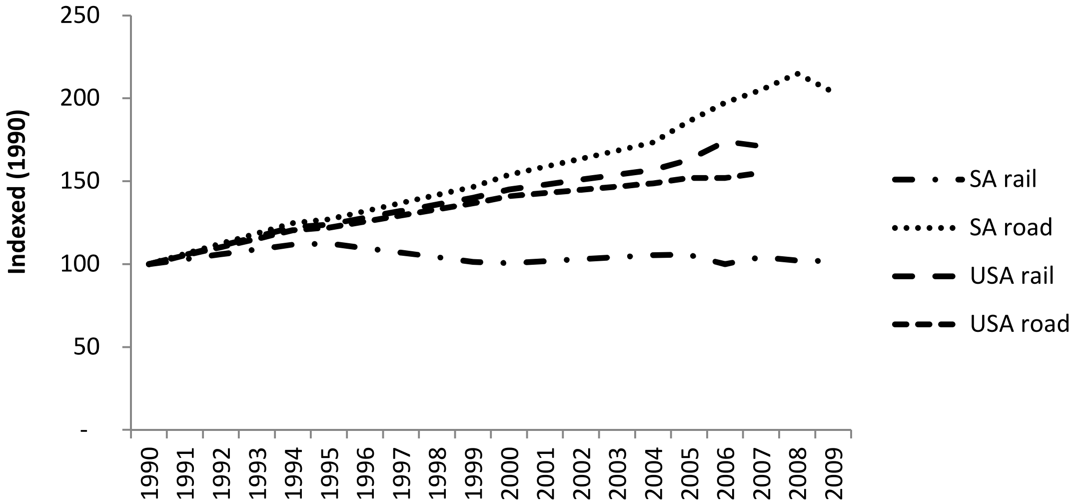

Figure 4: South Africa's road-rail corridor market share compared with the USA (Havenga, 2012)

Fuel cost challenges

A greater utilisation of rail transport (rather than road) should protect South Africa against the risk of fuel price instability and future environmental cost charges. In a scenario where oil prices triple in the next six years, transport costs in the country (as a percentage of GDP) will increase to 69% of total logistics costs (compared to the world's increase to 49%), i.e. South Africa's disadvantage relative to its trading partners will increase (Figure 5). South Africa is therefore more vulnerable to fuel price fluctuations (fuel cost is a higher component of transport costs in South Africa, than globally).

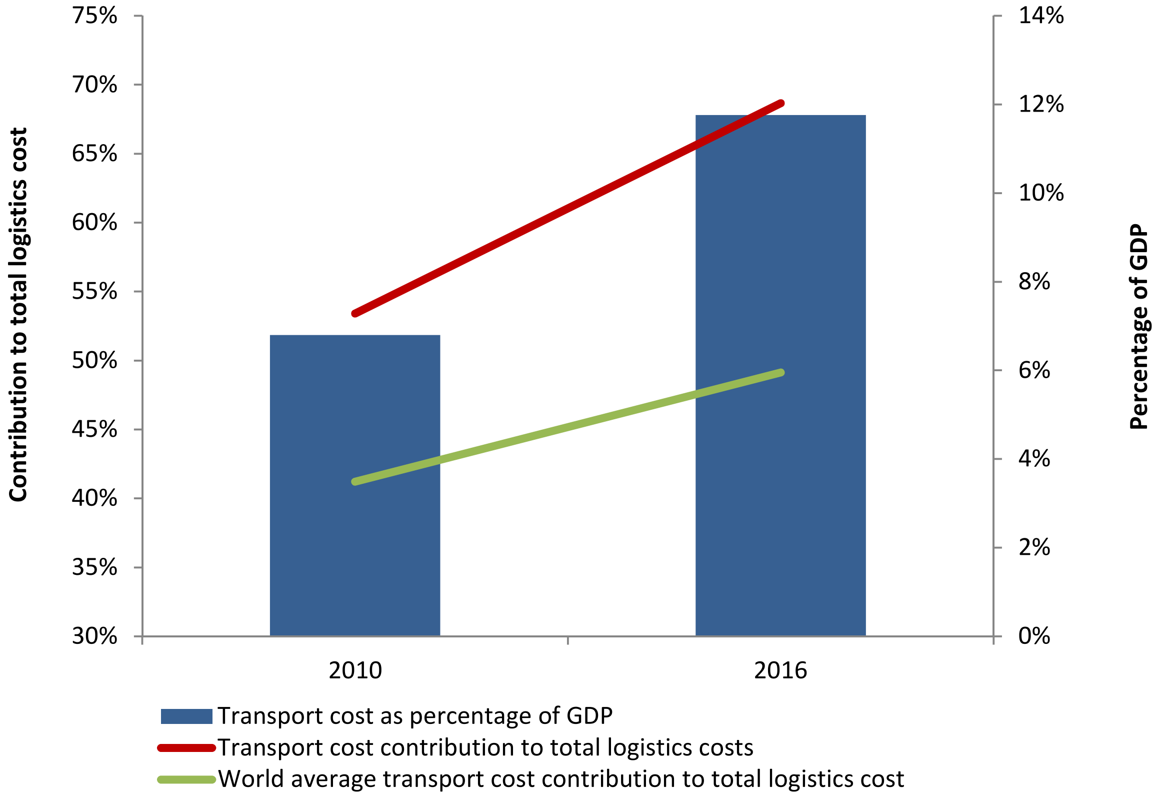

Figure 5: Fuel cost fuel price challenges

Infrastructure cost accounting

The modal imbalance is significantly impacting on the quality of road infrastructure in South Africa. The percentage decrease of bad to very bad national roads over a 10 year period from 1998 to 2008 varies from 7% to 9% and on secondary roads from 8% to 20% with significant deliveries routed via this road network[14]. The deterioration of road quality can and will lead to drastic increases in vehicle maintenance and repair costs leading, in turn, to higher product and logistics costs, unless addressed adequately and quickly. In addition, the role of rail in South Africa is declining to the role of the low value bulk export commodity service provider.

Road freight haulage contributes around R10.4 billion to infrastructure (through the fuel levy, license and toll fees) which is only about 4% to 6% of total costs. This figure is quite low and it should be considered that whereas improved road conditions will lower other cost drivers such as fuel, maintenance and capital costs of equipment – these improved road conditions

[14] Steyn and Bean, 2009

will require funding. The 4% to 6% contribution will have to increase. Repairing and upgrading roads is important, but the real solution lies in modal shift.

The low concern for the infrastructure component of road costs versus rail costs is clearly evidenced by the exponential rise in South Africa's truck fleet (from 20 000 vehicles in 1950 to 270 000 in 2006) (Figure 6).

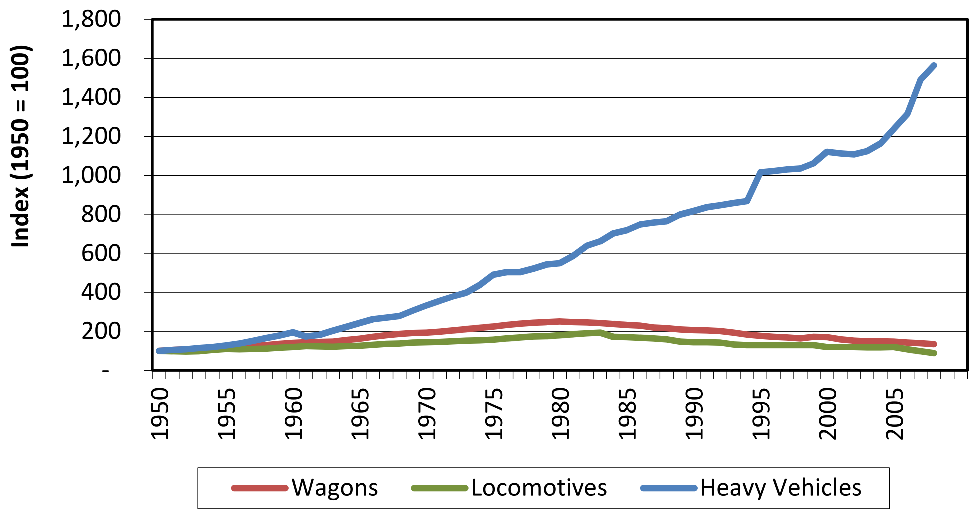

Figure 6: Growth in heavy vehicle population compared to rail wagons and locomotives[15]

In 1990, at the point of deregulation, user-pay principles should have been installed and the railway shareholder should have invested in new intermodal capacity to equal the playing field and lower corridor transport costs to the economy. This was not done, resulting in road truck fleet growth of 60% from 1990, whilst the rail wagon fleet actually declined by almost 30% (and the locomotive fleet with 17%). The absence of road economic regulation therefore played a significant part in the current transport industry challenges. This was compounded by considerable aging of the rail fleet (making it less suitable for the changing market needs). This made it more or less impossible for the railway to attract or retain corridor transport and impossible for the country as a whole to exploit the density advantage of the corridors.

[15] Havenga, 2011

Cost of externalities

The disproportionate road freight transport market share adds further to the logistics costs in the form of externalities. Externalities are estimated to have added an additional R28bn or 16% to the logistics costs of R180bn in 2010. The externality cost contribution was 49% for accidents, 23% for emissions, 20% for congestion, 4% for noise and 3% for policing. Adding these costs to transport costs increases the cost percentage of transport from 6.8% to 7.8% of GDP. The majority of the R28bn (96% or R26.8bn) was incurred by road transport. These costs further highlight the greater role that rail should be playing in the logistics industry and the economy. Figure 7 reflects a breakdown of externality cost categories and the relative cost of rail.

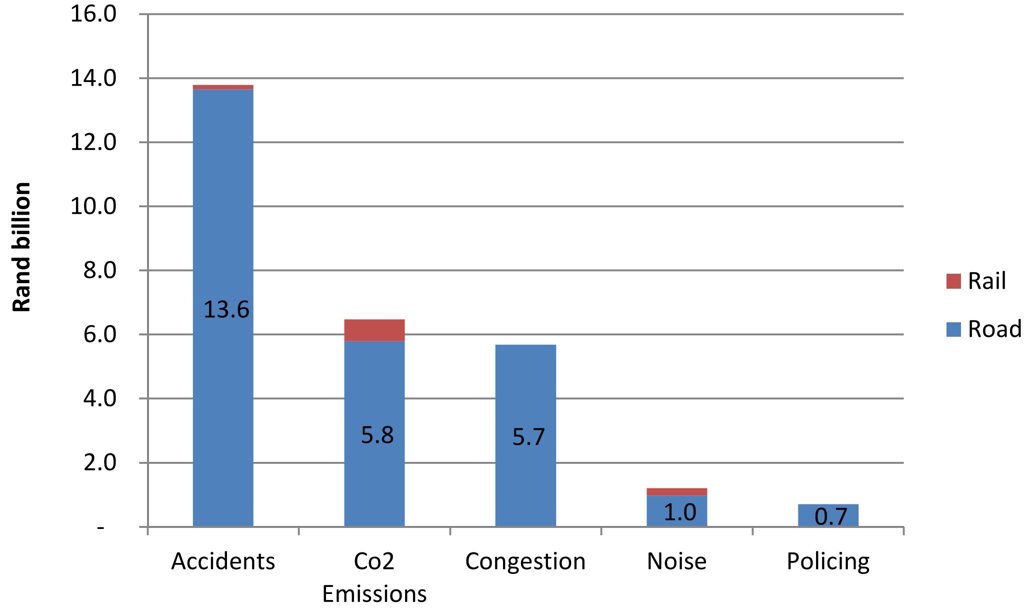

Figure 7: Externality costs by category in South Africa for 2010

The issue of environmental challenges is becoming an increasingly topical one and is one of the core problems facing transporters. By way of example, the BNSF (Burlington Northern Santa Fe Corporation) Annual Report 2008 strongly highlights environmental issues and the theme for the report centres on sustainability: “Over the next 20 years, global energy consumption is projected to increase by about 40%. As the demand for energy grows, it is crucial for us to continue improving the efficiency and sustainability of the way we transport essential goods."[16]

Growth in transport demand and specialisation

The logistics costs in the country are impacted negatively because freight growth is outstripping GDP growth. Figure 8 compares growth in South Africa's GDP against primary and secondary sector growth, as well as the growth in freight ton kilometres.

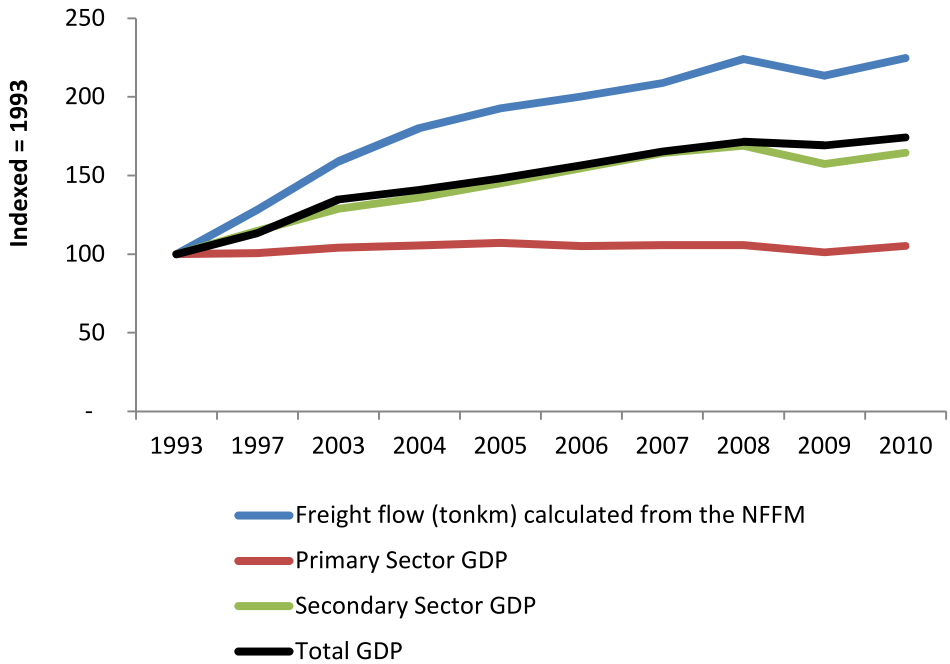

Figure 8: Relative growth in transport demand[17]

High growth in transport demand is impacted by the growing trend towards specialisation, requiring longer transport distances for the same level of output. Therefore, in terms of South Africa's growth objectives, specialisation relative to its trading partners will accelerate faster, further compounding the problem of abnormal transport demand (Figure 9).

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[16] Burlington Northern Santa Fe Corporation 2008 Annual Report and Form 10-K

[17] GDP data from Statistics South Africa, 2012

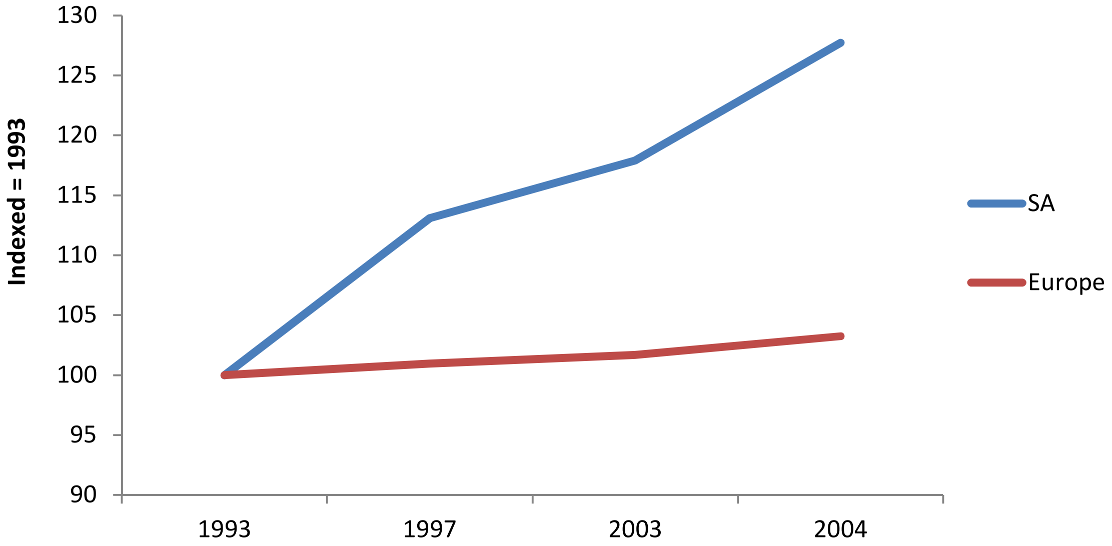

Figure 9: Tonkm growth higher than GDP growth[18]

The unsustainable situation in South Africa's surface freight transport market confirms the imperative for rail's revival. The evolution of South Africa's surface freight transport industry, discussed in the next section, provides a backdrop for these challenges, and also provides learnings for future reform and regulation.

4. Evolution of South Africa's surface freight transport industry[19]

The challenges facing the freight transport industry today are largely derived from an evolution of historical events.

After the creation of the Union of South Africa in 1910 (the unification of four previously separate British colonies), the role of rail transport was institutionalised with the railways becoming an official organ of state and duly applied in the economic development of the country and its primary resources, i.e. agriculture and mining, and also in the execution of political policies and agendas. In return for these "services" rendered by rail, the growing competition from road was kept at bay by regulatory practices favouring rail transport.

[18] South Africa: National Freight Flow Model; Europe: Ponthieu (2008)

[19] Adapted from Martin (2004), except where otherwise indicated

Through the 1930 Motor Carrier Transportation Act, the operational freedom of all road freight, except that used by farmers, local authorities and government departments, was restricted. Permits for isolated categories such as perishable goods could be obtained, but the Act, enforced by railway police inspectors, ensured that most land-freight was rail-based. Despite this there was an upsurge in road haulage in the decade following World War Two to support South Africa's significant economic growth. Repeated exemptions as well as some relaxation of the regulations led to road haulage replacing rail as the dominant form of freight from the mid-1970s[20].

Beginning in 1975, a long series of National Transport Policy Studies (NTPS) reviewed trends in transport deregulation around the world, with extensive participation by South African Railways and Harbours (SAR&H) management. Its findings reinforced the growing belief that distorted transport markets (with regulations protecting rail transport) hurt the South African economy. One early result was the Road Transport Act (No. 74 of 1977), which expanded the grounds for application so that road freight transport permits could be issued more freely.

The 1977 Act negatively affected rail's capacity to compete with road in that the maximum permissible vehicle mass was increased to 42 tons allowing a net payload of 22 tons (subsequent amendments to the 1989 Act have increased the road payloads to between 42 and 45 tons). The 22 tons exceeded the 20 tons carrying capacity of the ES-type rail wagon widely used at that stage.

In 1981 SAR&H changed its name to South African Transport Services (SATS) to reflect the fact that its activities comprised much more than railways and harbours. In addition to air and road services, it had opened petroleum pipelines in 1971. In 1977, regular intermodal container services began for both domestic and import traffic.

Total deregulation of road transport was implemented with the promulgation of the Transport Deregulation Act (No. 80 of 1988). Included in the recommendations of the study that instigated the scrapping of the permit system, was the recommendation to formulate and implement a regulatory regime to guide and control road transport. A Road Transport Quality System (RTQS) was accordingly formulated and enacted by the promulgation of the Road Traffic Act (Act No. 29 of 1989). Specific guidelines were given to regulate road transport operations and guide law enforcement on issues such as vehicle fitness, driver fitness, driver hours behind the wheel, speed, maximum loads and overloading, etc. The implementation of

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[20] Mitchell, 2006:1

the RTQS was however done very haphazardly and never regarded as a priority by the majority of provincial and local traffic authorities.

In the 1980s, economic problems increased. Anti-apartheid sanctions accumulated, and civil wars in neighbouring Angola and Mozambique required South Africa to mobilise its own military. The nation faced an acute capital shortage, forcing the government to prohibit further foreign borrowing by industrial concerns, and to regulate capital investment throughout the economy. In this environment, the capital spending habits of all state enterprises came under scrutiny.

Wim de Villiers was appointed to provide this scrutiny for the railways and he published his report, after careful analysis, in 1986. To people familiar with South African transport policy, the De Villiers' report[21] had few surprises. It provided a comprehensive and influential restatement of SATS' shortcomings under state control. The railways' freight market share had fallen to 37% by 1981 (General Freight had achieved its peak of 147mt transported in 1982 after which tonnages began to decline), increasing the requirement for cross-subsidisation by other services. In 1984 low-rated rail traffic lost R415 million, and passenger services lost R752 million; these losses were partially offset by profits of R89 million from high-rated rail traffic and R463 million from harbours and pipelines. De Villiers warned that if existing trends continued, losses would reach astronomical levels by the end of the decade. The De Villiers report recommended:

(a) A curtailment of new rail investment and a focus on increasing utilisation of existing assets given that rail traffic was likely to be stagnant in the face of freer competition from other modes of transport.

(b) Restriction of railway investments to services in which rail had a competitive advantage, and that a much more rigorous investment evaluation process be adopted.

(c) Reorganisation of SATS into autonomous divisions that reflected its major types of infrastructure: railways, harbours, airways, pipelines and road transport.

(d) Separation of suburban passenger services from the rest of SATS and subsidisation of these services directly by the government.

(e) Relieving SATS of its common carrier status thereby allowing complete flexibility to set tariffs that would provide adequate returns.

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[21] De Villiers, 1986

(f) Operation of SATS like a private, investor-owned company. (The report did not recommend the actual sale of SATS to the private sector, although this was considered. Rather, it suggested that SATS become a commercial enterprise under government ownership, earning an appropriate return on capital by cutting costs and managing its assets better.)

At the same time that the De Villiers study was in progress, the National Transport Policy Study (NTPS) finished its work with the recommendation that South African land transport be deregulated. In 1988, Parliament followed this advice and directed the Minister of Transport to phase out the permit system for road transport. At that point, SATS would be competing in a free market.

The dual process of corporatisation and preparation to compete required profound changes in SATS procedures, organisation and culture. Government did not, however, simultaneously institute policies and government structures to ensure adequate levels of safety and protection of the road infrastructure. As indicated earlier, the RTQS that was enacted in 1989, was never fully applied in practice. Government also did not allow SATS the freedom (that would have been normal for a free enterprise) to normalise and rationalise uneconomical services to the extent that would have been necessary to compete in this new emerging paradigm.

SATS investment was severely cut back. Traditionally, capital expenditure had been financed with a combination of capital grants from the government, borrowing and reserves from revenues. The capital grants, a cumulative sum of R4 208 million as of 1985, were converted to government loans. About 70% bore interest paid to the government, but the remainder was interest-free to compensate for investment in uneconomical services.

In the period prior to national capital shortages, the normal response was to allocate capital to a lack of capacity, rather than reallocate existing assets. Every year, Parliament approved capital expenditures of up to R2 billion. SATS was driven by technical excellence, such as experimenting and investment in a high-speed commuter train, the Metroblitz.

Technically, the challenges of operating with a narrow gauge had prompted the development of world-class rolling stock designs. Infrastructure was maintained and replaced on a schedule, and to book standards. In 1986, however, expenditure on fixed assets fell to R1 390 million, and following the De Villiers report it fell further to R699 million in 1988 and to approximately R500 million by 2000.

Commercialised railways would typically inherit substantial excess capacity in rolling stock, and billions of Rand worth of under-utilised infrastructure constructed to promote economic development in remote areas. In South Africa, it was no different. In 1986, about

21 000 wagons (12% of the total fleet of 175 000) were idle. About 60% of the rail network was utilised at less than half its practical capacity. Both rolling stock and the network required rationalisation.

In 1989 the Legal Succession to the South African Transport Services Act was approved. Transnet Limited was created in terms of this Act. On 1 April 1990, SATS was succeeded by Transnet, a diversified, taxpaying transport service company wholly owned by the South African government. The Legal Succession Act permits Transnet to deal with property as a public company but allows the intervention of the responsible Minister on behalf of the government if Transnet operates contrary to the economic interests of the country[22].

Market demands could still be met with surplus capacity from assets which had reached the end of its economic life. With investment averaging at about R500m per year, the overall condition of freight and passenger assets was deteriorating whilst the investment backlog was increasing steadily.

The net result of these historical events was that South Africa's freight rail business had lost market share to road and had reduced its capacity through partial rationalisation of equipment and staff (the railways were never allowed to rationalise the network) over a period of approximately three decades. A huge backlog in maintenance of infrastructure and rolling stock had accrued. Road transport had been allowed to grow, through free market principles, but without the implementation of a road transport quality system. This imbalance in modalism contributed to high logistics costs, high expenditure needs for road capacity and maintenance, congestion and possibly worst of all, little development in intermodal solutions.

Since 2005, Transnet embarked on a massive capital investment plan to address the investment backlog and create capacity for the nation's growing demand for transport. This will have a positive impact on rail volumes, and reduce the nation's freight bill, but is insufficient to affect a marked increase in rail market share or to assure sufficient capacity for projected freight volume growth. The significant funding requirements to meet this future demand can only be met in a more liberalised freight rail environment which allows the railway to operate on commercial principles. The only other alternative would be direct state investment.

[22] Van Niekerk, 2004

In the next section, South Africa's freight railway metrics are compared to those of the major international railway systems. The positioning of these railway systems, driven by their specific rail reform agendas, will shed light on the way forward for South African rail reform.

5. Global benchmark of South Africa's freight rail system

Railways globally have about one million route kilometre length of which about 2% is in South Africa. Even though almost all countries have a railway, only about 40 countries have useful statistics, with detailed statistics even less common. Two approaches are possible to deal with the data shortage and are followed. The first would be to summarise global railways in groupings, given unique characteristics and the second to select railways from each grouping for which detailed data is available and compare South Africa with these.

For summative descriptions global railways can be classified into five macro rail sectors, the two most extensive being the North American systems of the USA, Canada and Mexico with a combined route length of 337 791 km, dominated by American Class 1 railroads and Canadian National; and the more independent systems of the Russian, Indian and Chinese railways (RIC) (with 268 652 km route length). This is followed by the European rail system with 212 785 km route length, dominated by France and Germany, and the South American systems of mostly the Argentinian and Brazilian railways. SADC's system of about 40 126 km is next, dominated by South Africa's 22 051 km. Figure 10 confirms the dominance of the North American and RIC (Russia, India and China) railways. These countries have 58% of the world's railway route kilometres, 73% of the world's railway employees, 62% of the world's locomotives and produces 93% of the world's tonkms.

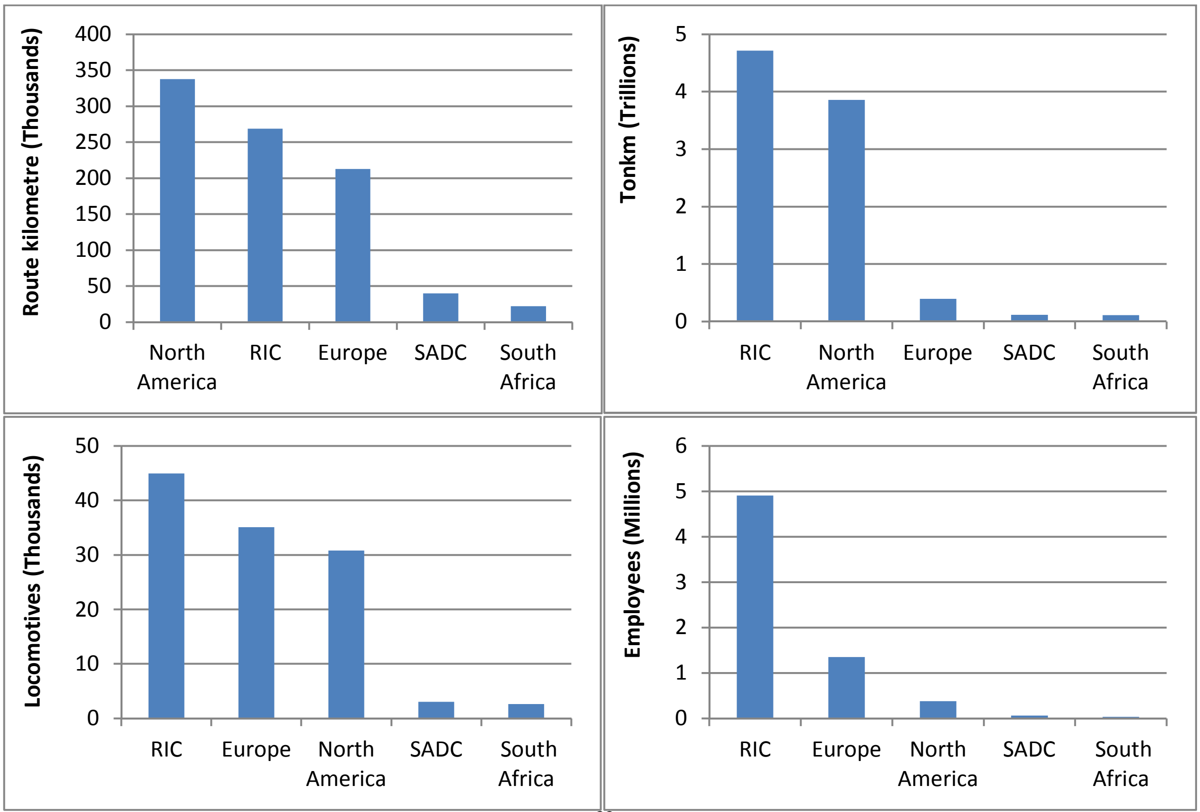

Figure 10: Relative sizes of world railway systems[23]

On a country-by-country basis, the geographical extent of South Africa's rail system is however significant. It is the 10th largest in the world by route kilometre and by far the largest system of note in Africa. South Africa also has the 7th position in terms of tonkms, 10th position for locomotives, and the 20th position in terms of staff (Figure 11)[24]. South Africa's railway therefore has a relatively small staff complement given its size. This is discussed in more detail under the section on productivity indicators.

[23] Piasecka, 2007

[24] To distinguish between the two type of rail business in South Africa, South Africa has been indicated as total rail (South Africa), general freight separately (South Africa GFB) and the export lines separately (South Africa Export Lines)

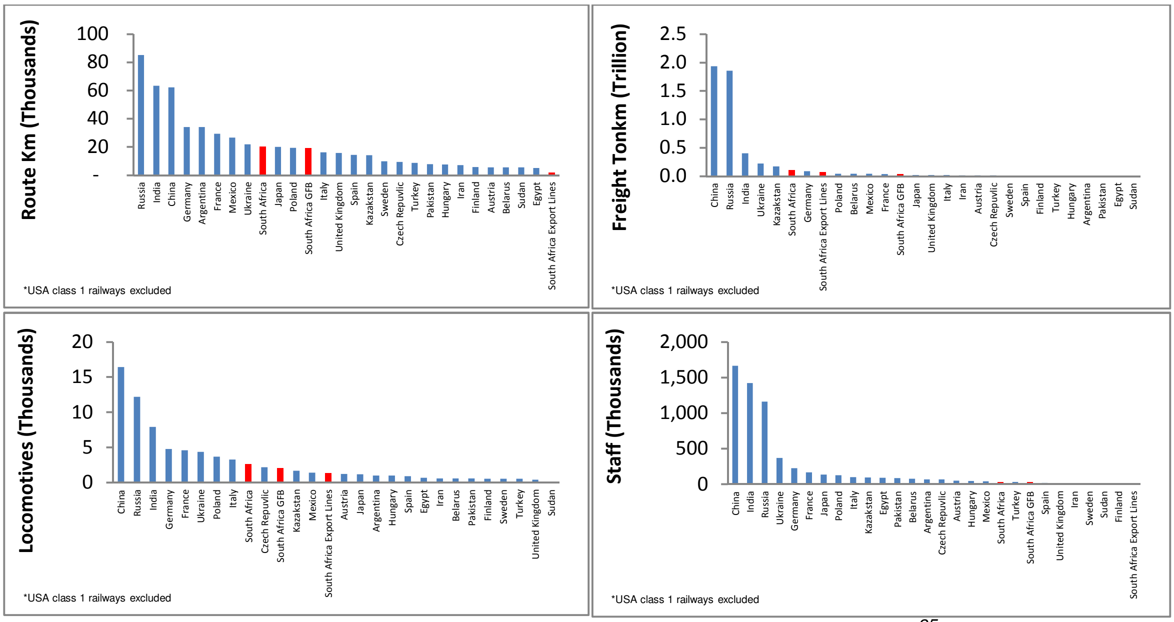

Figure 11: South Africa's global ranking in terms of key railway size indicators[25]

Comparisons between size indicator trends for all the major global rail systems are possible since 1980 and the linear regressions of these are depicted in Figure 12.

[25] Piasecka, 2007

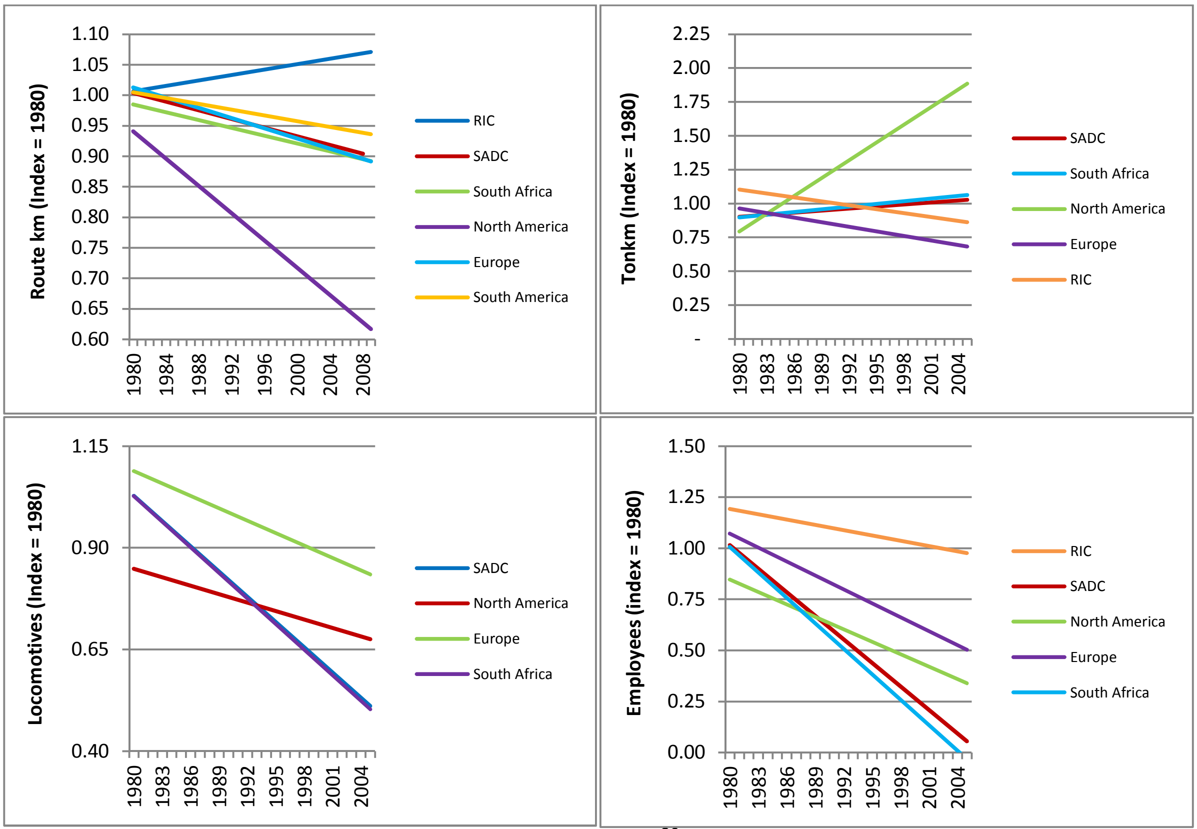

Figure 12: Linear trend of global rail systems' indicators[26]

During this time period between 1980 and 2004, the North American system's route kilometres were rationalised by 40% while the RIC railways' route length actually increased (all three countries now have longer route lengths than in 1980). North America's tonkms soared. The least drop in employment is observed in the RIC countries.

South Africa's rationalisation of motive power and employment is the most significant in this comparison. The country's network size (in terms of route kilometre) however remained almost unchanged, placing a heavy burden of fixed costs on a railroad that is now in effect understaffed for its size. South Africa's relative growth in output (tonkm) was a direct result of the relative performance of the two ring-fenced export lines.

Time series analysis of these size indicators is, however, more revealing, and discussed in the next section.

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[26] Piasecka, 2007

Trend analysis of size indicators

Due to data challenges, comparisons over a long time period are only possible between the USA, some selected countries mentioned in the groupings and South Africa. The quantum differs significantly – the USA's route kilometres were more than 20 times longer than South Africa's up to 1930, and is now approximately 12 times longer – but an indexed view makes it possible to compare growth over time as illustrated in Figure 13.

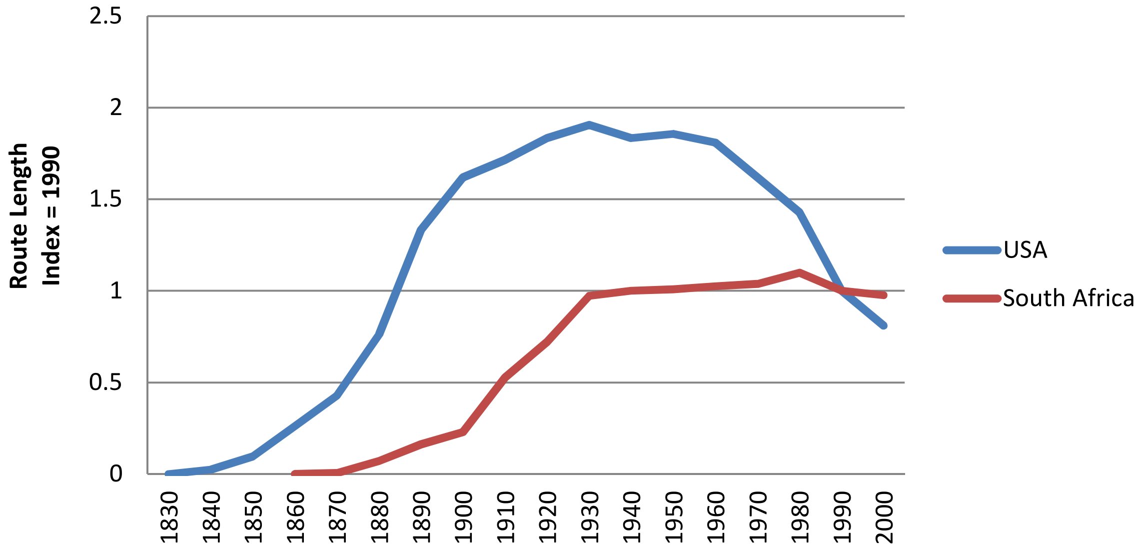

Figure 13: Growth in South Africa and USA rail route length[27]

The movement of higher volumes over shorter networks improves the density relationship and allows for the efficiencies achieved by American railroads (Figure 14).

[27] Perkins, 2009; Grenzeback, 2002; Unece Statistical Database and Key Stats Spoornet

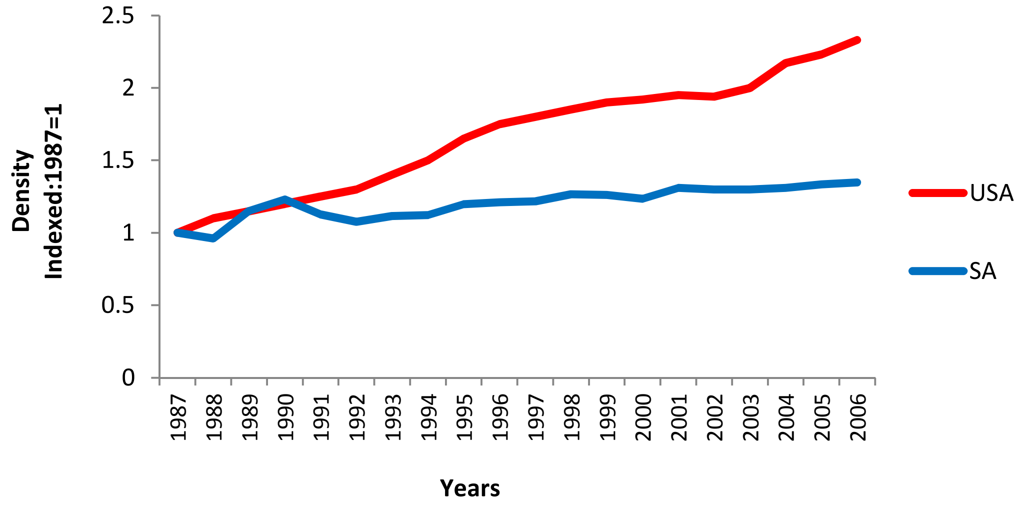

Figure 14: American railroad densification[28]

These efficiencies translate directly into phenomenal productivity improvements (Figure 15).

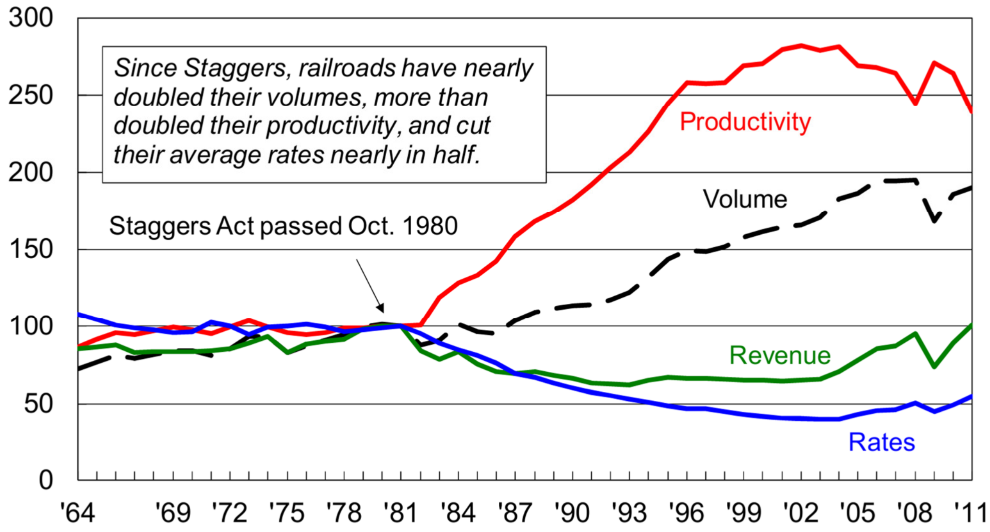

Figure 15: American railroad productivity improvements (indexed data: 1981=100)[29]

South Africa's railways did not have the opportunity to rationalise the GFB network after deregulation due to political pressure, could not attract sufficient investment to ensure the maintenance of rail-friendly traffic and a vicious circle of underinvestment, lower service

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[28] Key Stats Spoornet, 2009; AAR (Association of American Railroads), 2011

[29] AAR (Association of American Railroads), 2012

levels and loss of freight were experienced, resulting in a decline in South Africa's general freight rail (i.e. excluding bulk export lines) density (Figure 16). The depicted comparisons with other railways confirm this.

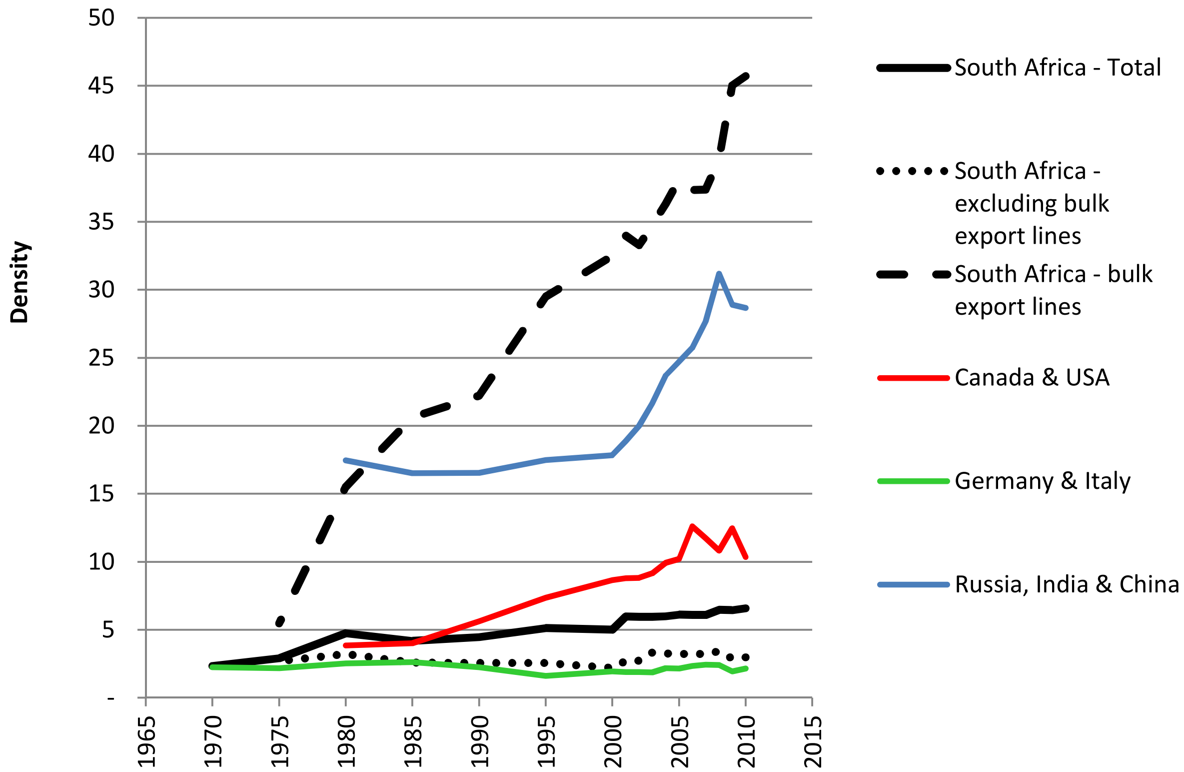

Figure 16: Comparisons of railway densities since 1970[30]

The outperformance of European railways is interesting, as these railways serves a socio-economic purpose relating to huge congestion in Europe, concerns for the environment and a generally well established rail ethos. The development state countries of the RIC nations do well, due to established concerns for modal shift, long transport distances and also, especially in the case of India, the position of rail as common carrier of the nation.

Employee productivity

South Africa's employees per route kilometre (Figure 17) are low and comparable with most North American lines – with much lower densities that is to be expected. Tonkm output per

[30] South Africa: Key Stats Spoornet, 2009; rest of world data: UIC, 2010

employee is however relatively high in South Africa, driven by the ring-fenced export lines (Figure 18).

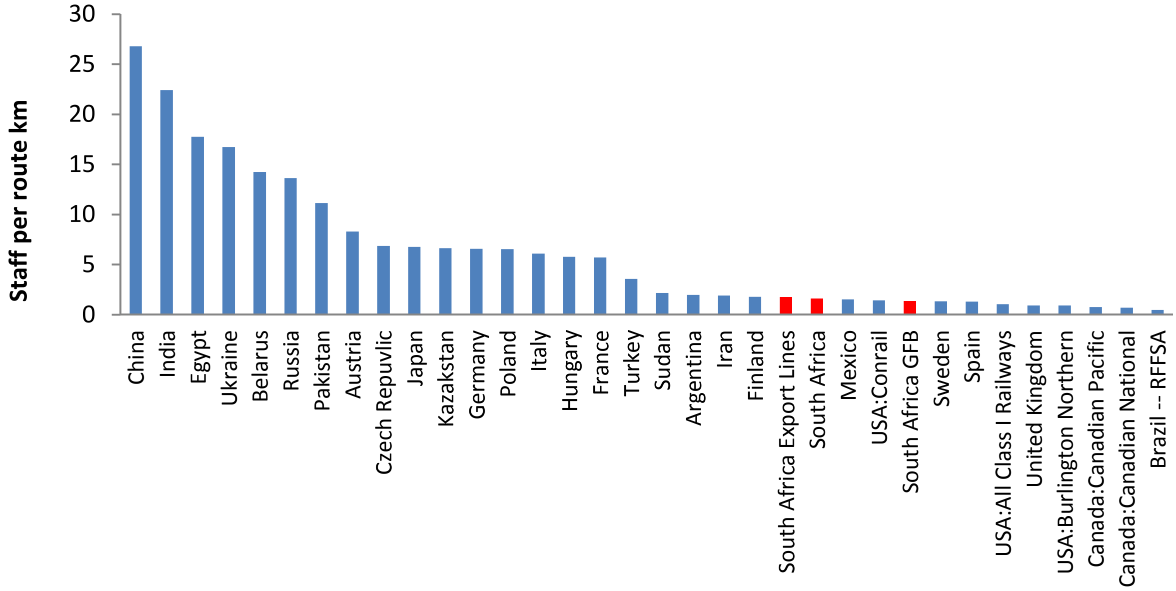

Figure 17: Current employees per route kilometre[31]

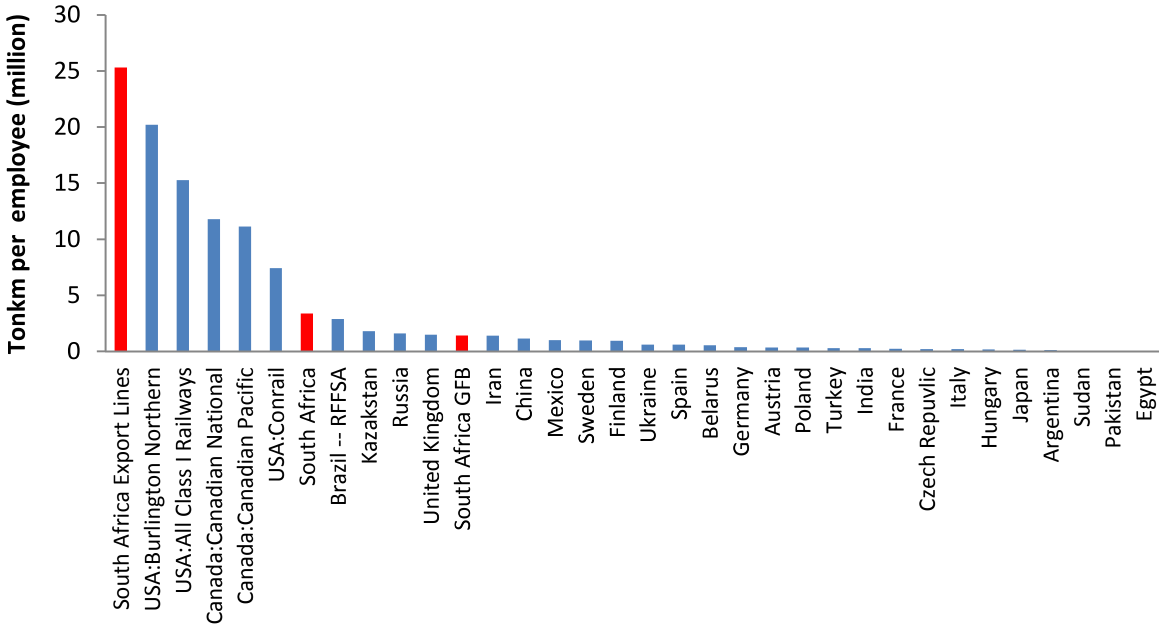

Figure 18: Tonkm per employee[32]

[31] Piasecka, 2007

[32] Piasecka, 2007

Route kilometre per employee can also be compared directly (Figure 19), illustrating the dominance of the USA, Canada, Russia India and China and the USA's relative low employment compared to route kilometres. When these dominant countries are removed South Africa's smaller workforce relative to route kilometre size can be seen (Figure 20).

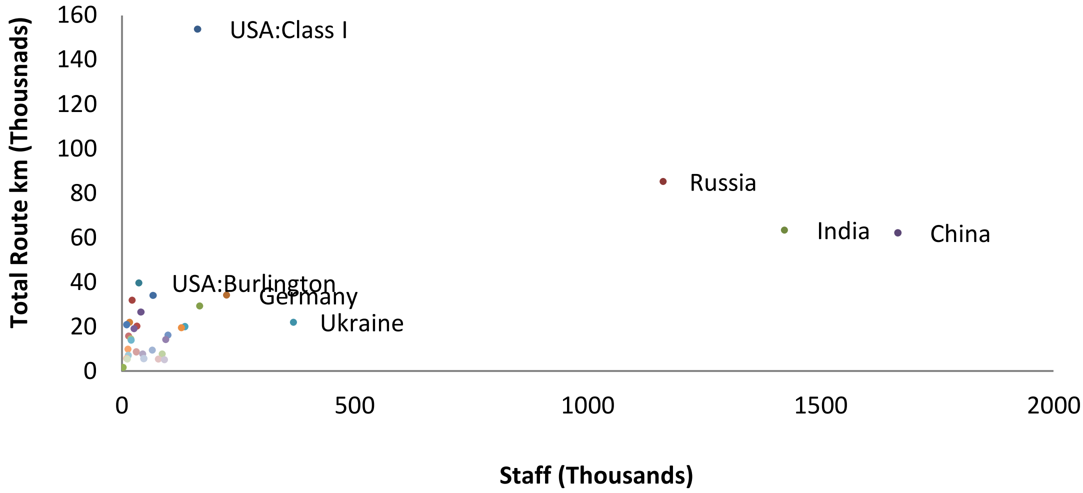

Figure 19: Route and employment comparison[33]

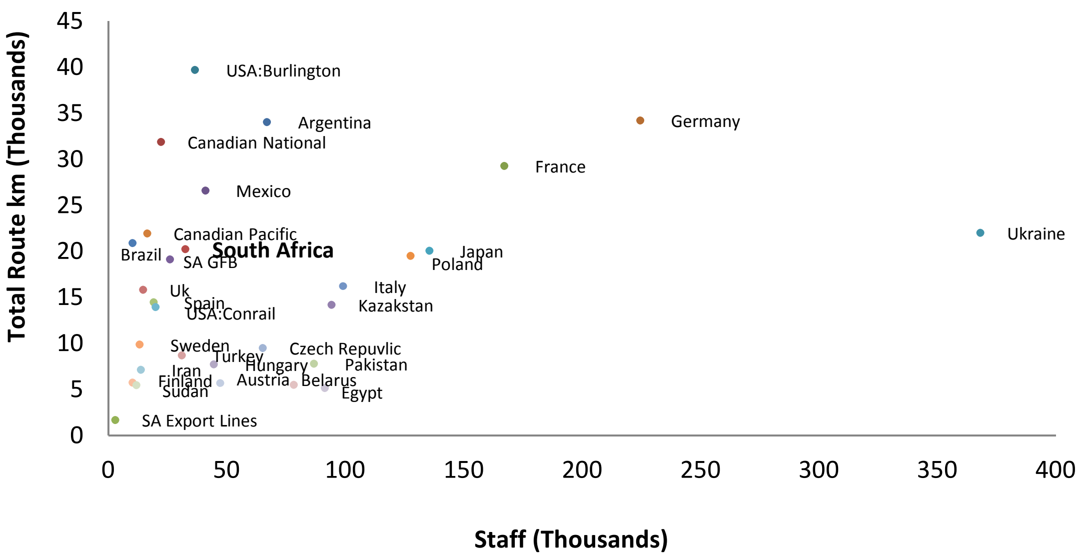

Figure 20: Route and employment comparison (macro systems removed)[34]

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[33] Piasecka, 2007

[34] Piasecka, 2007

Tonkm per employee can be compared in the same way (Figure 21) and illustrates the relatively high productivity of the North American railroads. It also confirms South Africa's reasonably favourable position if the macro rail systems are removed (Figure 22), although a distinct difference between the export lines and GFB can be observed here.

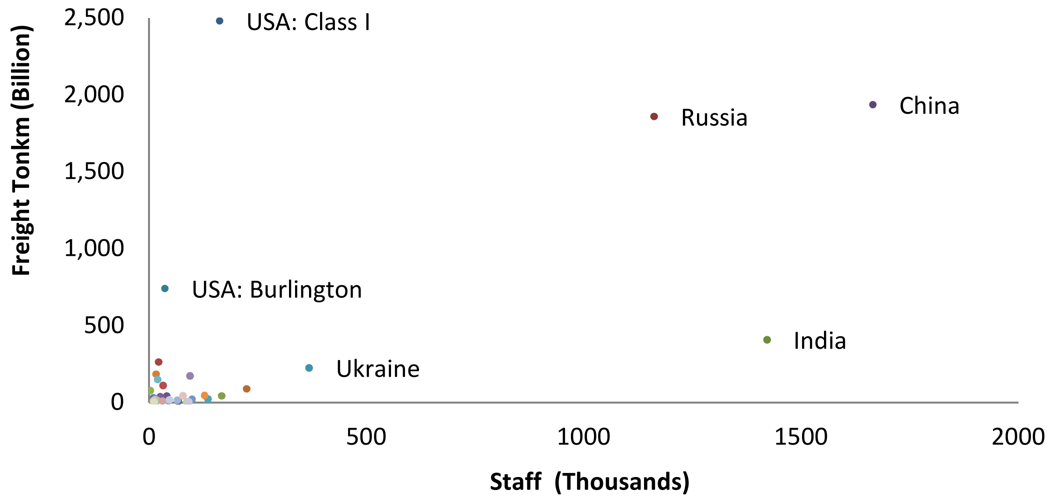

Figure 21: Tonkm per employee[35]

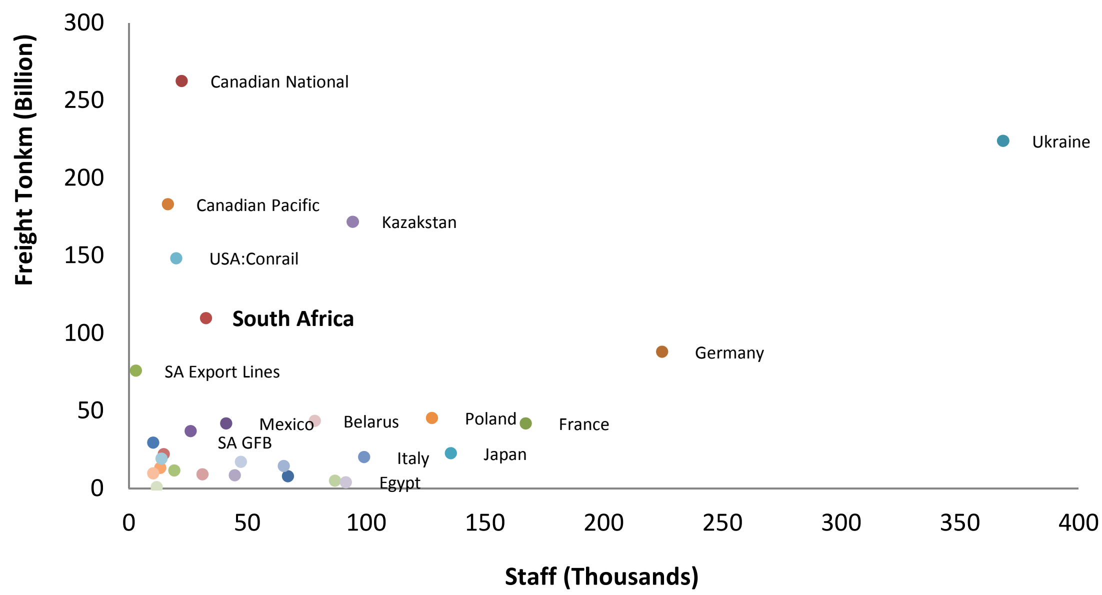

Figure 22: Tonkm per employee (macro systems removed)

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[35] Piasecka, 2007

This difference is well illustrated with the comparison of all South African output (Figure 23) over a long period of time (for which the GFB/export line split is not available) with the more recent figures (for which a split is available) (Figure 24).

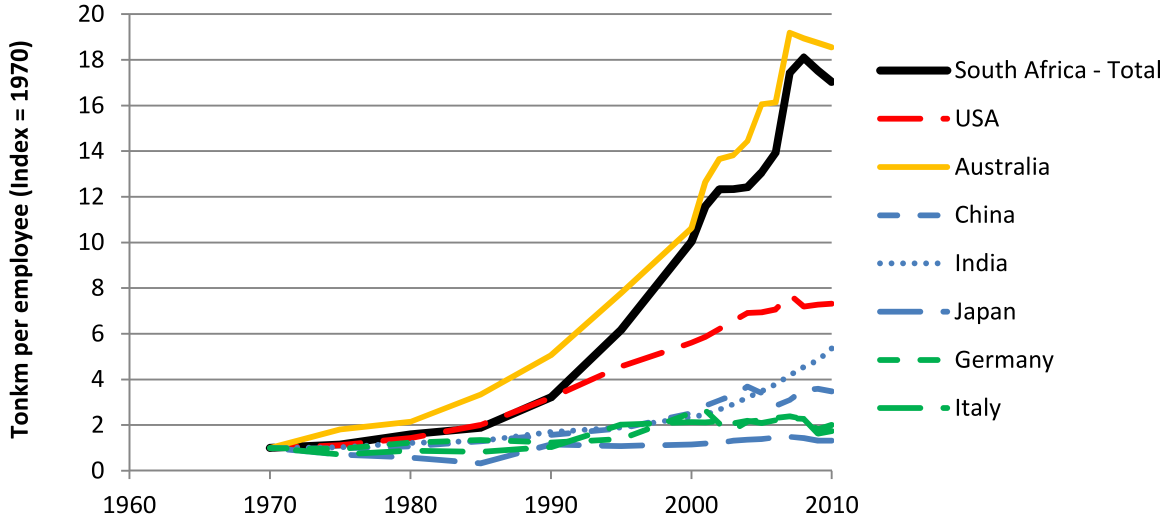

Figure 23: Indexed comparison of tonkm per employee since 1970

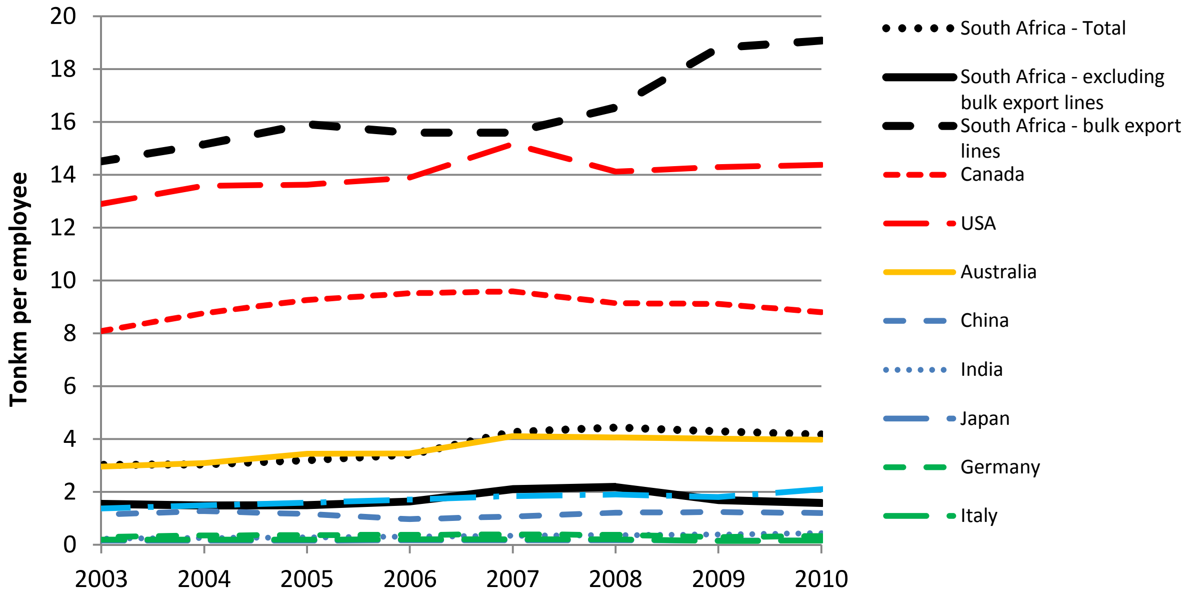

Figure 24: Tonkm per employee since 2003

Reform agenda as driving force

Trends in size- and productivity indicators for the three major global rail groupings were driven by three distinct reform agendas.

After deregulation, North American railroads' rationalisation resulted in private companies with extremely low cost bases, increased efficiencies and high densities, who managed to hold on to rail-friendly traffic in a deregulated environment, thereby attracting private sector investment. This rationalisation strategy, in turn, led to significant staff rationalisation. The relationship between deregulation and rationalisation was direct. Successful competition was only seen as possible in an environment where companies were allowed to rationalise route and staff at will. This lowered the cost basis, freed capital for investment in competitive solutions and attracted freight on dense routes, further allowing for lower costs and higher densities.

The RIC railroads were seen as tools for development, and their relative employment is extremely high (51% of the world tonkms on 26% of the world's route kilometres are observed on RIC railways, while 68% of the world's railway workers are employed there, as illustrated in Figure 10), but the railroads remained strong and expansive, with direct government involvement and the railroads very much part of the development state agenda.

In this environment European railways are a bit of an enigma. Transport distances are short, railways by definition less competitive and passengers "consume" a large portion of the output, because of dense living conditions and production facilities far from residential areas. Railroads contribute to lower congestion and are seen as important to alleviate environmental concerns. The relative small size of the many countries in Europe, that are all locked in the same rail system, made open access an absolute necessity in order for the railways to survive, increase its footprint and achieve the societal goals that was set for it. Even so most of the larger countries see their railways as important national assets, keep them vertically integrated, but are forced into open access regimes for the reasons given.

These distinct reform agendas are driven by three conscious paradigms. The North American paradigm is that very low transport cost will also keep the "social cost" of transport low – transport is a derived demand or a utility to solve the place element of the time and place discrepancy in logistics. Like all utilities a lower cost of the utility will lead to greater social benefits. This also means that funds are available for developmental projects, investment and social upliftment. The railways will attract private sector investment and will therefore not require subsidies. In the RIC countries, the relationship is more direct. Distances are so long and the road mode so uncompetitive that higher rail costs that contribute directly to social spending are tolerated. In Europe, railways provide refuge from a large array of externality challenges (specifically congestions and emissions) and institutional support to enable modal switch is entrenched. In short, in North America the drive is lower social cost; in RIC higher social employment and in Europe improved quality of life (related to lower social cost). Large dense vertically integrated railways can support either low social cost or high social employment. System disintegration (parallel or interlinking separate, independent vertically integrated railways) are only observed in the USA, where the biggest rail company, Burlington Northern's, route kilometre is only surpassed by Russia, India and China (i.e. Burlington Northern is the fourth biggest railway in the world).

No conscious decision has been made regarding the reform agenda for South Africa's freight railway. The railway is big enough to become like an American Class 1 railway if it remains vertically and systemically integrated and is allowed to be restructured into a rationalised, freight-densified company. This new business will concentrate on long-haul block trains for large industrial customers and mines, and intermodal for 3PL's. It will then move vertically upwards on some of the international benchmarks, for example reducing employees per route kilometre, increasing tonkms per employee, significantly improving densities and lowering costs. Alternatively, it could become a social instrument such as for the RIC countries. Transport costs in the economy will not only stay the same, but increase over time as the railway becomes less effective and efficient and the costs of alternative transport modes rise because of increased fuel and environmental costs. It will also require direct government involvement and investment.

There is a middle road between these two extremes: to create very clear "Chinese walls" between a core- and a development state network. The aim of the core network is to operate as a profitable business with returns that can satisfy both shareholders' and infrastructure capacity requirements, while reducing the country's freight transport bill (in essence, delivering savings to freight owners), and alleviating the risk of fuel imports, fuel price instability and externalities (especially congestion and emissions). The development state network (referring mostly to the current low density branch line network) will require government involvement, but it will facilitate the ideals of rural employment and equitable access to the core transport network, while the cost to the state for subsidies will be minimal, relative to the saving on the transport bill on the core network, job creation potential and future access benefits. Furthermore, portions of the development state network could become viable in future (i.e. requiring fewer subsidies), when the costs of alternative transport increases (due to the rising oil price and environmental charges) amidst an increasing demand for freight transport.

An understanding of the evolution of rail reform in other countries will facilitate the choice of optimal reform agenda for South Africa's freight railway.

6. Global rail reform case references

A Department of Transport ("DoT") position paper[36] argues that the current institutional framework governing South Africa's freight rail system allows for "monopolistic tendencies", fiscal neglect and poor demand planning (op. cit. p. 8). Reforms propose structural changes to achieve competition, private sector investment and quality improvements which will provide transparency and eliminate cross-subsidisation (op. cit. p. 2-5). The DoT position paper proposes that third party access should be engineered, while vertical separation in freight rail is the vision put forward by the National Freight Logistics Strategy ("NFLS")[37], leaving uncertainty as to Government's stance in this regard.

In the latter part of the previous century, railways worldwide experienced significant restructuring, including those in Canada, the Americas, Europe, Britain, and Russia[38].The purpose of this section is to indicate lessons learned, key principles of rail reform and historical developments of rail globally. The intention is to illustrate the role of rail in addressing national freight requirements and specific country objectives insofar as these principles contribute to the clarification of the role of the rail sector in South Africa. The main rail reform options are defined below, followed by the case reference analysis.

Definitions of rail reform options

Rail reform basically refers to how the relationship between railway infrastructure, and operations on that infrastructure, will be governed.

Vertical integration describes a market structure in which a firm undertakes two or more separable production stages. In the case of railways, it refers to the case where the owner of

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[36] Kuthele Projects, 2007

[37] Shaw, 2005

[38] Rennicke & Kaulbach, 1998; Sull *et al.*, 2004; Pietrantonio & Pelkmans, 2004; Yvrande-Billon & Ménard, 2005; Bitzan, 2003; and Pittman *et al.*, 2007.

the physical railway network (upstream market) also operates the trains on the network (downstream market)[39].

Third party access (TPA) imposes upon a vertically integrated railway the obligation to provide access to its track infrastructure to independent, non-integrated train operating companies (TOCs) [40].

Vertical separation refers to the splitting of the vertically integrated railway into two independent enterprises, one owning and managing the railway infrastructure and the other operating trains on this infrastructure, with the assumption that the incentive for discrimination by the infrastructure operator is thereby removed and that new TOCs will now enter[41].

Case references

There are less than 300 countries in the world and maybe less than twenty examples of rail reform (if Europe is seen as one as it should be). The core of the problems that led to the need for rail reform and that are evident in the case references are:

- productivity and efficiency issues (that seem to be effectively addressed by rail reform); and
- investment challenges (sustainability, affordability and funding).

The role that rail can and should play in a country – and the need for and nature of rail reform - is typically the result of a specific government intent or policy at a particular time (for example, nationalisation, privatisation, development, etc.). Analysis of South Africa's freight / rail transport system also has such reference. Rail reform and historical references are thus considered in developing the logic of this paper.

Railway renaissance and globalisation

Following World War II, railways in many countries were state-owned. Social criteria informed their objectives, and many did not adapt spontaneously to their shifting environment.

[39] Zauner, 2004

[40] Pittman, 2007

[41] Pittman, 2007

Deference to government, and insulation from competition stifled the organisational introspection, research and development, and culling and renewal, of perceptions, processes and technologies that drive vital adaptation.

Despite that setting, high-speed intercity passenger trains did appear in the 1960s, followed by heavy haul bulk-commodity unit trains in the 1970s, and double-stack container trains in the 1980s, a sequence hailed as a railway renaissance.

As leading railways transformed from regulated to commercial entities, they manifested a new global order. No longer the pre-eminent land transport mode, they now define and dominate distinct, unique market spaces.

Railways are corporate citizens of a complex, multivariate, economic, political, and social space demarcated by contending poles – command and free economies; competitive or monopolistic route structures; open access and vertical integration; heavy haulers and supra-nationals; monolithic state railways and independent operators; to mention some.

The process has accelerated in the past decade, as leading railways (such as BNSF and Canadian National in North America, ALL in Brazil, Queensland Rail in Australia, Deutsche Bahn in Europe and India Railways) have expanded operations, renewed assets, and generally raised their contribution to society, while laggards have atrophied.

Railways are entering the industry's third century: Those that prosper will be very different corporate citizens from their forebears in the first two centuries, if only because their environment has changed immeasurably.

Distinctions among countries and their railways

Research into forty variables reflecting attributes of competitiveness, market, networkability, ownership, presence, society and sustainability, for a global population of 114 meaningful (i.e. those with track gauge equal to or wider than yard, meter or 3 foot 6 inches) line-haul railway countries, provides some essential distinctions among countries and their railways. The list of variables is provided in Table 2.

Table 2: List of 40 variables

Group	Variable	Group	Variable
Competitiveness	Research & development level	Ownership	Infrastructure-operations separation
	Relative maximum axle load		Infrastructure ownership locus
	Relative maximum speed		Rolling stock ownership locus
	Distributed power presence		Infrastructure commitment horizon
	Heavy haul presence		Rolling stock commitment horizon
	High-speed intercity presence	Presence	Route km
	Double stack presence		Freight traffic volume
	Diesel traction		Passenger traffic volume
	Electric traction		Employee count
	Attitude to competition	Society	National economic freedom
Market	Route diversity		National population
	Operator diversity		Gross national income
	Concerned stakeholder sensitivity		Country physical size
Networkability	Narrow gauge		Initiative source
	Standard gauge		Determinism
	Broad gauge	Sustainability	Infrastructure investment capacity
	Networkability		Rolling stock investment capacity
	Strategic horizon		Stakeholder satisfaction level
			Service reputation
			Safety reputation
			Subsidy influence
		Time	Calendar year

The research highlights that railways reflecting turbulence between themselves and their environments indicated that they were open systems constructively positioning themselves with respect to global drivers. By contrast, railways that did not have the managerial freedom, or the stakeholder will, to expose their positions, depleted the entropy in their closed systems, until they no longer related meaningfully to their environments.

The research resulted in four clusters of railways, with South Africa being in a similar position, relative to its environment, as railways in emerging economies (Table 3). Although all of the railways in cluster 4 are International Heavy Haul Association members, the results of the research, reflects the apparent vulnerability and lowered sustainability of these railways – and hence the need for reform to improve competitiveness and a secure future role.

Table 3: Selected railway clusters

Cluster 1: Constrained Railways All countries except those in Clusters 2, 3 and 4 (77% of total count)	Cluster 2: Railways in Intense Competition Australia, Canada, United States, Mexico	Cluster: 3 Railways in Privatization Austria, Czech Rep., Italy, Sweden, Belgium, Netherlands, Switzerland, Denmark, Norway, Finland, S. Korea, Luxembourg, Germany, UK, Japan	Cluster 4: Railways in Emerging Economies Brazil, South Africa, China, India, Russia (all International Heavy Haul Association members)
Low freight and/or passenger traffic volume	Freight traffic dominates	Mixed traffic, moderate-volume freight, high-volume passenger	Substantial freight traffic, plus significant passenger traffic
Low operator- or route diversity	High operator- or route diversity	Operator diversity rising	Monopolistic markets
Low networkability, national strategic horizon	High networkability, continental strategic horizon	High networkability, conservative strategic horizon	Relatively low networkability, conservative strategic horizon
Low technology, members do not exploit rail's competitive strengths	High technology, exploiting freight competitive strengths (heavy axle load, double-stack, distributed power)	High technology, members deploy rail's high-speed competitive strength	Relatively high tech, occupying at least one competitive space (heavy haul, high-speed intercity, double-stack trains)
Public ownership, long commitment horizons	Private sector ownership dominates, relatively long commitment horizons	Emerging private sector ownership, moderate commitment horizon	Public ownership, relatively short commitment horizon
Low economic freedom, relatively low national income	Relatively high economic freedom, relatively high national income	Relatively high economic freedom, moderate-to-high national income	Low economic freedom, low national income
Low sustainability	Relatively high sustainability	Moderate-to-high sustainability	Relatively high sustainability

A case reference analysis serves to highlight key principles of rail reform[42]. It is imperative that these principles are carefully considered in determining the ideal type of reform applicable for South Africa. Table 4 reflects the key themes that drive rail reform.

[42] World Bank, 2011

Table 4: Key themes that drive rail reform

Theme	Description	Country
Productivity and efficiency issues drive reform	▪ Traffic levels too low ▪ Loss of markets / market share ▪ Fair access to rail ▪ Public subsidies too high	All Cases
Investment process broadly split into network, rolling stock, operations	▪ State underwrites the network ▪ Vehicle Finance Companies (SOE and Private) for Rolling Stock ▪ Train Operating Companies (TOCs) (SOE and Private) finance Operations, including rolling stock leasing and track access	India, China, Australia, EU
Welfare states favour vertical separation	▪ After 10 years in Europe and EU legislated since 2007, SOE railways still dominate freight flows ▪ All Australian Interstate rail is separated	EU, Australia
Eventually all state railways run out of investment capital	▪ PPPs and Joint Ventures are used to invest in terminals, regional lines, major new core developments	China India
Privatisation drives operational excellence	▪ Profit motive very quickly focuses the railway on increased Productivity, Safety and reducing the Cost of Capital	USA, Brazil

In addition to these core themes, the case references also identified some smart practices that were probably at the core of the rail reform success stories. Smart practices are summarised in Table 5.

Table 5: Smart practices

Practice	**Issue**	**Country**
The State offloads the rail reform problem to a Development Bank	▪ Finding the best agency to manage a concessioning process	Brazil : BNDES
Provide a state-owned recapitalisation catch net for failing concessions	▪ Management of the logistics network impact on the economy when a concession fails	Brazil : BNDES
Special back-to-back arrangements with BNDES to intermediate lending Customers buy new rolling stock on their balance sheets and TOCs and buy it back through tariff discounts	▪ State-owned assets are not on Concessionaire's balance sheet to gear against	Brazil : ALL
Rolling Stock Finance SOE	▪ Finding attractive specialised funding for Rolling Stock Modernisation	India : IRFC

The case references indicate that a number of funding mechanisms have been pursued by railways worldwide. Table 6 indicates the funding approaches for network, rolling stock and train operations that have evolved during rail reform and transformation. This also implies that there is no universal remedy for addressing the funding issue.

Table 6: Funding approaches

Case	**Network**	**Rolling Stock**	**Train Operations**
USA	Private TOCs	Private TOCs	Private TOCs
Brazil	BNDES (Old)	BNDES (Old)	Private TOCs
	Private TOCs (New)	Private TOCs (New)	
EU	Governments	TOC	Private / SoE TOCs
Australia	AusLink & State Govt	Private / SoE TOCs	Private / SoE TOCs
China	MoR / Prov. Govt	MoR / JV	CR / JV's
India	MoR	IRFC	IR / PPP's

TOC = Train Operating Company
MOR = Ministry of Railways
CR = China Railways
IRFC = Indian Railway Finance Corporation, a dedicated financing arm of the Ministry of Railways. Its sole objective is to raise money from the market to part finance the plan outlay of Indian Railways. The money so made available is used for acquisition of rolling stock assets and for meeting other developmental needs of the Indian Railways.

Table 7 summarises the funding issue in terms of State or private ownership which highlights the rail reform path taken by various railways worldwide.

Table 7: Ownership

Rail Reform Models		**USA**	**Brazil**	**Australia**	**EU**	**India**	**China**
Vertically Integrated				Hybrid state (QR) and privately owned	NA	State owned	State owned
Competitive Access		Privately owned and operated	Concessions	Rarely			
Vertically Separated	Train Operators	NA	NA	Hybrid state and privately owned	Hybrid state and privately owned	NA	NA
	Network Owner	NA	NA	Federal owned (ARTC)	Hybrid state and privately owned	NA	NA
	Terminals	NA	NA	Hybrid state and privately owned	Joint ownership – LSPs and railways	NA	NA
New expansion projects		TOCs balance sheet	Concessionaire's balance sheet	ARTC leads Interstate rail; Rest Private; IPO (QR)		PPP	Joint Ventures
Regulation		Deregulated		7 state regulators, national regulator on the cards	EU directive, country-level regulators	Self-regulated	Self-regulated

Success of rail reform

The DoT position paper specifically mentions that many countries are in the process of rail reform and that the process is complex[43]. A more specific view of the context and history of global practice are required.

Following deregulation of surface transport services in many countries around two to three decades ago, modal competition was encouraged. The primary objectives were to enable free market principles, to encourage efficiency and effectiveness in surface transport and to allow rail services to become profitable, often to prepare the rail operators for privatisation.

Some specific case studies surfaced like the World Bank's 2005 view that USA rail freight tariffs are the lowest in the world and outperform all other railways in productivity. Many problems however surfaced, indicating that not all the growth and optimisation objectives are reached with liberalisation. On the one hand, certain bulk freight transport services in low-cost long-haul markets were "captured" by rail due to its nature, but on the other hand rail-friendly traffic that did switch to road caused structural inefficiencies (often described as the "tragedy of the commons" phenomenon) on a macro-economic scale. Initially, freight owners on a micro consignment level experienced better service levels due to increased competition.

The loss of economies of scale on the rail network however caused higher rail costs and tariffs, with severe long term consequences on a national level due to the inefficiencies associated with dense long haul road transport. This was further exacerbated by the inappropriate allocation of externalities. Once the effect of these events on national competitiveness became evident, governments were motivated to develop strategies to revitalise rail as a preferred mode for long distance transport with the key outcome of lowering the total freight cost of the economy.

Returning to the free market principle, vertical separation and open access were seen as apparent obvious solutions, but with closer scrutiny a different truth emerged. Pittman specifically remarks that "one of the specific lessons of the experience to date is that the freight railways sector may not be a very promising sector for vertical separation." He continues to say that "analysts throughout the world are coming to understand ex post much better than they did ex ante that there are a number of characteristics of the freight railways

[43] Kuthele Projects, 2007, p. 11 and p. 19-20

sector that do not seem to fit well with the assumptions and requirements of the vertical separation model"[44].

In rail systems, the specific benefits that were expected to follow from vertical separation and/or open access were to encourage competition (as in Australia), facilitation of international services (as in Europe) and even to put different modes on an equal footing (as in Scandinavia)[45]. Focus on specific tasks by the rail infrastructure company which would lead to more efficient and effective maintenance is also sometimes mentioned, but specific failures in the United Kingdom and an analysis of other case studies has proven that when "specializing in mainly maintaining infrastructure, the maintenance cost is no different from the costs of integrated systems"[46].

Of these benefits only competition is relevant for rail reform in South Africa, as a very large percentage of current and medium term future traffic is considered domestic and because the road mode already enjoys significant statutory benefits over rail (rail market share for traffic that is considered "natural" for rail is extremely low and road hauliers' contribution to fix infrastructure establishment, compared to rail, is very low).

The different emphases placed on proposed vertical separation/open access processes as well as the motives behind it, lead to the rise of many different models for what was to be termed "rail reform". These models can however be summarised as the British and Brussels approaches[47]. The British model requires complete vertical separation, whereas the Brussels model maintains vertical integration while third party operators are allowed to use the vertically integrated operator's infrastructure (sometimes called the "third party access" model). A further and separate dimension to these issues is the extent to which rail operators are privatised. Despite the concepts of vertical separation and open access being around for more than a decade, success could at best be described as limited. By 2007, 97% of rail traffic was still handled by vertically integrated railways[48].

The reasons for failures or implementation difficulties of vertical separation include information asymmetries, high costs of execution and loss of economies of scale.

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[44] Pittman, 2005, p.182

[45] Gomez-Ibanez and de Rus, 2006, p. 5

[46] Mizutani and Shoji, 2004, p. 262

[47] Diaconu and Pittman, 2006, p. 2

[48] Amos, 2007, p. 3

Paradoxically, the problems associated with information asymmetries during vertical separation and the successful processes to address it, leads to deep relationships between interested parties. The mooted advantages of vertical separation are then negated by the fact that an industry with a few highly specialised players and highly integrated operations will require these relationships to be successful[49]. This inevitably leads to "co-operation, quasi-reintegration, all that limit the role of market forces contrary to what was apparently planned in the first years of the railway reform"[50].

According to Pittman, "common sense and econometric analysis both suggest that the application of the reformers' "default option'' of vertical separation in the freight railways sector may impose high costs on the system in their destruction of economies of vertical integration; thus arguments for the adoption of this option would seem to require the demonstration of high levels of corresponding benefits"[51]. These benefits have been hard-pressed to find. (Refer to the section on 'System density', page 48, for more on fragmentation penalties).

Many economies have also learned the hard way that, whereas vertical separation and open access work well in some utilities, this is not necessarily true of railways, because of high proportions of fixed cost, upstream economies of scale and the locus of vertical separation[52]. Research suggests that 25% of delivered costs of railroads are infrastructure costs[53] versus 5% for electricity and 2.5% for gas. In addition, small power plants, for instance, can be almost as competitive as bigger plants (if not just as competitive), whereas density is the holy grail of railroads. In fact, it is at the interface point between fixed and rolling infrastructure where real efficiency can be gained[54]. Or as Pittman states, "the effectiveness of the operations depends on the exact point where vertical integration or vertical separation takes place"[55]. In summary, vertical separation in specifically freight railways must at best still be

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[49] Sanchez, 2001, p. 7

[50] Bouf et.al., op. cit., p. 11

[51] Pittman, 2005, p. 193

[52] Pittman, 2005, p. 2-7

[53] Thompson, 2003

[54] Sanchez, 2001, p. 83

[55] Pittman, 2005, p. 185

seen as an "experiment" (rather than the developing *status quo* as the DoT position paper[56] implies).

Once the rail reform option has been chosen for a country, defining an appropriate regulatory framework is the next step. Market reforms are needed for more competition, transparency and accountability in large infrastructure investments, while regulatory reforms are needed for steadier prices and to ensure adequacy of supply (Eberhard, 2012)

7. Rail economic regulation vs. transport economic regulation

Economic regulation of public utilities (mainly the energy, telecommunications, transport and water utilities) has taken place in the United States since the early 20th century. Economic regulation was deemed necessary to ensure fair treatment to consumers and to ensure that competitors have fair access to essential network services controlled by incumbent service providers[57]. Government was therefore involved in the provision of utility services as well as in the regulation thereof. The global trend towards a reduced role of government in these industries through increased competition and privatisation, has led to the introduction of independent economic regulation. The role of independent economic regulators can be summarised simplistically as the protection of consumers and the creation of an enabling investor environment, while implementing government's policy objectives[58]. Regulation is therefore a substitute for competitive forces (e.g. a price cap). Competition law, on the other hand, is aimed at protecting and enhancing the competitive process (which will drive prices down) and to set boundaries for acceptable business conduct. Regulation is usually proactive and consists *inter alia* of legislation and directives aimed at preventing harmful business practices. By contrast, competition law, with the exception of merger control, is applied retrospectively by the competition authorities only once a concern in this respect is raised or identified[57].

In South Africa, the Competition Act of 1998 came into effect in 1999[59]. Since inception, the visibility and size of the cases before the commission and the extent of fines has grown, but the process is still a mere decade old. Independent economic regulation in industries where

[56] Kuthele Projects, 2007

[57] Van Basten, 2007

[58] TIPS, nd

[59] Chetty, 2005, p. 4

a few dominant players exist is even more recent. The Independent Communications Authority of South Africa came into operation in 2000, the National Energy Regulator of South Africa (NERSA) (regulating electricity, petroleum pipelines and piped gas) was promulgated in 2004 and the Ports Regulator was established in 2005[57]. With operating models in its infancy, the verdict is still out on the success of these agencies[60]. As far as transport economic regulation is concerned, as mentioned, pipelines are regulated by NERSA and ports by the Ports Regulator. There is however an absence of economic regulation in the surface freight transport industry.

Questions about rail economic regulation have recently resurfaced in South Africa around discussions to create a rail economic regulator ("RER")[61]. In the DoT position paper a particular framework was proposed that has an overarching objective of more efficient and effective rail services. To achieve this, international benchmarking of rail economic regulation and the development of key principles for a RER is proposed[62].

Given the specific circumstances in South Africa the possible role of a RER is limited as far as freight railways are concerned. Primary and corridor transport should not be affected and metropolitan freight rail transport is a non-issue, which means that only rural transport over branch lines could benefit by being ring-fenced and possibly restructured. If an RER is established anyway, this could be a point of departure to consider third party access (i.e. the Brussels model).

If the overarching objective of any reform and the process of regulation is increased efficiency and effectiveness, this objective should be considered for South Africa's freight system and not railways in isolation (after all, only 9% of the nation's freight bill is spent on rail). It is implied that modal shift will decrease total freight costs, but one of the direct drivers is in fact the cross-subsidisation of road freight by other road users. The DoT position paper also acknowledges that conditions for various countries would differ. Given the above analysis a role for a transport economic regulator, if considered, could be the following:

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[60] Eberhard, 2012; Hogde *et al*., 2008

[61] Radebe, 2008

[62] Kuthele Projects, 2007, p. 1-2

1. Pricing:

a. The export lines: These lines are “captured”, but systemic integration is key. The lines, the mines being served, and the ports from which coal and iron ore are exported, form one systemic process or “machine” that competes with other comparative processes around the world. In fact, in some cases around the world, the lines and mines belong to a single owner. Vertical separation will drastically hamper South Africa’s competitiveness. Transnet and the mine owners should be completely transparent in this regard and a regulator could play a role in engineering, overseeing or facilitating this mutual process in both directions – in summary ensure that in terms of price neither the freight owner nor the railway is exploited (it should be remembered that just as the commodity is rail “captured” the railway is commodity “captured”).

b. The corridor network: Everything possible to achieve modal shift should be done. As far as pricing goes the same process of transparency should be engineered between both rail and road modes and freight owners. If road transport is conducted according to the user pay principle and if the turnaround strategy for rail that is already showing results is allowed to continue, modal shift as already being demonstrated should happen. This is especially if no additional costs (such as what vertical separation would bring) is added to rail costs. Once user pay principles are installed for road and cross-subsidisation is therefore removed from road freight, a regulator could facilitate the transparency that would be required from a single vertically integrated railway, the terminal operators and the freight owners - in summary determine real costs of all modes and ensure that resultant pricing is related to this costs.

c. Branch lines: Branch lines are clear targets for third party access as the analysis illustrates. In this case the regulator could assist with this process, but in the same manner as other property transfer processes also ensure that the economic viability of the different structures and its roles are protected. A good example is the two overarching principles of land reform, i.e. to ensure the sustained commercial viability of transferred land and the protection of the country’s food supply. This means that the rural freight system in total should be considered and pricing could even be subsidized to meet development objectives. A regulator could assist with this process – in summary determine real requirements and ensure that pricing, including subsidies, achieve the required objectives.

d. Metropolitan: A regulator could play a role in decongestion, by promoting passenger modal shift, but also through the regulation of road freight, through congestion charges, etc. – in summary, as for the corridor network determine real costs of all modes and ensure that resultant pricing is related to this costs.

2. Planning:

The regulator could play a role in promoting an understanding of the symbiotic relationship between road and rail planning. Once the real potential of modal shift is understood the effect of that shift should lead to an understanding of what infrastructure would be required. The regulator could facilitate the process of ensuring that both the required rail and road infrastructure that would lead to efficiency and effectiveness (the overarching objective) is developed. A performance management system could then be considered to ensure that both the rail and road infrastructure are economically maintained and efficiently used.

The development of rail reform and regulation options for South Africa is, on the one hand, informed by the country's transport industry evolution and *status quo*, as well as global experience in rail reform. On the other hand, the main purpose of the freight rail system is to provide sustainable freight transport solutions for the country's future transportation needs. The rail reform and regulation agenda must therefore be informed by the market demand for such solutions, which can only be understood through a systematic market segmentation exercise. The market segmentation exercise is a match between market demand and the freight railways' value proposition, which in turn, centres around rail's economic fundamentals, as described in the next section.

8. Rail economic fundamentals

The key rail economics principles are density (of terminals, lines and railway systems) and freight uniformity. From these principles genetic technologies, that satisfy the exploitation potential of rail, can be derived.

Terminal density

A terminal is any place where freight is received or dispatched. Railways are less distance sensitive than road transport but distance sensitivity is also impacted by the efficiency and location of terminals.

High level analysis for South Africa suggests a crossing point of 300km average transport distance (ATD). This means that, theoretically, the additional terminals handling charge that a railway attracts (more than road transport) is discounted by the lower rail costs from 300km onwards (Figure 25).

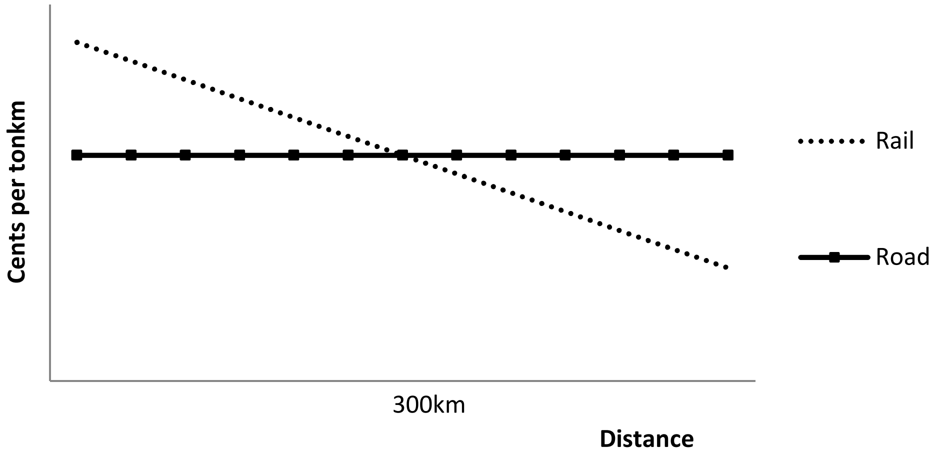

Figure 25: Rail and road cost compared to distance

Dense terminals lead to standardisation of equipment and processes which drive down costs. Highly densified terminals will lower the ATD crossing point at which rail becomes more cost effective than road (Figure 13). In flow segmentation and identifying a natural core railway network, terminal density should be considered.

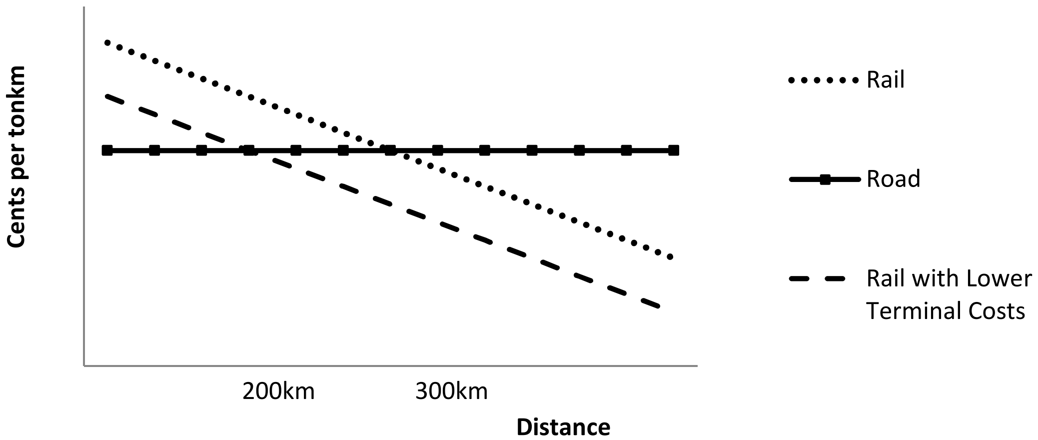

Figure 26: The effects of terminal density

Line density

Railways have a high infrastructure component. A railway therefore becomes increasingly more competitive (and therefore cost effective for a country) if less track is required for higher volumes of traffic (expressed as million ton kilometres per route kilometre). This means that the cents per ton kilometre total cost of a railroad will decrease with each additional ton kilometre activity over the same track length. This is illustrated in Figure 27.

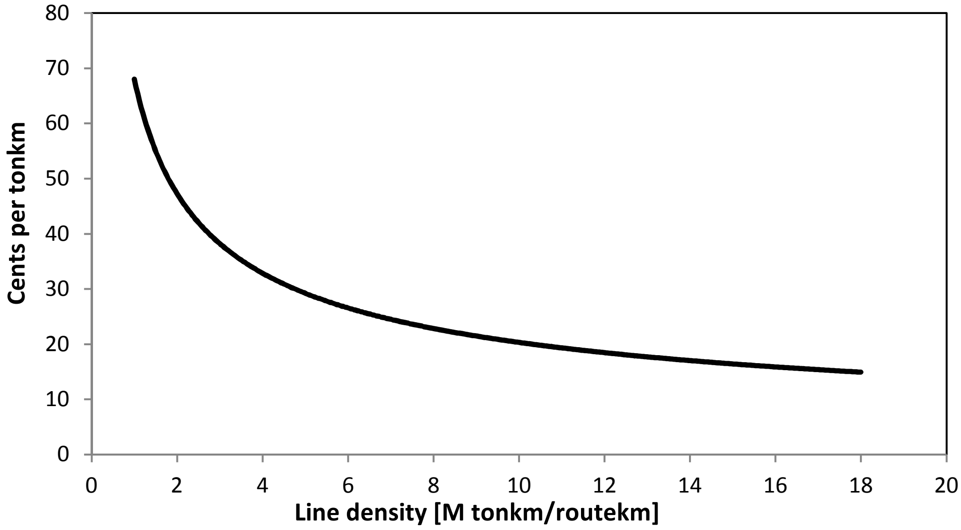

Figure 27: The economics of rail density[63]

In 1977 Robert G. Harris wrote a paper (1977: 556) stating:

"The extent of economies of traffic density in the rail freight industry is a matter of critical importance with respect to public investment in and the financial viability of the United States rail system. The evidence strongly supports the hypothesis that significant economies of density exist, and that many of the light-density lines, which comprise 40% of the rail system, should be eliminated. "

After presenting his argument, Harris concluded with a message on policy implications that still ring true, and even more so for the branch line strategy debate in South Africa:

"To the extent that our empirical results offer a fair representation of the relationship between traffic density and the cost of rail freight service, we can draw from them the following policy implications.

[63] Adapted from The Economies of Freight Density in the Rail Freight Industry (Harris, 1977)

1. First, the cost of rail service on light density lines is much higher than earlier studies have claimed. Accordingly, for at least those 30,000 miles of railroad with less than 250,000 revenue ton miles per mile of road, it is highly likely that, on the basis of quality-of-service compensated costs, motor freight represents a cheaper mode of transport.
2. Second, the costs of rail service on high-density lines are much lower than at average density levels. Hence, policy decisions based on a comparison of the costs of alternative modes (e.g. slurry coal pipelines) to the average cost (i.e. at average density) of rail service are unduly biased against railroads.
3. Finally, railways should move toward a rate system, which reflects the widely differing costs in the provision of rail services among shippers. Railroads should be allowed to raise rates on light density lines (which would in turn lessen opposition to abandonment of redundant lines), and to lower rates on long-haul freight moving over the high-density mainline rail network. Such policies would greatly enhance the financial viability of the rail freight industry, and significantly reduce the need for massive public investment. ”

It is interesting to note that following deregulation in 1980, the 2006 USA rail network consisted of 561 freight railroads operating with aggregate freight revenue of $54 billion and redesigned along density lines:

- A backbone network of seven Class 1[64] railroads, which comprise just 1% of USA freight railroads, but account for 67% of the industry’s mileage, 90% of its employees, and 93% of its freight revenue;
- 33 regional line haul railroads with at least 350 miles, between 75 and 500 employees (a few have more than 600 employees) and / or revenue of between $40 million and the Class I threshold;
- 323 local point-to-point single state line haul railroads operating less than 350 miles and earning less than $40 million per year (The vast majority earn less than $5 million per year).

[64] Class 1 railroads are defined as those with revenue of at least $346.8 million in 2006. Class 1 railroads operate between 3 200 to more than 32 000 miles with 2 600 to more than 53 000 employees. The big 7 are: •The BNSF Railway (BNSF); CSX Transportation (CSX); Grand Trunk Corporation, which consists of the U.S. operations of Canadian National (CN), including the former Grand Trunk Western (GTW), Illinois Central (IC), and Wisconsin Central; Kansas City Southern (KCS); Norfolk Southern (NS); the former Soo Line (SOO), owned by Canadian Pacific (CP); and Union Pacific (UP).

- 196 switching and terminal (S&T) carriers primarily providing switching and / or terminal services including pick-up and delivery services within a specified area for one or more line haul carriers with whom they connect, often in exchange for a flat per-car fee.

The Harris curve describes economies of density, not economies of scale. Economies of scale refer to a long-run average cost curve which declines as the size of the firm increases, i.e. the larger the firm, the lower the cost per unit of output. While this issue is of considerable importance (e.g. with respect to merger policy in the industry), the critical determinant in pricing and (dis)investment policies is whether or not there are economies of density. Specifically, the question is what happens to average cost as output increases, holding the route system, or miles of rail line, constant. A small firm with high traffic density may very well have lower average costs than a large firm with low density.

The development of the view of an ideal railway for South Africa should thus strive for a core network with greatest possible density or based on a critical density threshold (dependent on local circumstances). Initially there are significant reductions in cost (or opportunities for cost reductions) as density improves. These cost benefits become increasingly difficult to achieve despite density improvements beyond the threshold point. (Statistically the threshold is the inception point of cost and density at the peak of the curve and is usually found around this point).

System density

Pittman (2007) argues that “the generally accepted result that most railways are operating in a region of continued economies of density suggests that neither open access nor vertical separation is likely to lead to a vibrantly competitive train operating sector in any but the most densely operated rail systems”, which he identifies as existing only in Russia, China and India. The “single-network characteristic” of South Africa’s railroad, based on density requirements, has also been suggested (Simpson & Havenga, 2010). Multiple operators will cause a loss of system density. The effects of increased fragmentation, with the resulting loss in system density, should therefore be considered (Figure 28).

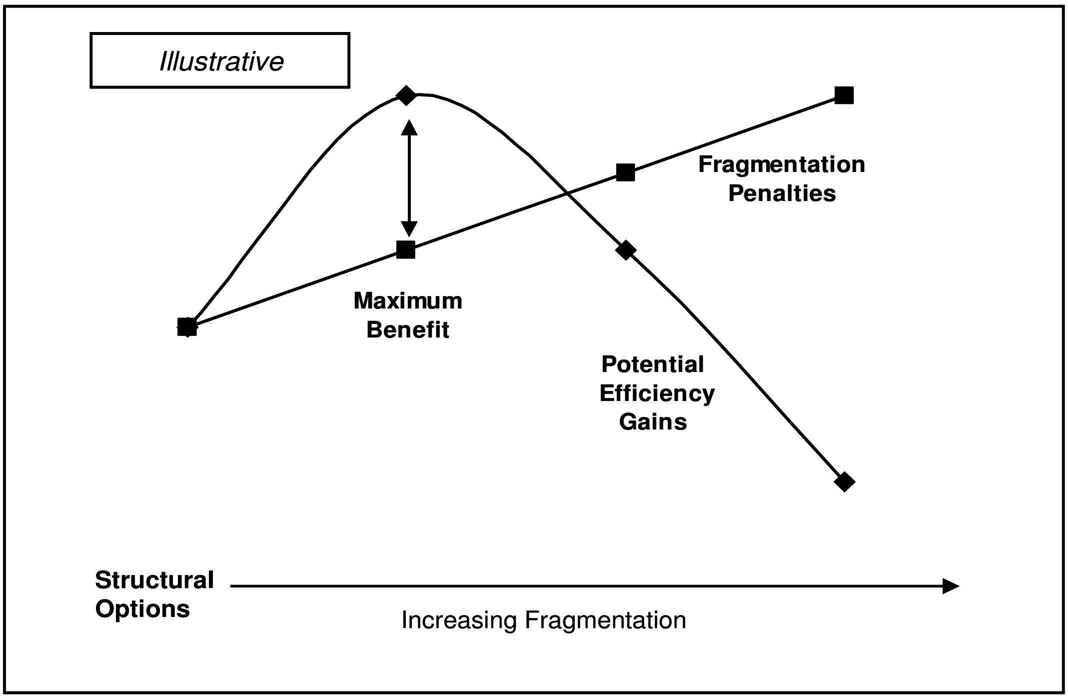

Figure 28: The effects of fragmentation

According to Pittman (2005), there are strong *a priori* reasons to believe that economies of *vertical integration* are significant in the railways sector; the very locus of vertical separation, between the wagon wheel and the track, is a point where investments, maintenance, and other actions on one side may have a significant impact on costs on the other. The econometric estimates of Ivaldi and McCullough (2004) suggest a cost advantage of 20-40% for an integrated railway versus separate infrastructure operators and diversified train operators (Figure 29).

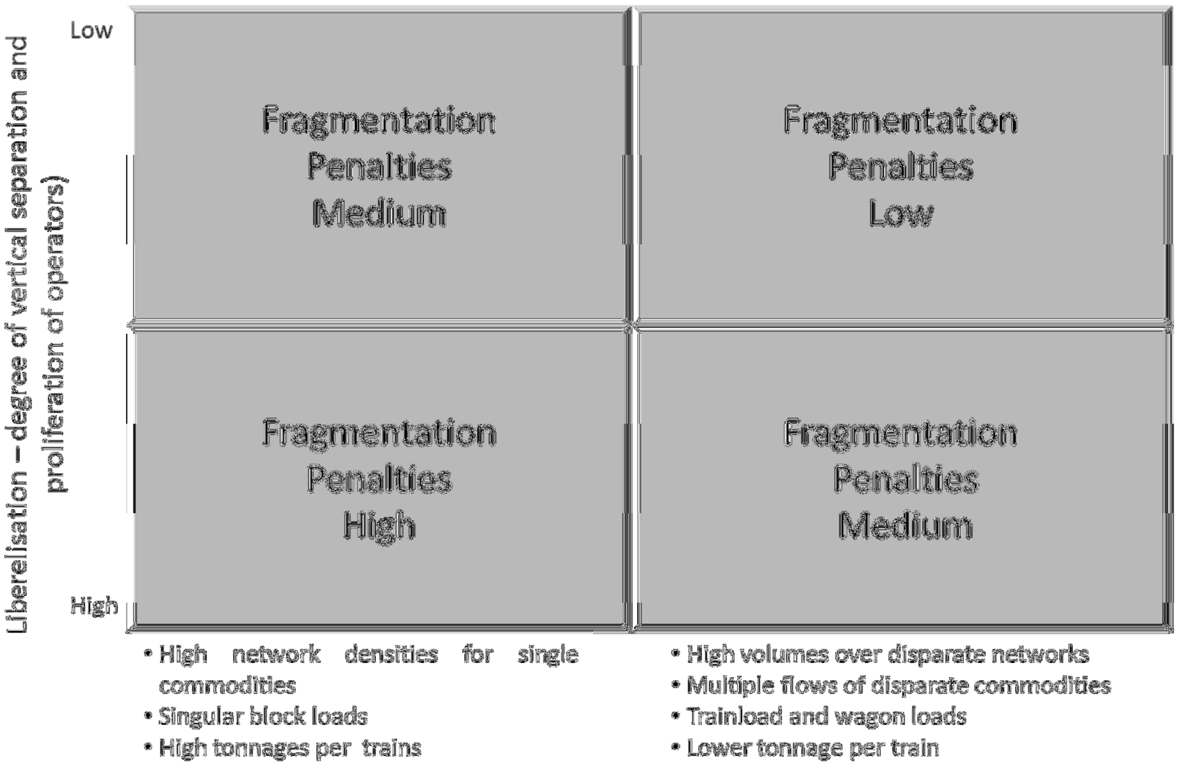

Figure 29: Fragmentation penalties[65]

The penalties associated with fragmentation of railways relate to overheads, operational scale and external coordination, as detailed in Table 8.

Table 8: Penalties from fragmentation of railways[66]

Penalty	**Rationale**
Overheads • Corporate • Business	Large operations do not need proportionately larger overhead organisations • Tasks are duplicated in each new entity • Most tasks are more efficient when performed in high volume
Operational Scale • Crew • Locos	Large crew or loco group is more productive than a small one • Peak requirements in specific flows cancel out for large groups • Flows to fill working day in large groups easier • Unscheduled sickness / failure profile smoother in large groups
External Coordination • Interfaces • New external bodies	Fragmented industry is more complex, needs more coordination among parties • Railway operator – to - railway operator interfaces for revenue division and joint facilities • New bodies for regulation and franchising • Interfaces between railways and the new bodies

65 Ivaldi and McCullough, 2004

66 Adapted from Mercer Management Consulting, 2002

Fragmentation charges can be mitigated in cases where a degree of systemic "separateness" or vehicles for funding is necessary. This could be achieved through creating PSP vehicles, but it would only work in certain environments where ringfencing could be targeted without system integration loss. This is often the case where haulage remains integrated, but freight owners own vehicle fleets and operate own terminals. This would also be possible in shared systems with LSP's, especially with intermodal technology and operations.

Freight uniformity

In order to monetise terminal density, expensive equipment in terminals, rolling stock and train length up to the point of unit trains only, products need to be uniform (such as dry bulk – i.e. coal, iron ore, maize, wheat) or require some form of standardisation, such as being palletised[67]. The uniformity of the product allows allow enormous quantities to be handled quickly and efficiently through mechanical handling. The economic advantages of standardisation are both direct (in lower distribution costs) and indirect, e.g. in packaging cost and damage rate reductions. The direct advantages accrue not only to the consignor, but also to the transport companies and often to the consignee as well. The consignor saves on handling and storage cost in his own warehouse, as well as on shipment charges.

Unitisation or palletisation enables transport companies to achieve larger and faster throughputs on very flexible systems. The consignee may receive a direct benefit from unitisation in a similar way to consignor, saving on handling and storage costs. Some companies have instituted systems with all their suppliers so that all goods are sent unitised on pallets of agreed dimensions.

The indirect advantages can also be considerable, stemming from the fact that large unit loads handled mechanically are subject to lower transport risks, and therefore lower transport costs. This ultimately reduces the proliferation of handling equipment, wagons, loading and offloading equipment and decreases the cent per tonkilometre charge of this freight. It also reduces commercial and marketing overheads as customer needs, contracting and integrated supply chain systems can be standardised, reducing the cent per tonkilometre cost component of these elements as well (Rietveld, 2008).

One of the genetic technologies of railways is coupling, or the ability to build trains. This ability to scale transport capacity is maximised when commodity handling is uniform, such as

[67] Havenga *et al.*, 2011

train services associated with heavy-haul coal or iron ore exports, and the container industry – based on a twenty foot equivalent (TEU) standard. Also, the parcel size distribution (PSD) function is an important factor to consider. The PSD function describes the range of parcel sizes in which cargo is transported and is determined by its economic and physical characteristics, e.g. iron ore is transported with individual consignment sizes ranging from 20 000 tons to 32 000 tons. The PSD and the nature of the commodity allows for unit loads to be composed, with standard handling equipment used from origin to destination. The PSD of other commodities or goods may be too small to fill a rail wagon completely. Containerisation has made it possible to pack these commodities with other freight, creating "bigger parcels" of uniform dimensions, allowing for uniform handling.

In segmenting freight flows, commodities with uniform or very similar freight handling properties are clustered together. In making strategic choices about which freight segments to serve, rail should consider its ability to standardise the freight in order to serve a chosen market

Genetic technologies

The advantages of rail as a transport mode can be monetised, and railway competitiveness determined, by the extent to which railways exploit their intrinsic technologies i.e., bearing, guiding and coupling. Bearing, which indicates the axle-load (and therefore volumes) that can be maintained, and guiding, which indicates the wheel-on-track differentials (and therefore speed of movement), are added to coupling, which means long trains with massive volumes (therefore combining high-volume time and long-distance solutions) (Van der Meulen, 2007). These technologies naturally support four freight-rail market spaces:

1. General freight: Slow moving light axle loads – typically siding to siding break bulk general cargo;
2. Heavy haul: Slow moving heavy axle loads – typically minerals from mines to ports or plants and mineral imports;
3. Heavy FMCG: Fast moving light axle loads – typically road / rail bimodal transport of heavy (palletised) fast moving consumer goods; and
4. Heavy intermodal: Fast moving heavy axle loads – typically long-distance (preferably) high volume container movements.

The grid of genetic technologies may be used as a framework for strategic positioning of rail systems and may be useful in assessing opportunities and selecting appropriate technologies for a railway in a chosen market space (Figure 30).

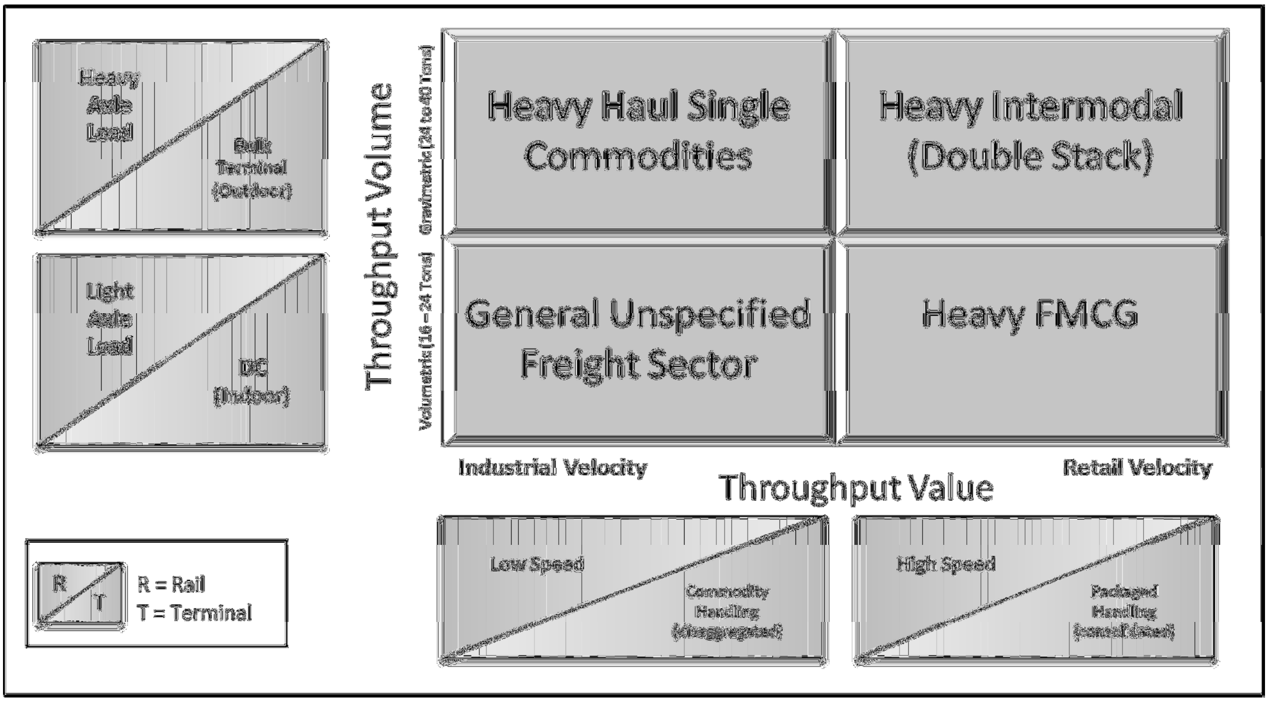

Figure 30: Positioning Framework for Rail Systems

These generic railways systems are briefly described:

General freight

Notwithstanding its popularity historically, this business resides in the weak market space. This freight often (though not always – compare bags of cement with bicycles or wheel barrows) attains heavy axle load, and maximum line capacity is attained at relatively low speeds:

- The Bearing and guiding genetic technology strengths are elusive. However, the Coupling genetic technology combines vehicles into trains, thereby attaining higher capacity within given headways than autonomous vehicles can:
- This leverages rail's throughput beyond the domain of competitive general freight transport.

In South Africa and Africa, general freight line haul railways are a subset of railways that represent the lion's share of current applications. Line haul railways are corporate citizens of continents, and perhaps very large countries, while general freight railways are corporate citizens of local environments.

The typical waybill refers to tons or units transported of disparate semi-beneficiated products such as intermediate transport of steel coils, ingots, logs between manufacturing facilities.

Heavy haul

This market space requires easy gradients, to limit coupler forces in heavy trains, but accepts relatively tight curves, because permissible maximum speed is relatively low.

It typically conveys bulk commodities, which are sufficiently dense that a heavy, competitive axle load can be achieved within a modest loading gauge.

Heavy haul competes over haul distances of less than 1 000 km against sources in other countries or other regions.

The typical waybill refers to tons transported from a mining stockpile to a manufacturing facility or port and is often measured in trainloads per day.

Heavy FMCG (Bimodal)

For high speed intercity passenger transport this market space requires wide curves, but accepts relatively steep gradients because of its high momentum and power. High-speed Intercity traffic ideally requires new, dedicated infrastructure to fully exploit rail's genetic technologies. High-speed intercity competes in the 300 – 1 000 km mobility market space:

- At the lower limit, private and public road transport offers more competitive solutions; and
- At the upper limit, air transport is more competitive.

These limits are important in order to ascertain whether high speed passenger transport is possible. Once this is established, a complimentary effect with freight can be sought.

South Africa requires an efficient freight transport service for its large inland consumer economy, separated by long distances from seaports. For rail to be effective it needs to emulate at least road line haul activities for the heaviest of consumer goods road freight – i.e. palletised FMCG products. These products generally flow between distribution centres (DC-to-DC) or between factories and large wholesale operations. For freight, this market space requires high throughput line haul transit and terminal transhipment characterised by bimodal road–rail technology solutions. The typical waybill will refer to a number of high value pallets sent from DC-to-DC.

Heavy intermodal or double-stacked containers

This market space is similar to heavy haul, except that it requires high vertical clearance (unless built for double-stacked containers, routes typically require special clearance). Freight in this space competes in the 3 000 - 12 000 km market space against road and maritime transport, providing a basis for globally aware railway positioning strategies. Heavy intermodal is crucial to railway strategic horizon - the two other competitive market spaces maximise out at 1 000km, whereas heavy intermodal supports continental and intercontinental networking. The typical waybill will refer to containers of high value manufactured products sent from port to DC or DC to port or manufacturing plant to DC or port.

Relationship between genetic technologies and supply chains

For commodities extracted (e.g. mining commodities), freight requires heavy axle load technology (bearing) but speed is relatively less important (transport to manage stockpile sizes). Comparatively, as parcel sizes become smaller (commodities transported for consumption by the end user), they are typically higher value goods in nature. To reduce inventory carrying costs, transport speed to convey these goods to DCs, becomes increasingly important (e.g. just-in-time principles need to be met).

An appropriate genetic technology should be selected for the freight market solution required. (By way of simplistic analogies – one would not utilise a bakkie to move coal from a mine to a power station nor utilise a 40ton truck to deliver milk from the corner shop to your door). The relationship between genetic technologies and supply chains requires better understanding of supply chains in South Africa and how these chains lead to freight flows (Figure 31).

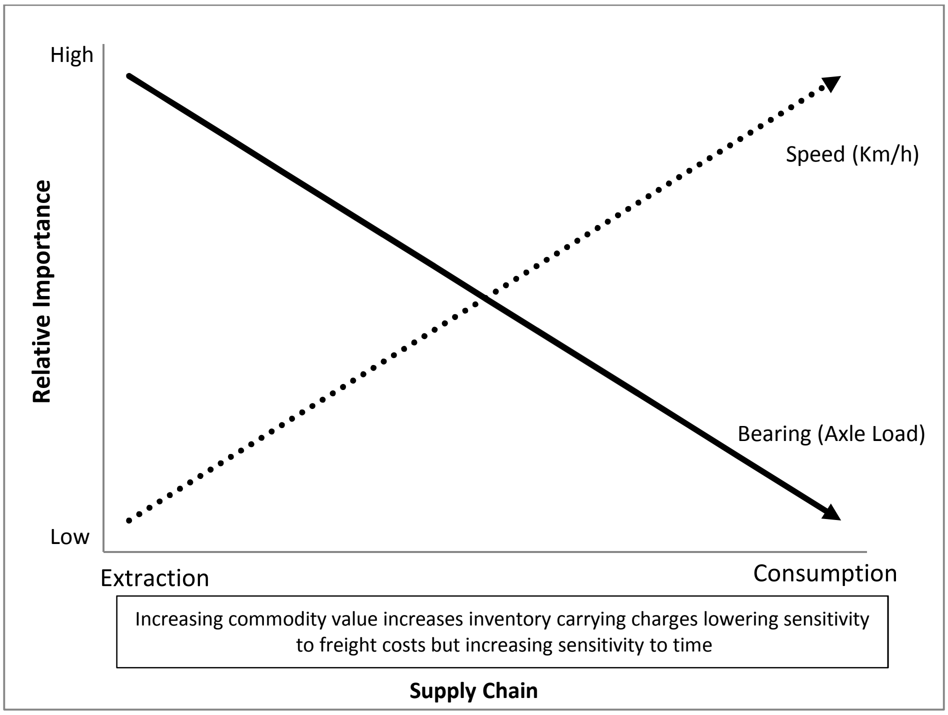

Figure 31: Relationship between genetic technologies and supply chains

Detailed flow segmentation indicates which freight flows have been identified that improve density on a core freight network,

- With maximum network volumes,
- Requiring the lowest number of high throughput terminals with,
- High volumes of standardised commodities,
- With suitable genetic technologies that can serve these segments.

9. Flow segmentation

Economic context

The literature review indicated that restructuring successes and failures could be attributed not to specific reforms, but to adherence to three basic principles, namely, (i) sound macro-economic principles to reduce logistics costs and improve the country's competitiveness, (ii) sound business principles for investment decisions, and (iii) sustainable development principles. As such, the case references provide a mixture of macro-economic goals and investment drivers for rail reforms, but not a specific categorisation of the markets a railway should serve, nor an explicit indication of where and to what extent the benefits of a railway could be exploited.

Therefore, in order to address the economic problems and choices around the optimal structuring and positioning of the freight transport and logistics industry, the industry must be considered within its economic context. This is especially relevant in the case of South Africa because there are several unique aspects to the country's economic and institutional context, such as the institutional structure of the port, rail and pipeline network, the spatial location of economic activity and the modal balance of freight in the country.

Bryan *et al.* (2007: 5) distil five themes for consideration in rail's revival opportunities, one of which is segmentation. They state specifically, "public action needs to address specific segments due to their discrete behaviour".

Segmentation is a business fundamental. It is the first step in understanding demand or market opportunity, which should lead to the matching of a firm's capabilities with this demand and finally investment to create the mechanisms required to serve the opportunity. Whereas market segmentation can be defined as the search for customer groups with homogenous needs, Harrison and Kjelberg (2010: 784), like Quinn *et al.* (2007) before them, maintain that the identification of homogenous customer groups is a managerial assessment rather "than a naturally occurring market phenomenon". Segmentation is therefore not a gestalt in it is own right, but rather a continuous matching of the firm's capabilities with observed customer needs. In this continuous dance, capabilities can be upgraded, changed or streamlined given new lucrative observations, or customer groupings can be adjusted given entrenched capabilities.

Freight flows can be segmented in detail to identify homogenous groups, but also, in light of the managerial assessment view of segmentation, segmented according to utilisation of core competencies, in this case railroad core competencies. This was done by classifying all freight using basic economic principles and applying sound railway economics principles, to enable strategic marketing segmentation of the industry.

An understanding of the freight flow segments of the total market space enables the choice of specific markets that rail should serve and contributes to the development of recommendations for the business model and structure of an ideal railway business/es for South Africa.

Economic structure

Figure *32* illustrates the broad economic structure of production (GDP) in South Africa where tonnages are moved by road and rail (transportable GDP).

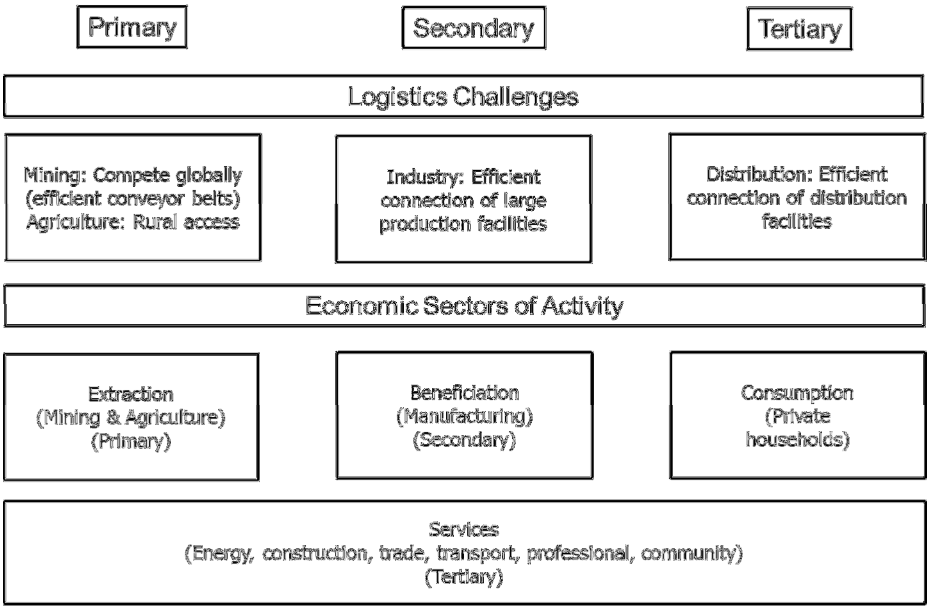

Figure 32: Flows as a result of economic structure

This economic structure translates into flows[68] for road and rail as depicted in Figure 33. It highlights the current dominant position of South Africa's railway in transportation of mining commodities and that there are significant opportunities in other transport market spaces.

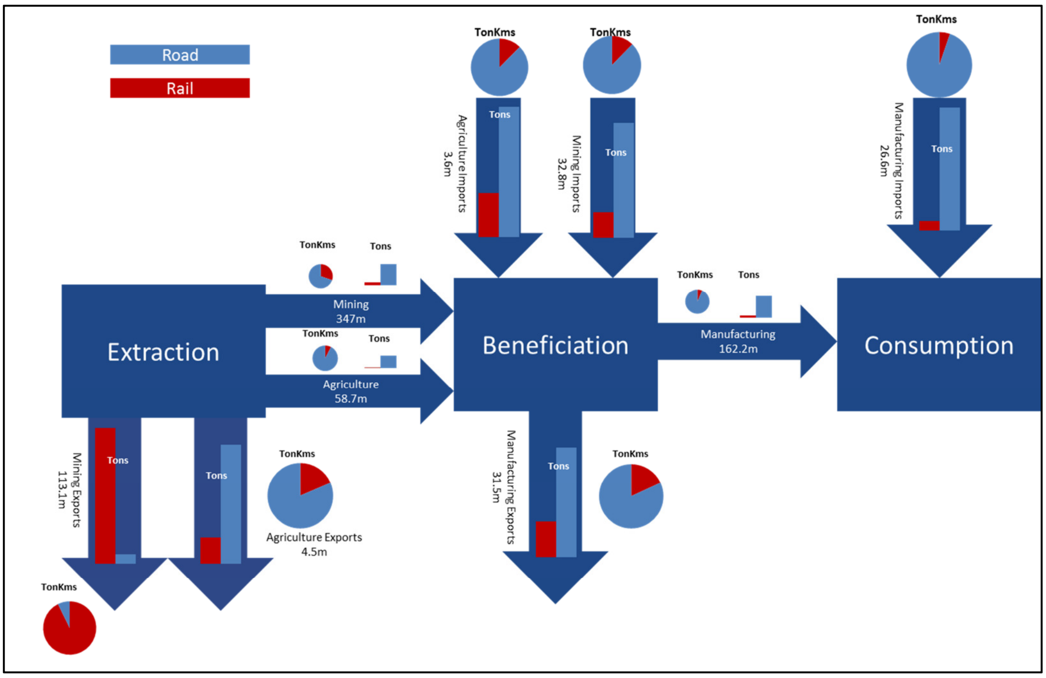

Figure 33: Economic structure and flows in South Africa

Freight segments

Freight flows are a result of the economic structure. Commodities are transported between nodes – from the place of extraction / manufacture to their place of utilisation or consumption. Within this economic structure, freight can be grouped into clearer clusters or segments as indicated in Figure 34 which reflects the key flows of goods in the South African economy.

[68] A flow is the net result of specialisation that requires exchanges between points of production and consumption (for example, in subsistence farming, which is not specialised, no exchanges are required and no flows are observed). The major driver of flows is gravity (supply and demand attraction is proportional to volume but inversely proportional to distance) but in advanced societies, multiplication of variety, brand and value increases freight flows.

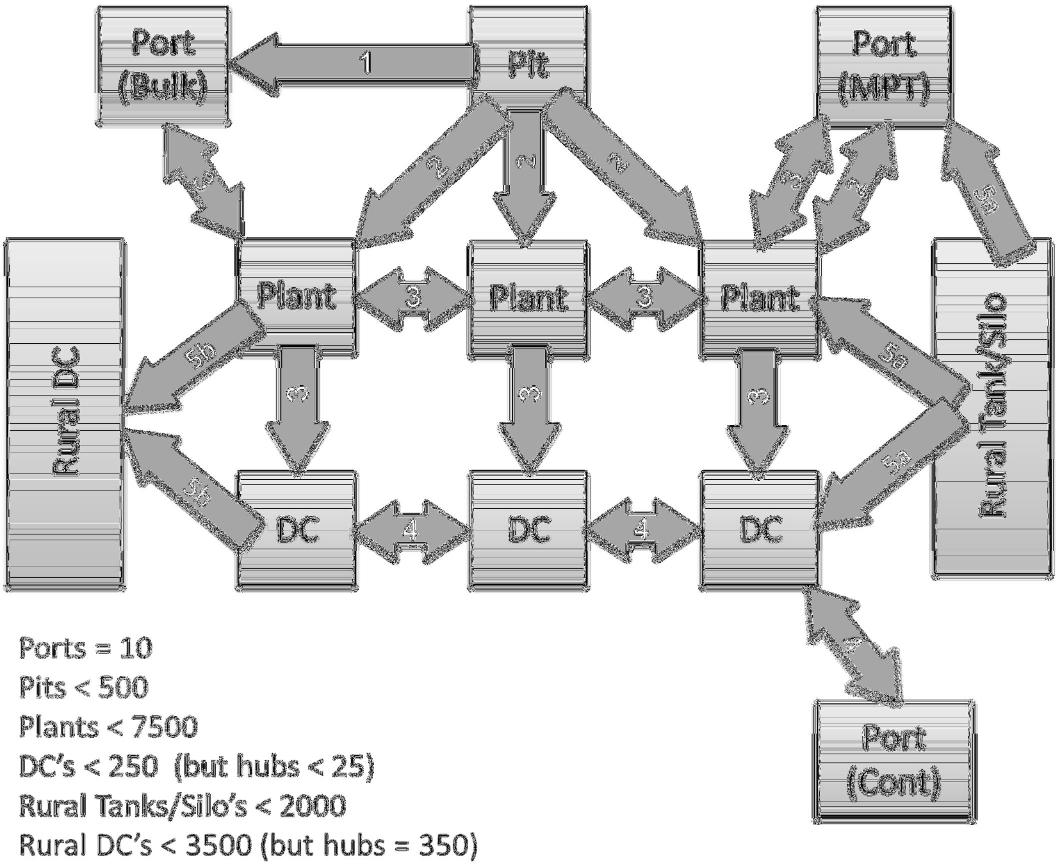

Figure 34: Segmenting freight flows derived from economic structure

Freight flows may be described in terms of the nature of the commodity, service requirement and the way the commodities flow:

Pit to Port

In the primary economy, commodities are extracted or mined and are shipped to ports for export. These bulk mining commodities are thus moved from a stockpile at a mine to a stockpile at a port. These are relatively simple flows from <500 mine / pit origins to one of the country's ten ports. This freight moves in a simple conveyer belt fashion and uses standard bulk wagons. These flows typically evidence a high line density over relatively long distances. These flows may be described as 2PL long distance heavy haul business requiring competence in stockpile management with direct interaction between the railway and the freight owner.

Pit to Plant

Commodities in this group are also primarily mineral mining products and are transported from a mine / pit to a manufacturing plant where they are beneficiated in some manner. This type of flow is typically from a stockpile at a mine to customers' sidings at a plant. Standardised bulk wagons are used on bulk unit trains for conveying raw material inputs to plants. Flows become more complex as the origin – destination pairs are from one of <500 "pits" to some of <7 500 plant destinations. Line density is usually high and freight flows over distances of between 400 and 900km. In cases where imported commodities are required in the manufacturing process, some freight may flow from a port to a plant.

These flows may be described as 2PL relatively long distance, heavy haul business requiring competence in aligning railway operations with customer manufacturing processes (supply chain management) and involve direct interaction between the railway and the freight owner.

Plant-to-plant/ DC

These freight flows comprise of heavy break bulk commodities moving from one plant to another in the country as input to the manufacturing process, or as semi-finished / finished products moving to distribution centres (DC). This mixed type of freight flows over many origin-destination pairs (between ±7 500 plants to the 250 DCs or one of <25 hubs) in the country and over long distances (>500km). Flows may also be concentrated in metropolitan areas where freight is conveyed over distances of less than 100km.

Freight transported by rail over long distances requires specialised wagon types, particularly for finished products that are not containerised / palletised. Trains are built according to supply chain requirements for manufactured outputs. These flows are dense. Railway operations in this 2PL / manufacturing sector require competence in integrating rail operations and train planning with the manufacturing supply chain process. The railway interacts directly with the freight owner.

Finished Palletised Goods: DC – DC

These flows are more complex in terms of logistics or supply chain management requirements – but less complex in that they only flow between a few DCs or hubs. Goods are typically completely finished goods and are often palletised. Dedicated wagon fleets of standardised container wagons are required and bulk trains (that are never broken up) are scheduled and capacity on such trains is reserved. A wide range of goods is included in this segment – from food and clothing to building materials. Being palletised, these products are standardised and benefit from multimodal transport solutions. Such goods flow from one DC to another and can be grouped into short distance flows in metropolitan areas (<100km) to long distance flows in excess of 600km. These are all dense flows. Core competence is required in the operation of precision, scheduled trains on which customers or LSPs can reserve capacity in advance. Speed is often a requirement (e.g. for perishable or other time sensitive consignments) and customers are likely to have need of information to track and trace delivery of consignments.

Rural

Flows to, from and within rural areas are possibly the most complex of all flows as they are seasonal and of low density – typically conveyed over branch lines. Three types of rural flows are evident:

- Rural Agricultural Extraction – products that are extracted and shipped to cities or production centres for beneficiation or consumption (e.g. sugar cane to sugar mills). Some products may also be shipped to ports for export (e.g. export fruit). These are usually low density flows over distances of <500km across many parts of the transport network
- Rural Agricultural Manufacturing Delivery – these flows are characterised by products that are required to be moved from cities / production centres to farms and rural areas and include foodstuffs, farm machinery and equipment. These flows are conveyed over distances of approximately 600km from many origins to many rural destinations. These are low density flows
- Rural interchanges – farm products that flow from one farming area to another and never reach a city or production centre. These flows can be characterised as low density, seasonal flows mostly on branch lines.

Subsequent analysis does not consider unique ring fenced flows (segment 0), which are non-rail flows (in pipelines, quarries and on conveyer belts). The remaining five freight flow segments are analysed in detail.

Total freight flows resulting from the freight-flow model are depicted in Figure 35, as well as rail's share of these flows (the dense rail lines reflect tonnages over the heavy haul export lines).

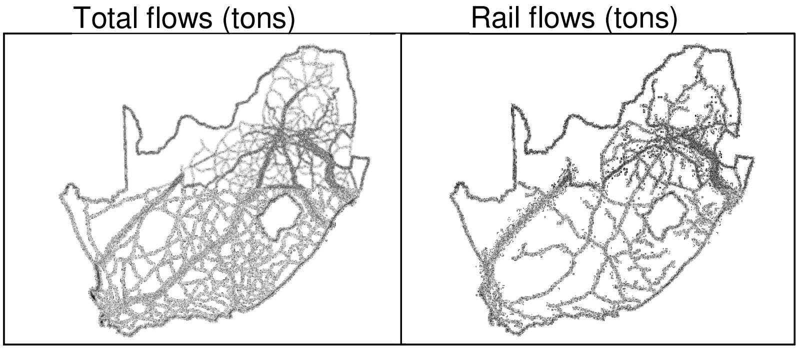

Figure 35: Total surface freight transport flows compared to rail flows

Considering that the price elasticity of freight transport decreases with an increase in freight value, flows can also be depicted as the flow of **value** in South Africa, as illustrated in Figure 36. The dense lines reflect the intense flow of value of goods transported between key ports and the economic hub. Note that coal and iron ore flows are *included* in this picture which depicts all flow volumes multiplied by the values of the commodities that flow over each segment of the total South African transport network.

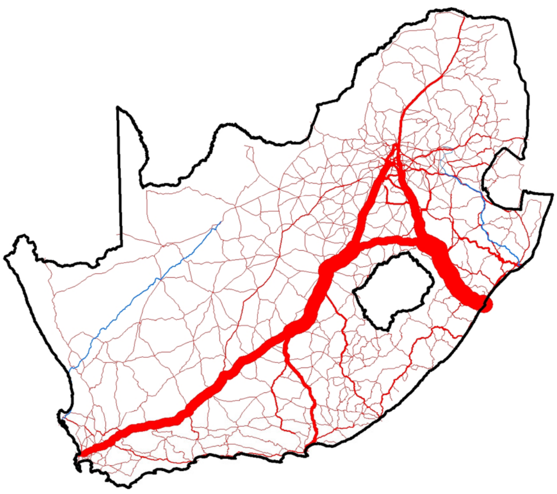

Figure 36: All freight flows in terms of value

This serves to highlight the importance – and opportunities – of flows not necessarily being served by rail.

Analysis of the total freight flows in the country within the five overarching segments described previously led to the identification of 15 sub-segments as illustrated in Figure 37. These characteristics are described in Annexure A. Rail market share is also indicated[69], highlighting the dominant position (and core competence) of the national railroad in the transportation of mining commodities, as well as significant opportunities in other long-distance transportation market spaces.

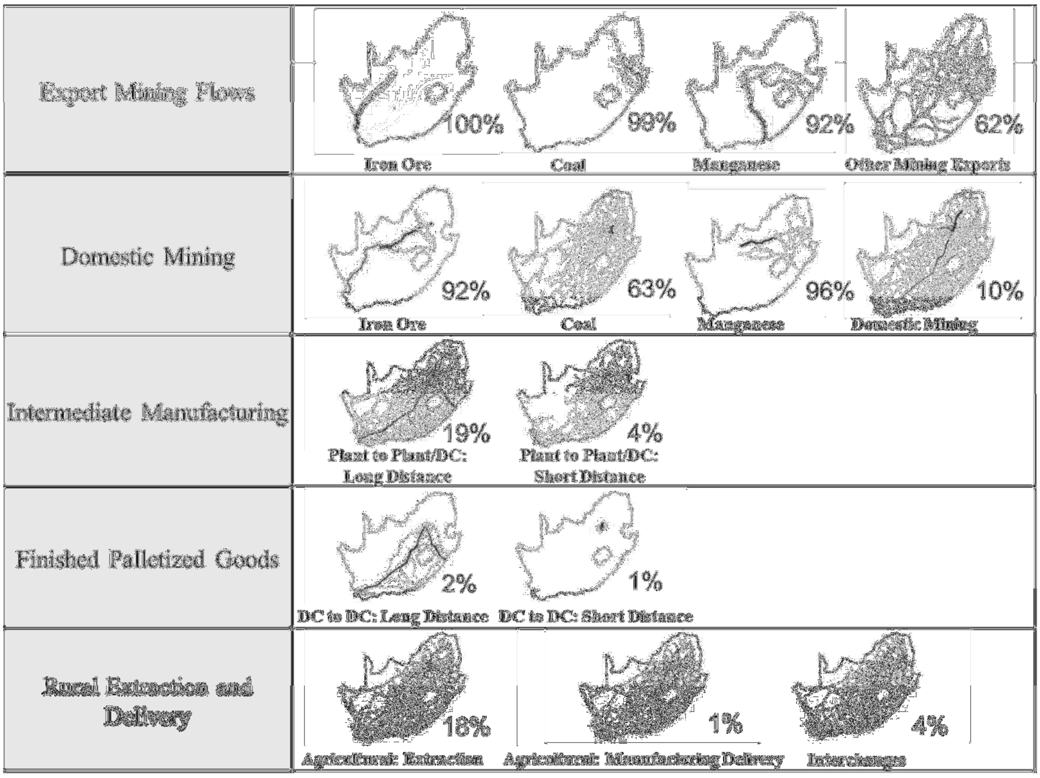

Figure 37: Freight flows per sub-segment in tonnage terms; rail share in percentage (2009) [70]

The rail economics principles discussed previously indicate that freight flows with high density over longer distances are well suited to transportation by rail. The next section therefore focuses on a density analysis of these segments.

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[69] Unique ring-fenced flows which are not suitable for road or rail (that is commodities in pipelines, quarries and on conveyer belts) were identified and have been excluded from further analysis.

[70] For each of these flows needs around terminals, distance and density were developed in order to inform genetic rail technologies. Volumes and costs are used to identify capacity shortfalls and effectiveness. The required logistics complexity is identified as well and future needs. Bear in mind that the data are for all flows using all modes of transport.

Freight flow market space

In order to identify "rail-friendly" flows, transport distance, density and cost are considered (Figure 38).

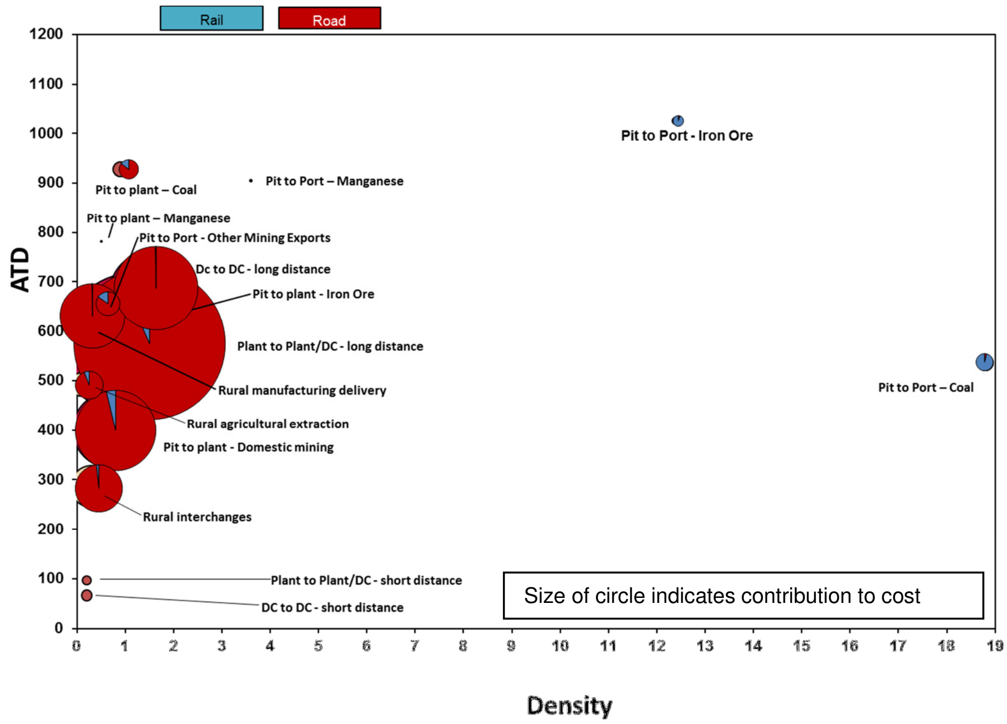

Figure 38: Freight-flow market spaces based on distance, density and cost (2008)

At the highest level, only three freight flows – export coal, iron ore and manganese – could *theoretically* be seen as standalone rail businesses with unique operating models, but in real rail economic terms this is not the case:

- The Manganese flow is too small to be economically viable as a stand-alone business and it is also linked to the core network where it makes a sizeable contribution to density,
- Although the coal flow on the coal line is not on a major core corridor it has (by its nature) attracted sizeable general freight business. In a stand-alone environment access for these other commodities will be threatened (and therefore rural access limited) if the coal line is seen as a mere "conveyor belt" extension of the mines,
- The iron ore flow is possibly the closest candidate for a standalone business, but in the context of future rural access and the rerouting of other commodities to the line, a single "experiment" of this nature should be carefully considered.

All other flows will have to share network infrastructure and systems to be viable. When export coal, iron ore and manganese are excluded from this description, a different picture emerges (Figure 39).

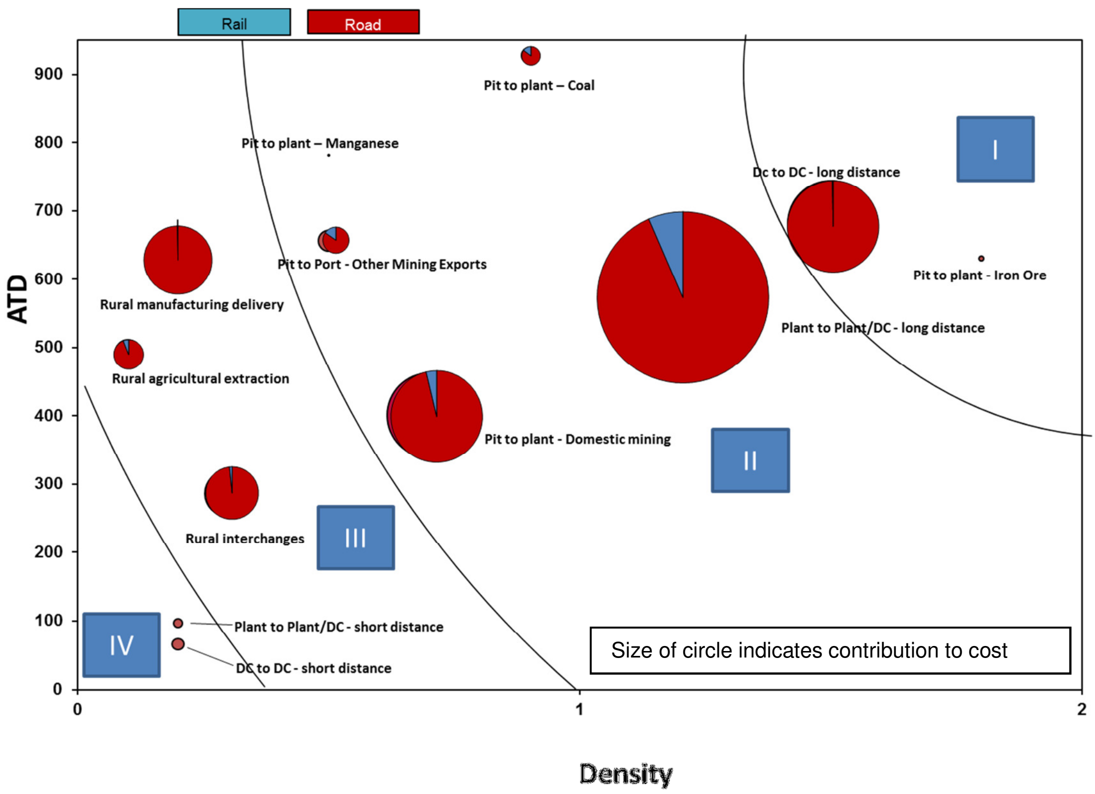

Figure 39: Freight-flow market spaces based on distance, density and cost (2008) (excluding export iron ore, coal and manganese)

Four distinct freight flow segments emerge:

I. <u>Higher Return – Easier to Execute.</u> This is typically logistics hub to logistics hub business ideally suited for intermodal traffic. The flows are high value, can attract above average tariffs and do not diverge at the nodes / end points. It is naturally bi-directional, lucrative business. Most First World countries with medium to highly densified transport distances have developed intermodal (or multimodal) solutions. South Africa has not exploited this market. In terms of genetic technologies, this segment requires high speed, light axle load technology – ideal for bimodal road/rail (piggyback trailer or trailer-in-train) and single stack container trains. Double stacking of containers could require higher axle loads.

II. <u>Higher Density – Long distance.</u> This segment represents the core siding to siding business ideally suited to rail. This is high volume, high density over long distances and requires many sidings with traffic divergence at the end points / nodes. In terms of genetic technologies, this segment requires low to medium speed and light axle load technology.

III. Low Density. Much of this traffic is in rural areas and is characterised as being low density even though distances are between 250 and 600km. A portion of these flows share the (core) network with more viable freight flows. In terms of genetic technologies, this segment requires low to medium speed and light axle load technology.

IV. Short Distances. This comprises short distance flows from plant-to-plant/ DC. This is typically not a flow that rail would target due to low density, tonkilometre and short distance – although the volumes are relatively large.

The attributes of each of these segments are summarized in Table 3 which also indicates the suitability of these segments for transportation by rail.

Table 9: Freight segment attributes

		Tonkm (billion)	Cost (R bn)	Rail Market-share	Suitability for Rail
I	DC-to-DC – Long Distance	18	19.1	3%	▪ Long distances, high line density ▪ High terminal density, ▪ Uniform / standardised product ▪ Highly viable for rail
	Pit to Plant – Iron Ore	7.5	0.3	100%	
II	Pit to Plant – Coal	6.9	1.5	52%	▪ Long distances, reasonable density – especially if shared network. ▪ Low terminal density challenges remain, ▪ Non-uniform / standardised product ▪ Viable if core is defined correctly and monetised as an integrated network
	Pit to Plant – Manganese	1.2	0.2	97%	
	Pit to Port – Other Mining Exports	8.4	3.7	53%	
	Pit to Plant – Domestic Mining	27.6	14.4	12%	
	Plant to Plant/DC – Long Distance	61.1	32.3	17%	
III	Rural Manufacturing Delivery	11.3	13.1	1%	▪ Long distances, but density is too low – ▪ Viable with different operating model where capacity is already installed
	Rural Agricultural Extraction	7.3	5.7	18%	
	Rural Interchanges	14.3	13.1	5%	
IV	Plant to Plant/DC – Short Distance	3.1	1.9	6%	▪ Distances too short, ▪ Density too low density ▪ Not viable for rail
	DC-to-DC – Short Distance	0.5	1.1	3%	

These freight segment attributes can also be presented reflecting the relationship between tonkm and cost (Figure 40). In such segments as DC-to-DC long distance, costs (for the country) are arguably higher than they ought to be and they could be reduced if additional tonnages / tonkm of such freight were to move by rail. There are thus opportunities, to the country, of modal shift in certain sectors.

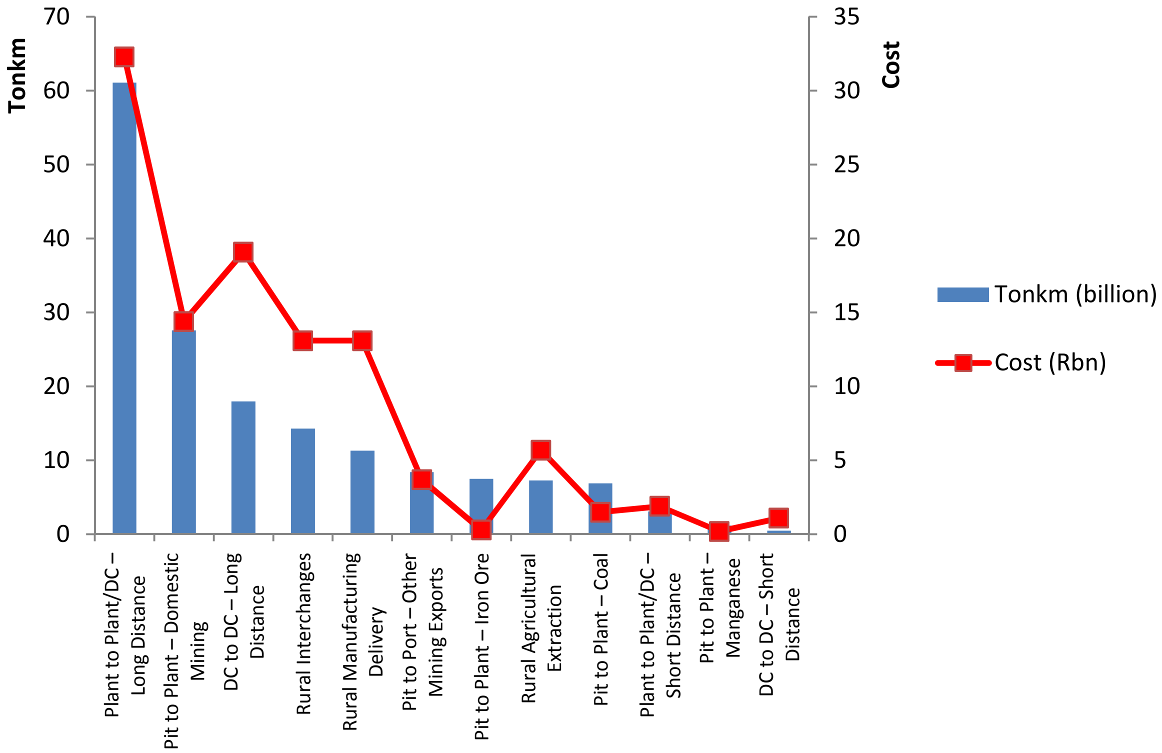

Figure 40: Relationship between tonkm and cost per sub-segment (2009)

Freight market segmentation analysis also enables calculation of the density of freight flows in South Africa. Figure 41 below plots the freight market segments on the Harris Curve according to density and approximate cost of the operation. This highlights the relative positive position of Pit to Port traffic (such as coal, iron ore and manganese) in terms of ability to be self-funding against the relatively poorer position of rural traffic flows due to higher costs and lower density.

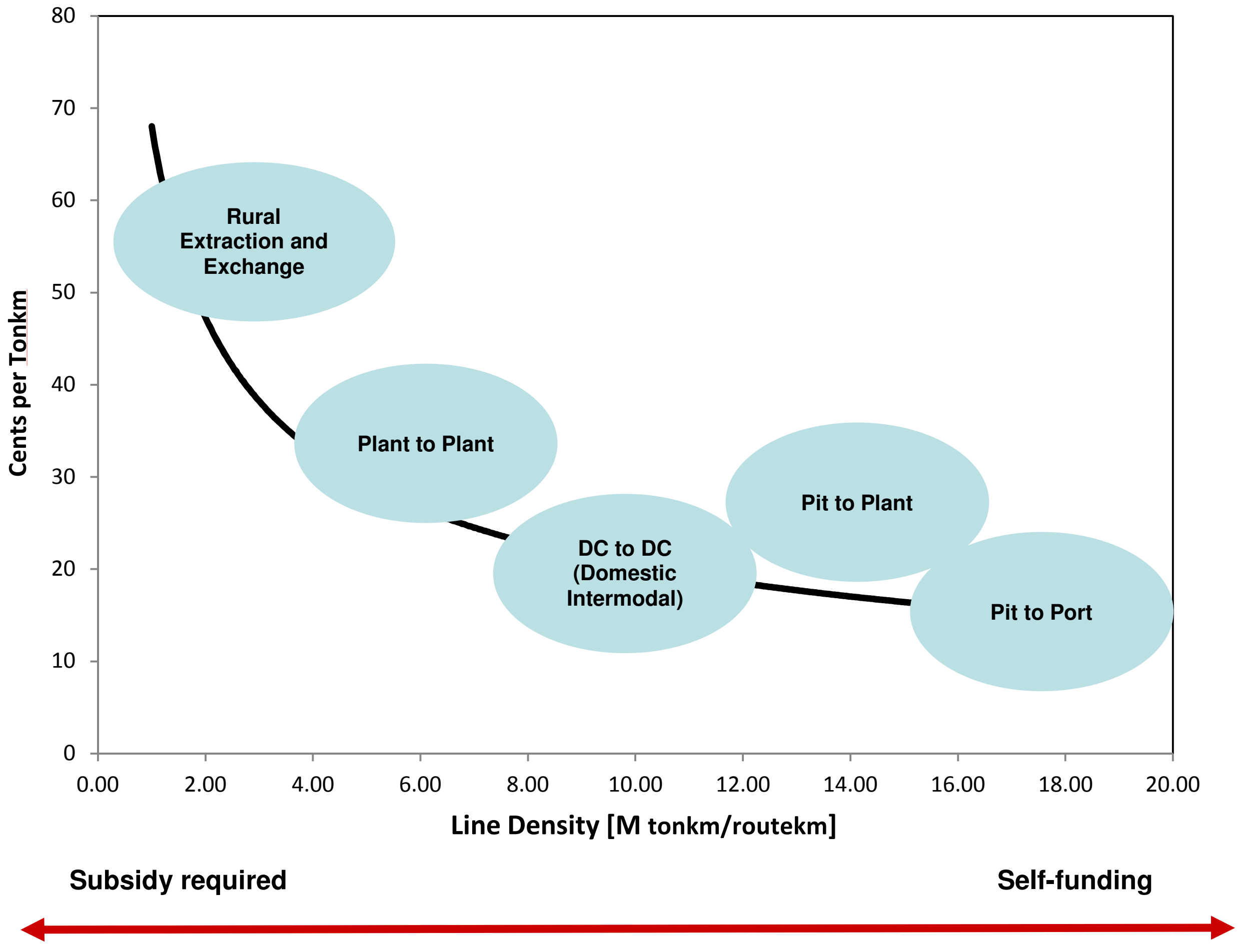

Figure 41: Harris Curve and Freight Market Segmentation

Potential plant-to-plant and DC-to-DC traffic share the same network although the former diverges in metropolitan areas. Rural traffic shares this network partially and most of it either originates or terminates in metropolitan plants / DC's.

Four distinct operating models for a potential railroad emerge:

1. **A pit/plant-to-plant 2PL business** with industry market segments such as steel, cement, fuel and chemicals. Traffic will attract medium tariffs. Efficiency and capacity will lower the nation's freight bill. Most sidings still exist (although sometimes abandoned and underutilised). Each industry requires different equipment (wagons and loading / offloading equipment) that is suitable for its unique commodities and will multiply the wagon fleet of such a railway. The 2PL business with its pertinent statistics is depicted in Figure 42 and reflects data for total current tonnage, tonkm, cost, ATD and rail market share.

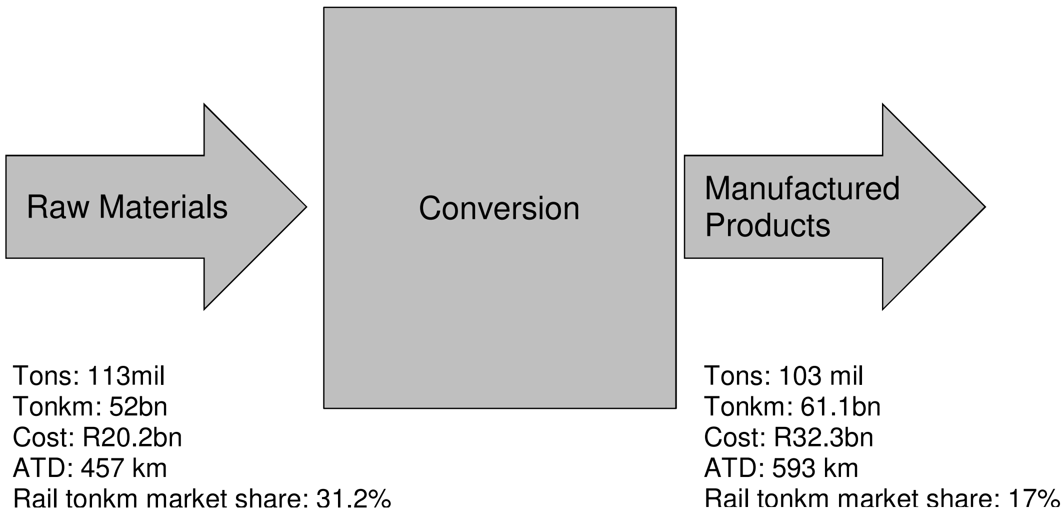

Figure 42: Pit/plant-to-plant potential rail business for South Africa (2008 data)

2. **A logistics hub to logistics hub business**. There is no divergence of freight and the wagon fleet is standardised. As this business is currently almost non-existent on rail, the current road-only option is the most costly of all freight segments and large savings per tonkilometre are possible with workable intermodal / multimodal solutions. This business will have to be designed and developed from virtually nothing as only the core lines exist but *no multimodal logistics hubs* and *no workable road-railer rolling stock* is in use. Although the relative savings on the nation's freight bill will be the highest if rail conveys this traffic, it will require major initial investments to make it work. The DC-to-DC business is depicted in Figure 43, which depicts all flows that could be described as DC-to-DC flows. More or less all of these flows could be targeted for modal shift.

Figure 43: DC-to-DC potential rail business (2008 data)

3. **Branch line businesses that are ring-fenced** (in order to attract subsidies for regional / social development due to low densities on the short lines) but with an access model (potentially mandated access) to the core. Concessioned lines are possibly an optimal model for these services (in Northern America branch lines have been sold off to SME (small and medium enterprises) operators and some still operate successfully under an entirely different business model and with a lower operational cost structure).
4. **Pit to Port export business**. This would include the heavy haul export lines which are already largely dedicated or ring fenced businesses. This would also include other mining export commodities that share the core network (for example manganese, chrome, magnetite, etc.). There is no divergence of freight and the wagon fleet is largely standardised and suited to offloading equipment at ports. This business would attract medium to high tariffs. This type of business may be described as being rail's current core competency although there is room for efficiency improvements as well as long term capital requirements to expand existing capacity.

This freight flow segmentation can now be used to postulate an "ideal" network or railway, that will be the desired object for rail reform and economic regulation, rather than considering the as-is state of the current railway.

10. Flow segmentation: postulating the "ideal" railway

The degree to which the various segments ***share the same infrastructure*** is a next deliberation when market segmentation is considered. If many segments share the same line it would not be possible to consider stand-alone vertically integrated rail businesses. This would be possible in a vertically separated environment with one dominant operator, or alternatively multiple operators.

In order to determine the degree of sharing that exists, the drivers of rail economics – line density, terminal density and freight uniformity – were applied to the original data with the aim of deriving an ideal rail network for South Africa. If one were to design an ideal railway, one would strive for a network where many uniform, long-distance flows share the same infrastructure.

A means of determining which flows of freight could share equipment and network is to segment the freight flows into freight market segments.

The following rules were applied:

1. **Line density**: Flows sharing a network contributes to raising the density of lines (and lower the cost) through increasing the tonkm per route km. 100 000 tons equates to two, 1 000 tons trains per week, given a turnaround time of 3 days, this would constitute an efficient railway service for a specific cargo type and could be described as a critical density cut off point. Only separate flows (unique per cargo type and per terminal pair) above 100 000 tons were therefore considered. This resulted in 789 unique dense flows.
2. **Terminal density**: If these flows were conveyed to fewer collection or distribution points or terminals that are in close proximity, then terminal density would also be optimised. Magisterial districts within close proximity were clustered into potential terminals or collection-distribution points. This clustering resulted in the identification of 21 areas for South Africa as possible terminal sites.
3. **Uniformity / standardisation**: It is unlikely that an optimal number of terminals / collection-distribution points could be found unless similar types of freight could share these collection-distribution points and thus share similar (standardised and somewhat uniform) loading and offloading equipment (and rolling stock). The freight market segments established through the research process enabled grouping of freight into nine cargo types (Annexure B) that require the same handling technologies and transport equipment.
4. **Network sharing**: Finally, line segments were identified where flows of more than five segments (of the 20 segments identified in the flow segmentation exercise) overlap – this describes the postulated core network. If the level of overlap is low the resulting flow could not be described as "core", but rather as a ringfencable flow.

The postulated core freight transport network (based on actual surface freight flows), identified through the combined application of the rules described above, is depicted in Figure 44. (The coal and iron ore lines were not specifically excluded, but the criteria in point 4 above – sharing of lines by more than five segments – were mostly not met (although ± 6-8mtpa of general freight is conveyed on the export coal line and ± 0.3mtpa of general freight on the export iron ore line)).

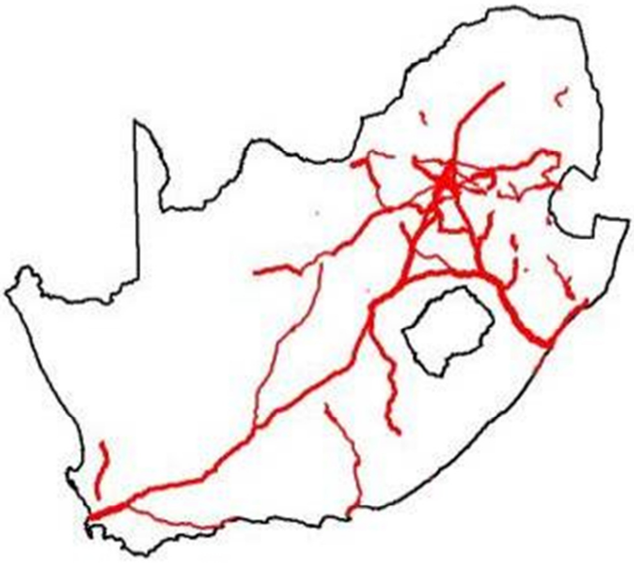

Figure 44: Postulated core freight transport network (based on current freight flows)

This postulated core freight transport network should form the backbone of an integrated South African rail solution. If the coal and iron ore export lines are included in this network, it can be depicted as in Figure 45, showing the rail export lines in blue. The export lines are currently the highest density lines in South Africa.

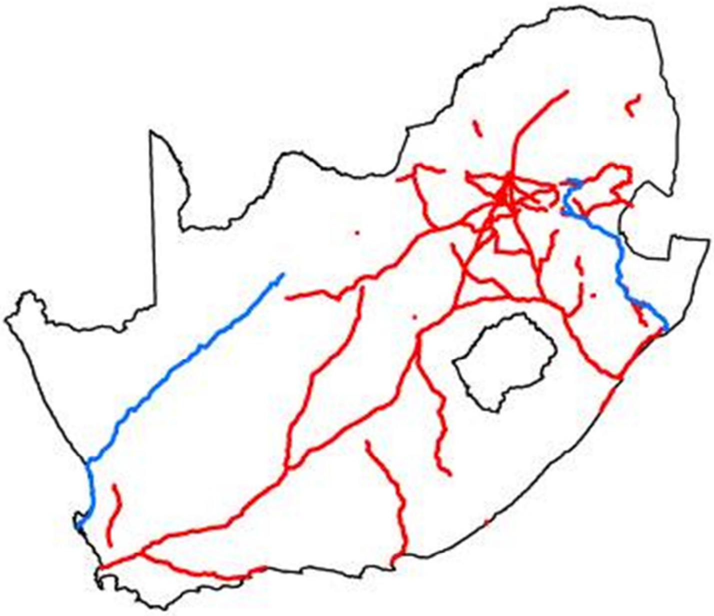

Figure 45: Postulated core network (based on total current freight flows) with export coal and iron ore included

Table 10 provides the pertinent statistics of the postulated core freight transport (excluding coal and iron ore).

Table 10: Pertinent statistics - Postulated core freight transport network (excl. coal and iron ore)

Network length	7 670 km (current = ±20000km)
Total tonkilometre of all freight	90.4 billion tonkm
Density	11.8 million tonkm per routekm
Current cost of road transport portion	R36.2 billion
Current cost of rail transport portion	R3.6 billion

It is clear that rail has a negligible share of the traffic that takes advantage of rail's economic principles. The discussion of what freight specifically should be on rail is by definition complex. Corridor freight (which relates mostly to freight over the postulated core network) was identified and on a specific origin/destination base workshopped with specialists from the railway. It was established that the postulated core freight (90.4 billion tonkm) was a perfect sub-segment of freight identified by these specialists as targetable rail freight. The sum of all the freight thus identified ranged from between 42% and 50% for Capecor (between Western Cape and Gauteng) and Natcor (between Natal and Gauteng). (Current rail technology was considered and it could therefore be hypothesised that the shift potential is even higher). The potential density of the postulated core freight transport network is therefore based on the assumption that 50% of long distance road traffic will switch to rail (Table 11).

Table 11: Density potential of the postulated core freight transport network (excl. coal and iron ore)

	Million tonkm per routekm
Total current TFR density	4.9
Total current GFB density	1.8
Density of total flows on postulated core network	11.8
Current density of rail flows on the postulated core network	2.1
Potential density for rail if 50% of current long distance road switches to rail	6.7

The trends in the United States' modal corridor performance compared to South Africa's (both countries have long, dense corridors), further highlight the opportunity for rail corridor growth in South Africa (Figure 46).

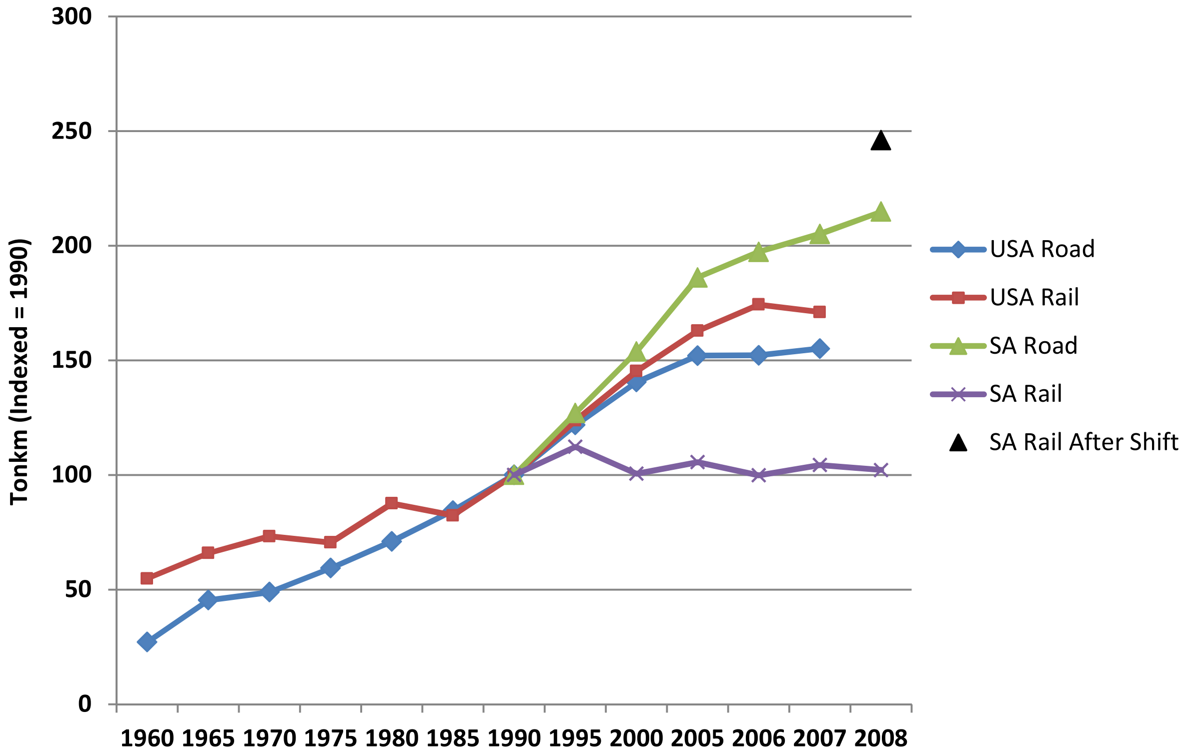

Figure 46: Corridor freight in the USA vs. SA

The potential rail density, if 50% of the current long distance road traffic switches to rail, can be applied to the Harris curve to develop a first view of possible cost savings. The improved density on rail reduces costs from 30 cents/tonkm to less than 15 cents/tonkm for general freight) (Figure 47).

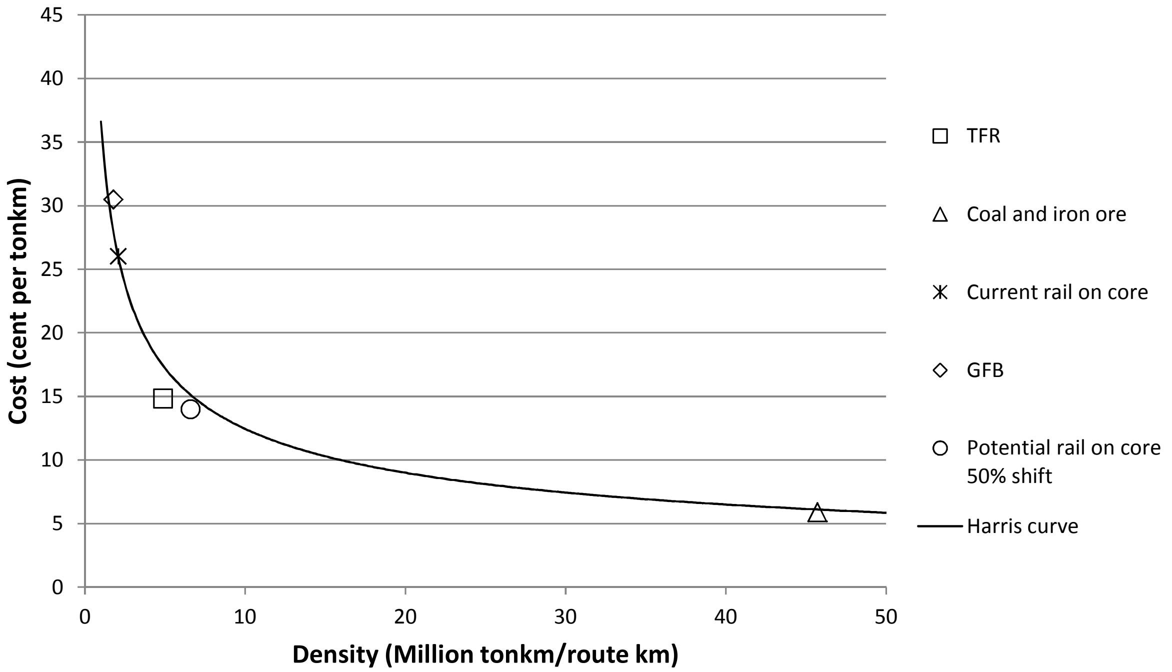

Figure 47: Potential rail cost savings resulting from implementing postulated core and modal shift

This “new” railway would require both a change in business model (redefinition of customer value propositions in line with market choices, revised investment strategies, clarification of revenue streams and operations strategies to address business needs) and in institutional arrangements. Institutional arrangements are likely to cover both financial structures for funding infrastructure and operations as well as the structuring of operations relative to infrastructure with some form of vertical separation or integration, access agreements and regulation.

A conservative high level calculation shows that the “new” rail business (excluding coal and iron ore) will shed R3 billion of revenue (this refers to the current branch line business and is revenue that could potentially still be attracted by concessioned branch lines). This is revenue attributable to freight that currently uses low density lines with low density potential. The additional traffic which is currently on road corridors, that could however be shifted to rail, will lead to densification of the core. The freight bill for road transport for this traffic is currently R18.1 billion. If rail’s current cost structure is applied to the total traffic on the core after the additional traffic has been added, rail cost should only increase by R3.6 billion (this is possible because 21.2 ton kilometres is added to a network that decreased from 20 189 kilometres to 9 170[71] kilometres – an application of the Harris curve). This constitutes a R14.5 billion saving on the nation's freight bill (The difference between the current road cost and the new total rail cost).

Development of an ideal network for logistics hub to logistics hub business

Once the principles of a core network have been applied (overlapping flows of at least five freight segments that meet the requirements of line density, terminal density, uniformity and standardisation), an ideal network of minimum length segments and major collection and delivery points for the country could be developed by adding collection-delivery points to meet the requirements of providing the logistics hub business. This ideal network consists of what the country *requires* (in terms of future capacity, density, location of terminals, etc.), and *not what is available*. Furthermore, the concept of this ideal network is different from merely "chopping" off the branch lines from the current network.

Figure 48 indicates the probable location of major collection and delivery points (terminals) based on population concentration and traffic flow.

[71] The postulated core network of 7 670 km describes a virtual idealised design, and cannot be achieved by rationalising the current network. To do the same work the current network can only be rationalised to 9 170 km.

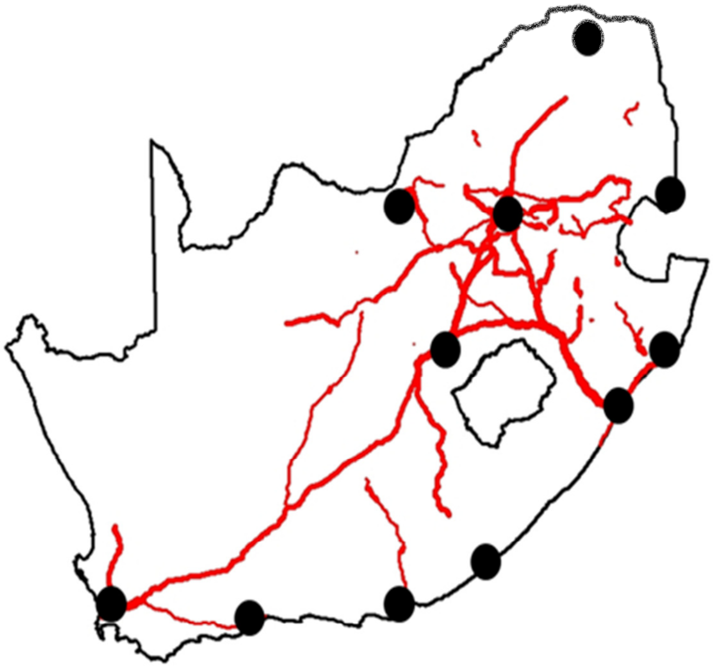

Figure 48: Postulated core freight transport network with major terminals

Once the terminals are added, magisterial districts within feasible collection or distribution ranges were identified (Figure 49).

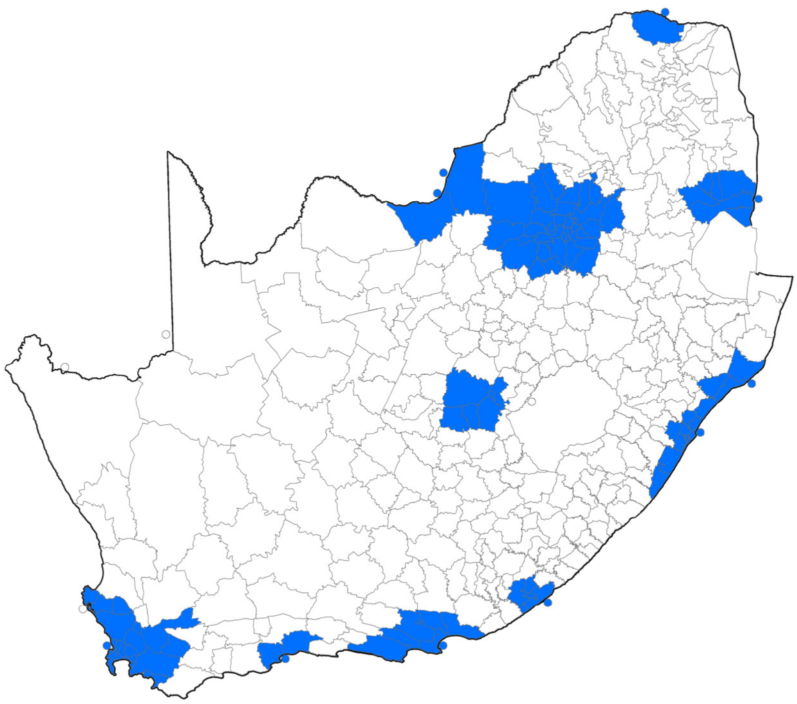

Figure 49: Magisterial districts where terminals should be located

The establishment of links between these terminals results in an ideal network of 5 700 kilometres (Figure 50).

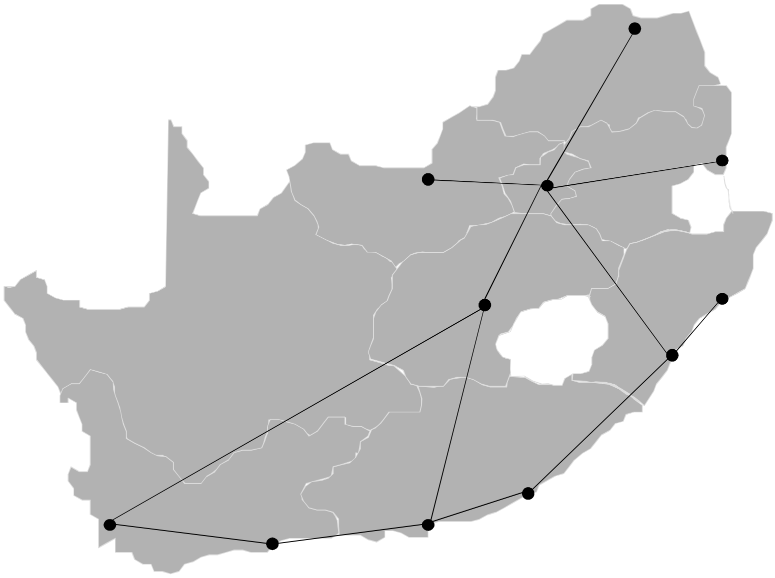

Figure 50: Ideal network for South Africa

This network would be required to target the logistics hub to logistics hub business described above which is currently almost in its entirety not served by rail. This network design exploits the rail economic potential of dense flows of uniform product (mostly palletised) over a minimal network distance originating and terminating in dense terminals.

It should be noted that the ideal network described in Figure 50 is the network that would be required in order to facilitate modal shift. The network that is described in Figure 44 and Figure 45 is the current core network of all modes given the principles applied. Once the ideal network is fitted to the current network of all flows the result is expected to be slightly different as critical lines and terminals are connected.

The most predominant commodities for the base and future years on this network are summarized in Table 7.

Table 12: Predominant commodities on the ideal network

2008				2039			
Commodity	**Tons (millions)**	**Tonkm (billions)**	**ATD**	**Commodity**	**Tons (millions)**	**Tonkm (billions)**	**ATD**
Food	10.2	10.3	1 008	Food	20.5	20.8	1 013
Beverages	5.4	5.6	1 047	Beverages	10.9	11.5	1 054
Other chemicals	3.6	3.6	994	Other chemicals	10.2	10.2	999
Iron & steel products	3.5	2.7	781	Industrial chemicals	7.4	5.7	766
Wood products	1.9	1.7	908	Wood products	6.1	5.6	911

This virtual network covers 5 700km, and consists of 43 million tons and 40 billion tonkms for 2008, and increases to 120 million tons and 110 billion tonkms for 2039. Freight volumes per direction and line segment, are shown in Figure 51 and Figure 52.

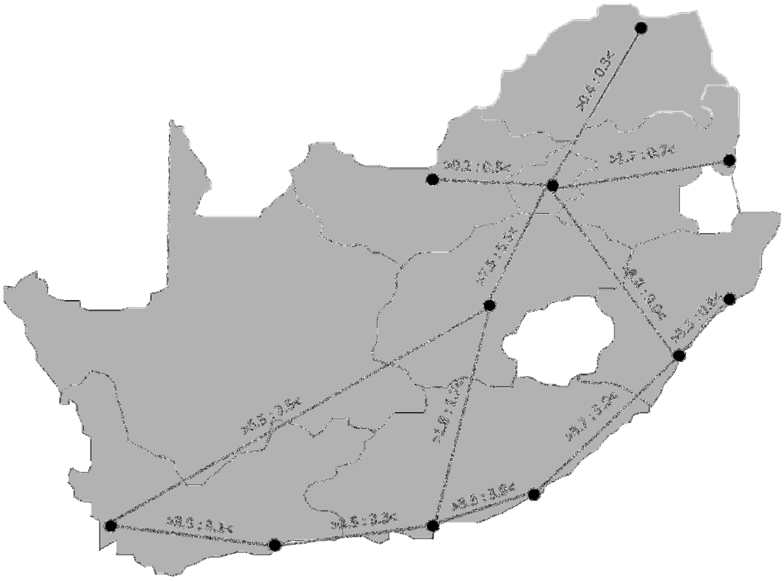

Figure 51: Ideal network million tons by direction – 2008

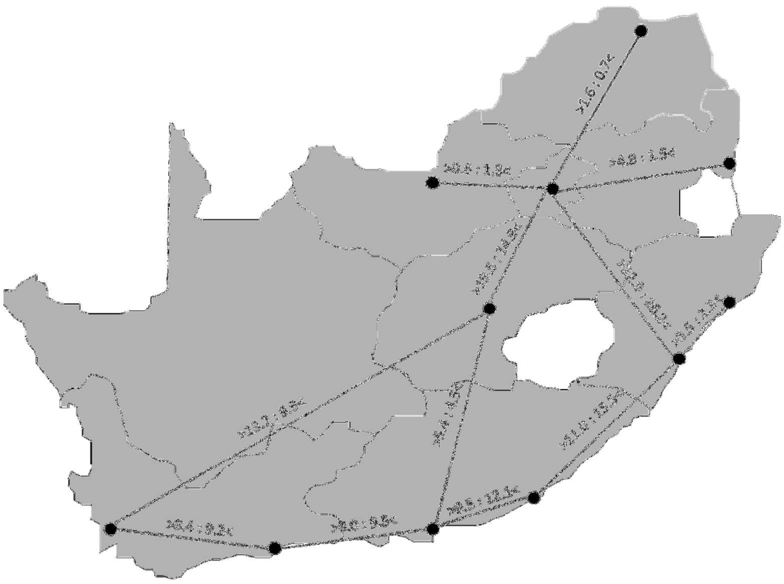

Figure 52: Ideal network million tons by direction – 2039

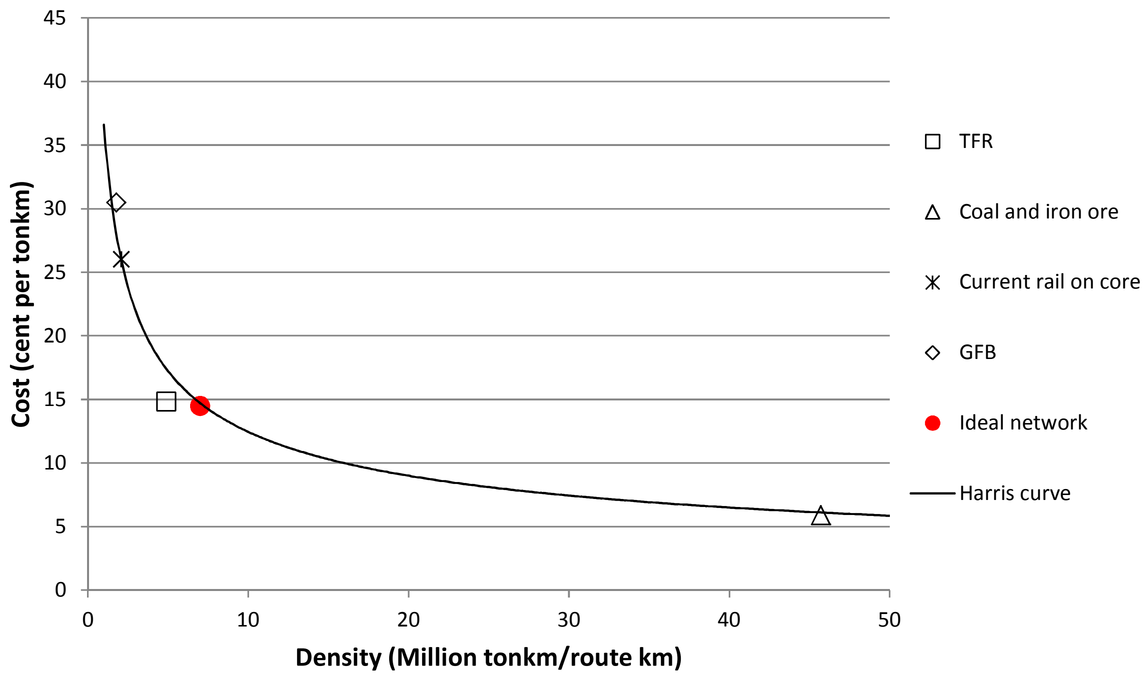

Figure 53: Potential rail cost savings resulting from an ideal network

This ideal network plays an important role in thinking about the future positioning of South Africa's railway, but it does not discount the fact that much of the "work" that is required from it could be executed by the current railway, given correct investment levels (especially in the short to medium term – over a fifty year planning horizon it will probably be inadequate). The current National Infrastructure Plan (NIP) begins to address this issue, and should be considered, but additional investment to reached installed capacity would probably be required. The ideal network has a clear hub and spoke character and it does fit the current railway, where some terminal development is installed and planned with NIP funds. With external funds for terminals and rolling stock some interim goals could be reached, but how optimum this would be for the long term should be investigated.

A high level model for the development of an ideal network has been developed. A high and low scenario for different rail rates were considered for this ideal network, based on the current average road transportation rates, for the same commodities, also over long distance corridors. The current average road line haul transportation rate for corridor traffic is 47.1c per ton kilometre. This rate excluded externality costs at an average rate of 15.6c per ton kilometre. Thus the average line haul transportation rate including externality costs is 62.7c per ton kilometre. In order to estimate a chargeable rail rate, rates of 10% below the average road transport line haul rate (both excluding and including externality costs) were considered, being rates of 42.4c and 56.4c respectively. Two variable rail network types were considered, the conventional ballasted rail line compared to the tubular modular track, referred to as the high and low infrastructure cost scenario respectively. These costs were considered for building the entire 5 700km ideal network, as well as considering the option of just the 600km Natcor line, or both the Natcor and Capecor lines, totalling 2 200km. The outcomes for these scenarios are shown in Table 13.

Table 13: Scenarios: Investment and return for the ideal network

		Total Network		**Natcor**		**Natcor + Capecor**	
Rail rate	**Scenarios**	**High**	**Low**	**High**	**Low**	**High**	**Low**
	Investment required (R billion)	R697bn	R635bn	R75bn	R68bn	R245bn	R223bn
56.4c	High scenario internal rate of return 20year	6.2%	7.6%	8.8%	10.2%	8.5%	10.0%
42.4c	Low scenario internal rate of return 20year	3.1%	4.5%	5.5%	6.8%	5.2%	6.6%
56.4c	High scenario 5% break even in years	18 years	16 years	15 years	13 years	15 years	13 years
42.4c	Low scenario 5% break even in years	24 years	21 years	19 years	17 years	20 years	18 years

This resultant network of 5 700 kilometres will require 496 locomotives and 93 train sets of 200 wagons each.

Figure 54 below indicates the lifespan of major transport assets with rail networks expected to last for up to 150 years. Given this, the funding (depreciation and writing off of the capital for the development) of a new railway becomes a huge challenge as financial markets will not accept this period as a viable financial construct. Shorter periods are required by financial markets (rather than the 50 to 150 years over which a railway should be written off).

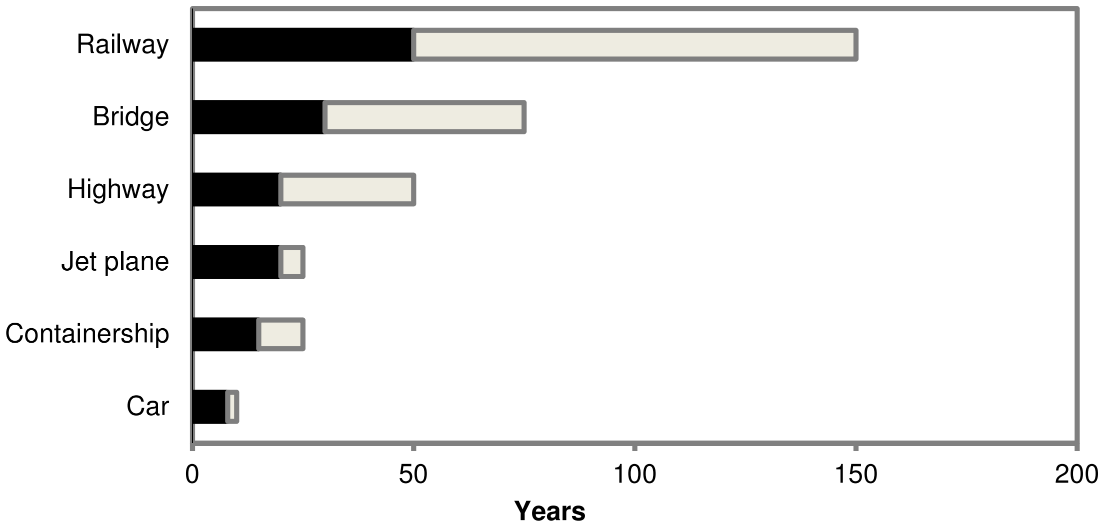

Figure 54: Lifespan of Transport Assets[72]

Part of this challenge is the high fixed cost component of railways (Figure 55)

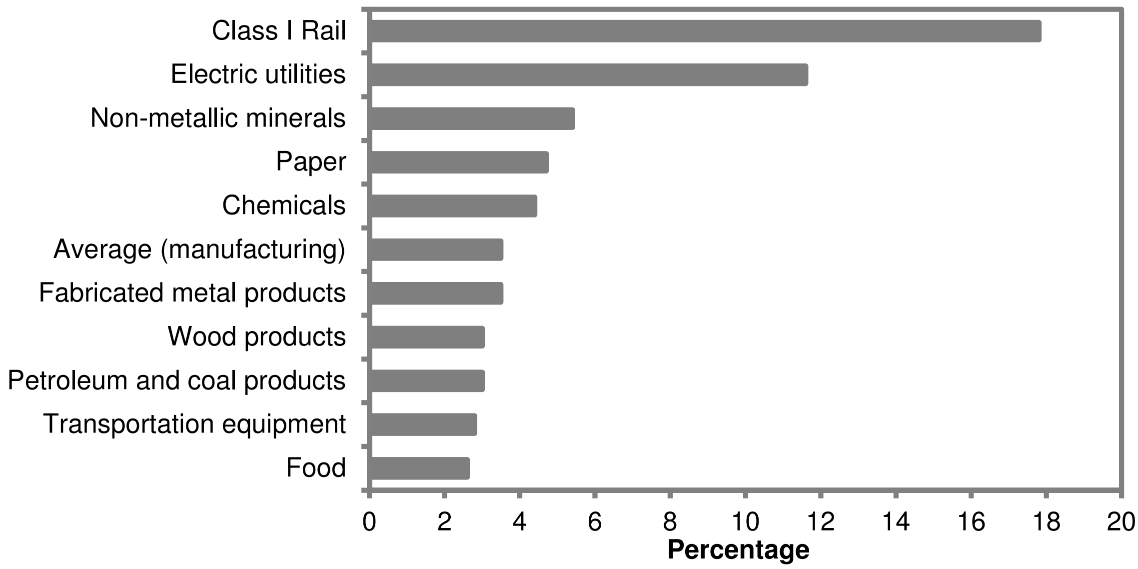

Figure 55: Capital expenditure as a percentage of revenue[73]

Over long periods of time large capital investments become viable if the density potential of volume growth is exploited.

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[72] WWF, 2006

[73] Rodrigue *et al.*, 2009

Alternative to not developing a new network

Figure 56 depicts current and future volumes of all flows in the Pit / Plant-to-plant(2PL) business and DC-to-DC (3PL/4PL) business – which form the base of the ideal core network that was identified. The current capacity of the network and theoretical capacity that can be ramped up is also depicted.

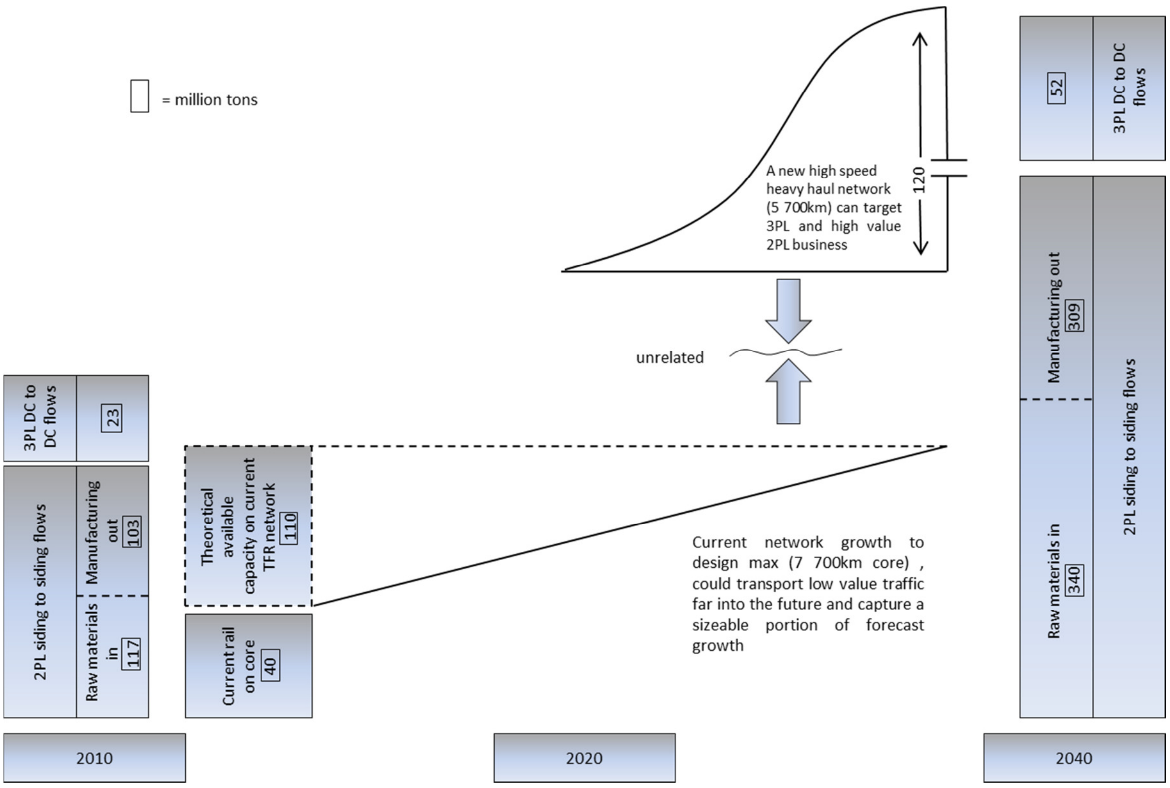

Figure 56: The future role of rail

A simple reality emerges from this picture. There is a large enough capacity gap in 30 years' time to warrant the co-existence of two networks. Furthermore, the service requirements of the two networks are so different that transfer points between the networks are not required.

Beyond 2020, the current rail network will not be able to cope with forecast growth even if it is developed to its full theoretical capacity. It is widely accepted that this growth in traffic should not be transported by road. In fact, many industry players indicate that a large volume of current road traffic should already be on rail.

There are some analysts[74] who suggest that dedicated road corridors are an option, but the arguments presented are mostly flawed. These arguments are often presented based on Transnet Freight Rail's current performance and not on the rail efficiencies that could be achieved if rail economics are exploited, service levels are improved and operators are allowed to run the railroad on pure efficiency principles.

There is also another consideration that is mooted to improve the current network to its ultimate design limit and continue to move additional freight to road. Apart from the risks in terms of fuel, the environment and high costs in general that have already been explained, the issue of land use will also require attention. A new rail network will require a huge effort to disappropriate land, but the disappropriation required to move large volumes of freight to road could be much more dire (Figure 57).

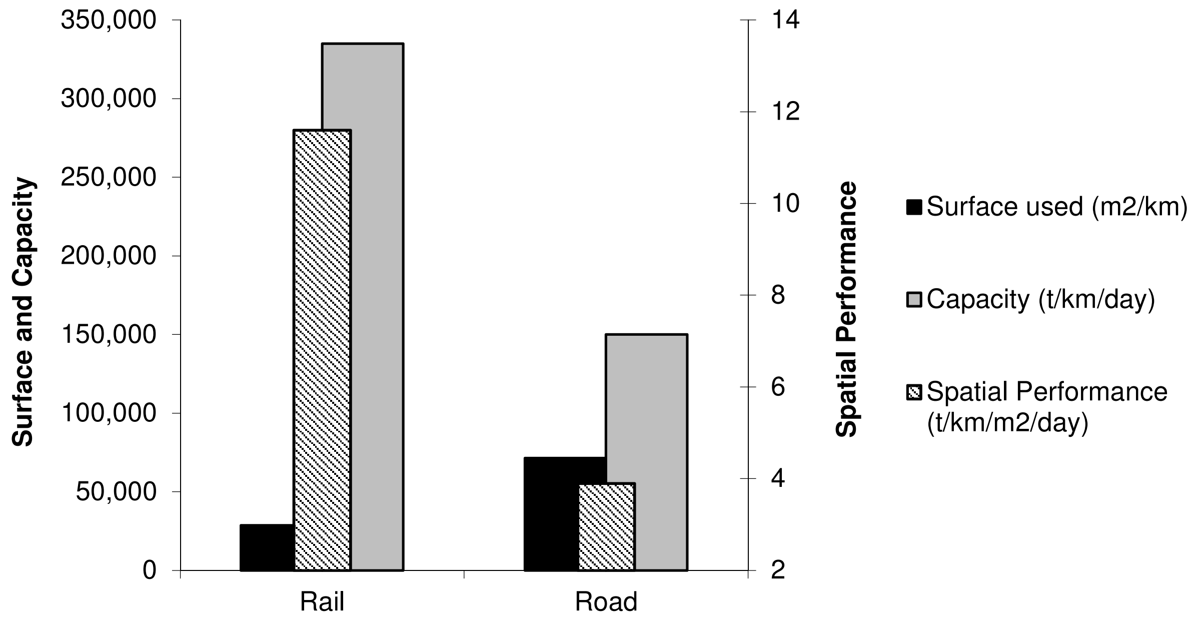

Figure 57: Land use per tonkm[75]

As the total available space on many of the main arteries are already occupied it could be expected that the disappropriation effort for road transport in preparation for the 30 year forecast horizon could be up to six times more difficult (the spatial performance of road is almost 6 times worse than that of rail, as indicated in Figure 57.

[74] Marsay, 2012

[75] Rodrigue *et al.*, 2009

11. Implications for rail reform

The development of a business model and institutional arrangements for the "ideal" railway should be guided by a set of core principles for two key concepts that drive rail reform:

- **Liberalisation** – need to improve competitiveness, productivity, efficiency, effectiveness, and promote modal shift.
- **Network** – nature and capacity of the railway system required by the country to meet future demand and sustainability needs. The rail system should address demands for growth in freight, for passengers and rural / agricultural access.

Apart from these two core principles, the funding principles should also be considered. Network development would be impossible without strong balance sheet considerations of the current network owners and the availability and affordability of funds for development. The effect of liberalisation decisions on costs will also directly impact on required and available funding.

The core principles are overriding objectives that are intrinsically linked to South Africa's economic policy and the ideals of a developmental state. As such it could be difficult to adhere to all of these, but the fact that they should be guiding principles in strategic and economic regulatory discussions cannot be disputed.

Liberalisation: Core principles and philosophy

Liberalisation may be described as the degree to which a railway structures (institutional form) operations and infrastructure to achieve its objectives. Rail reform is typically driven by commercial and market forces that encourage competition amongst transport operators through efficiency and effectiveness. The case references are however, not conclusive with regard to the success of the various institutional forms in achieving this goal. A few core principles should guide the extent of liberalisation of the rail sector and its development in South Africa. Liberalisation core principles are summarised in Table 14.

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Table 14: Liberalisation core principles

	Liberalisation core principle	Rationale
1	Liberalise to achieve a specific national objective.	• Free market vs. development state. • Inducement for growth / employment / capacity etc. • Liberalisation is not a goal in itself.
2	Liberalisation should realise effectiveness and efficiency.	• Lower transport unit costs due to the strategic resource status of transport.
3	Liberalisation should improve global competitiveness.	• South Africa's relative size and distance from foreign markets generate different realities than in other countries where rail liberalisation was effected.
4	Liberalisation should improve sustainability.	• The universal goals of growth, equitable distribution of wealth and environmental protection are a global requirement.
5	Liberalisation should enable the participation of other willing railway operators / stakeholders.	• Cross-subsidisation, non-transparency will make private investment impossible.
6	Liberalisation must induce modal shift and revive rail.	• Due to the environmental unsustainability, high cost and fuel risk of road transport.
7	Liberalisation should enable a performance culture.	• Rewards for performance related KPIs leads to relevant performance related outputs – "you get what you measure".

Network: Core principles and philosophy

South Africa already has different network "segments", and these are mostly connected or integrated to some extent. Even so, certain commonly accepted classifications have already been established. Of these the three most important distinctions would be between the core rail freight network which carries some passengers, the rail commuter network (which shares a gauge with the freight network) and the Gautrain, (a separate high speed standard gauge passenger service). The rail freight network, in turn, has four somewhat separated segments (but not completely and separated to a varying degree), i.e. one each for heavy haul coal and iron ore exports, a core corridor network and a branch line network. The degree to which these networks are adequate for future demand and the extent to which these networks should be integrated requires consideration based on the following drivers:

- Based on existing and future capacity – can the current rail system, if operated efficiently, deal with country's future demand for transport?
- To what extent can different freight typologies share or not share the network?: This will be determined by the operating models required to cater to the needs of the different freight typologies, in particular speed and economics of density will determine the extent to which gauges can be shared or whether new gauges / networks are required. (Speed and economics of density also indicate if heavy haul is required).
- The extent to which the same freight categories can and do move over more than one identified network
- The aim of an efficient railway – according to basic economic principles - is to densify the network to reduce costs (cents/tonkm). Over-densification combined with reckless cost-

cutting could however lead to a tipping point (e.g. corridors are so dense that slots allocated for routine maintenance are limited).

Core principles and their rationale are summarised in Table 15:

Table 15: Network core principles

	Network core principle	Rationale
1	Optimise Density	• Higher density traffic is self-fundable • Lower density traffic requires rationalisation or subsidy • Mixed densities within the same network leads to cross subsidisation and other adverse market economic outcomes
2	Cost	• Cost should be directly attributable to the traffic on the relevant network
3	Need for integration with existing / other new rail systems	• Traffic transfer between different systems should be organised efficiently and as seamlessly as possible where it is necessary for different freight typologies to transfer from one network to another
4	Terminal density	• Terminal types and their location in terms of the economic structure of the country should be an important indicator of network categorisation
5	New routes.	• New investment should consider more efficient technologies (such as speed / load / gauge / containerisation technology)
6	Operating model required to address needs of a freight market segment	• Try to separate train building, shuttles
7	Passenger requirements	• Consider long distance “sweet spot” of three hours between terminals before alternatives are considered
8	Rural access	• Current and future requirements of rural growth and development must be a key determinant of network

Funding and cost

Although Transnet has made significant investment in the railway (and ports) over the past five years – this is not sufficient to meet the needs of the “ideal” railway nor to meet the national growth objectives. A railway cannot sustain profitability by saving or borrowing, but only by growing volumes and earning the income. Funding core principles are summarised in Table 16.

Table 16: Funding core principles

	Funding core principle	Rationale
1	Only new capacity must be funded from the balance sheet.	• If 30 to 50 year assets are to be accounted for on the balance sheet, it must be accepted that replacing them could cost up to ±200 times the book value.
	Any upgrade or upkeep of existing capacity must be funded from cash flow resulting from operations	• Railways must operate frugally. Assume that the existing below-wheel infrastructure and rolling stock carry such low value that all investment decisions must realise sufficient EVA in a 3-5 year window to be funded out of cash flow from operations. • The funding of existing capacity is essentially a maintenance budget on the income statement.
2	Implement accounting separation to effect accounting transparency and attract alternative funding sources.	Separate the railway vertically in the books and account separately for: • below wheel infrastructure (as if a network company exists), • rolling stock (as if a rolling stock company exists), and • Haulage operations (as if a train operating company exists).
3	Empower engineers to maintain the below-wheel infrastructure creatively to significantly reduce maintenance cost and capital investment requirements.	• Below-wheel (infrastructure; perway; etc.) cost of infrastructure at Spoornet was some 40% of turnover in 2000. • By setting a target for engineers to halve that figure through creative maintenance, (similar to ALL's" Vietnamese Way"), this figure was eventually reduced to 17% of turnover for the same service level by 2006.
4	Deploy a meritocracy that substantially rewards cost reduction / frugal behaviour.	• Reward a reduction in the cost of maintaining existing infrastructure. • Reward projects justified and funded from operating income. • Punish investments against the balance sheet other than new capacity.
5	Maintain network synergies rather than thoughtless fragmentation.	• Anchor the long-term profitability in bulk ore transport. • Exploit intermodal and bimodal road-rail opportunities primarily to contribute to the carrying cost of the network through increased rail traffic volume.
6	Develop performance management criteria that rewards correct funding behaviour.	• Organize management to focus on earning income, not gearing the balance sheet.

Options for rail reform

As mentioned, the two major policy decisions that are likely to drive the form that rail reform in South Africa should take, are liberalisation and whether or not a new network is required to accomplish the nation's future freight task. A matrix may be used for visualising these key choices (Figure 58).

The outcome of the options for these policy decisions will in turn have an impact on the extent to which regulatory intervention is required and also on ownership of parts of the current and / or new railway. Ownership in turn has implications for the consideration of funding mechanisms.

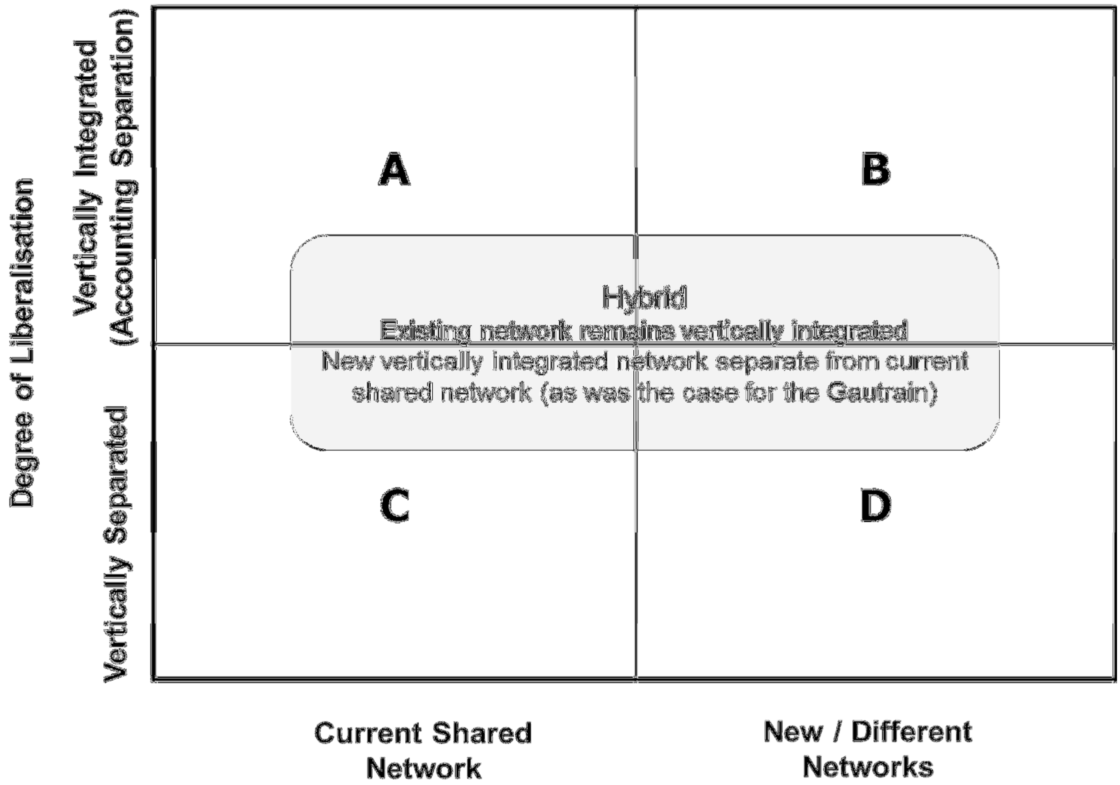

Figure 58: Railway reform options framework

The matrix presents four options (and potentially additional options where hybrid permutations tend to present a logical position for South Africa) for rail reform.

The X axis of the matrix represents a choice of developing a new network to accommodate expansive growth forecasts vs. the alternative of optimising the capacity of the current network only to meet mid-range growth in demand. (It should be noted that the “choice of developing a new network” does not exclude optimising the current network to its full potential). The Y axis reflects the two extremes of the liberalisation decision of either vertical separation or vertical integration.

Accounting separation of the current Freight Rail infrastructure and operations should in all cases be implemented immediately. It is imperative that this is done to effect accounting transparency (dispel perceptions of inefficient practices such as cross-subsidisation) and to facilitate structures that enable the attraction of alternative funding sources. This separation will also enable ringfencing of parts of the business that pave the way for the introduction of different business and funding options, as well as enabling the isolation of pure infrastructure costs that are required for making appropriate comparisons with road infrastructure costs.

Freight market segmentation & rail economic principles to develop options

The flow characteristics of the freight market segments identified earlier will guide the nature of rail reform options that will optimise the network or is best suited to a specific freight market segment. These are summarised in Table 17.

Table 17: Market segments and rail reform requirements

Freight Segment	Commodities	Flow Characteristics	Rail Reform Requirements
Export Mining Flows *Pit to Port*	Mostly Coal, Iron Ore and Manganese	• Stockpile to stockpile - Conveyer Belt • Simple flows from few mines to few ports • Standardised Wagons • High line density over long distances • Heavy Axle Load (20-40t); Low Speed • Bulk Terminal for single commodity • Industrial Velocity	• Ring fenced & fully integrated system for optimal heavy haul rail-wheel interface • Requirement for a different network dependent on extent to which the line is dedicated to a heavy haul commodity or also conveys other general freight
Domestic Mining *Pit to Plant*	Mostly Coal, Iron Ore and Manganese	• Stockpile to Siding flows - More complex flows • From <500 "pits" to some of <7 500 plant destinations • Distances of 400 - 900km • High line density • Heavy Axle Load (20-40t); Low Speed • Commodity specific handling • Industrial Velocity	• Share a network to optimise density • Liberalisation should seek to attract Investment required to increase volumes on current network and ensure access to junior miners
Intermediate Manufacturing *Plant to Plant /DC*	Break-bulk – "uglies"	• Siding to Siding - Mixed and complex freight flows • Heavy break bulk commodities • From +7 500 plants to 250 DCs or one of <25 hubs • Long distances >500km • High Line density • Lighter Axle Load (16-20t); Low Speed • Commodity specific handling • Industrial Velocity	• Many OD pairs over current shared network, potentially high fragmentation costs of over-liberalisation which could also result in lower densities • Vertical integration into many smaller railways would lower densities and fragment the network • Attract additional rail friendly traffic for improved densification
Finished Goods *DC to DC (Domestic Intermodal)*	Palletised	• Terminal to Terminal - Flow between few defined DCs or hubs • Multimodal (Road-Rail) transport solutions • Long distance flows in excess of 600km • Dense flows • Light Axle Load (10-20t); High Speed (may be required for perishable or other time sensitive commodities) Consolidated / packaged handling (Heavy Intermodal) • Retail Velocity	• Current shared network should be densified with these flows • Longer term (30 years) may require an alternative network with strategically positioned hubs / dense terminals (ideal network) • New network does not necessarily have to be

Freight Segment	Commodities	Flow Characteristics	Rail Reform Requirements
			integrated with existing network if operating model would be compromised by sharing
Rural Extraction and Delivery	Agricultural products, break-bulk and palletised goods	• Various light density and complex flows • To, from and within rural areas • Distances vary from <200 to >600km • Light Axle Load (<20t); Low Speed • Consolidated / commodity specific • Retail Velocity	• These services reduce the density equation and raise costs of overall shared network • Collaboration with customers and consolidation of traffic required to increase density but would not be significant enough to reduce costs unless a different operating model and costs structure is applied

Based on these attributes (Table 17) it is possible to plot the freight market segments in terms of density advantages, network and degree of liberalisation (Figure 59).

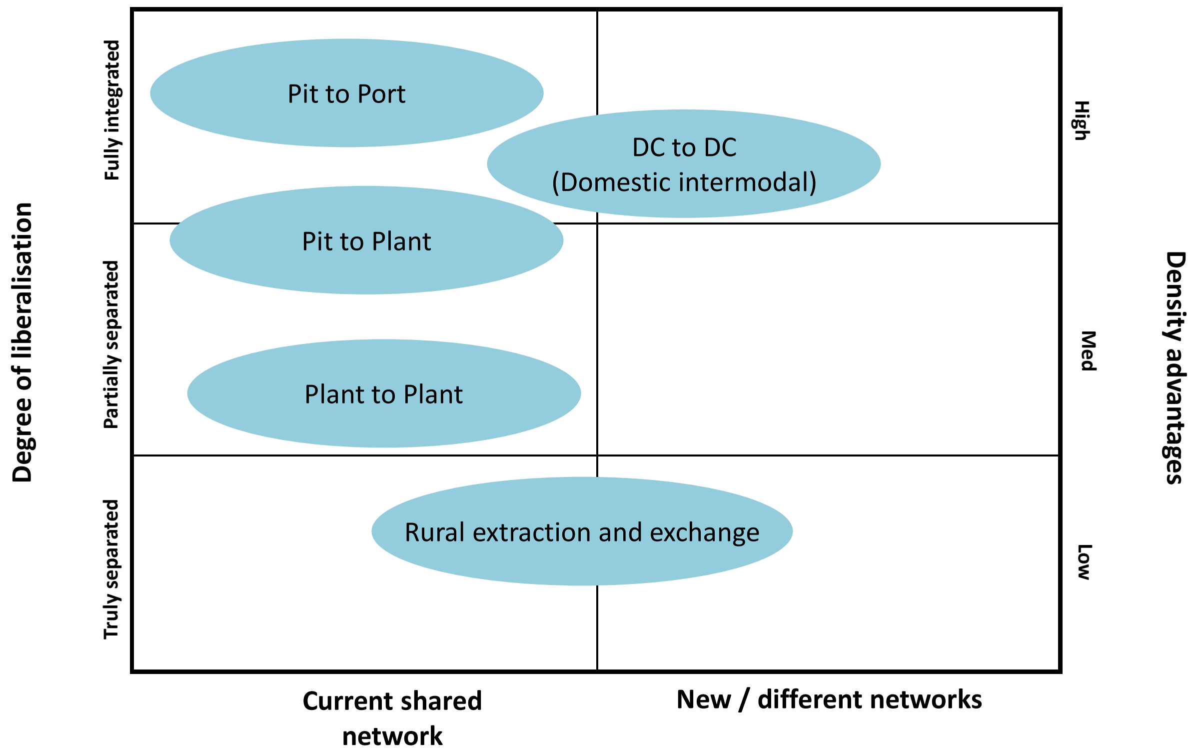

Figure 59: Freight market segments positioned on the rail reform options framework

This framework indicates that a vertically integrated core network, as it currently exists, will be useful for the short, medium and long term with the following exceptions:

- Due to funding considerations and somewhat smaller densities, plant-to-plant traffic, which is mostly 2PL traffic between sidings, can accept a degree of system separation. Being 2PL orientated and with non-standard freight and terminals, freight owners or industries could invest in own wagon fleets and terminals, hauled by a railway that still exploits integration benefits with haulage over the core
- Rural traffic over branch lines' densities are too low to contribute significantly to a future core. By ringfencing these and placing them in subsidy vehicles (or subsidised concessions), movement over the core network, contribution to density can still be exploited by both the core and the cheaper resulting rates for the concessionaire.
- Calculations (refer Figure 56 on page 83) indicate that the current network will not be able to convey the targeted and highly rail friendly DC-to-DC traffic efficiently by 2020. Depending on investment timeframes, passenger demand and job creation scenarios for a future South Africa a stepped approach towards developing a new network that can be ramped up between 2015/2020 and 2025/2030 should receive serious consideration

The econometric estimates of Ivaldi and McCullough (2004) suggest a cost advantage of 20-40% for such an integrated railway versus separate infrastructure operators and diversified train operators. In order to understand fragmentation penalties, these percentages can be applied to the identified freight market segments (Table 18). (Refer to the section on 'System density', page 48, for more detail on fragmentation penalties).

Table 18: Fragmentation penalty space with depiction of freight segments

	Network Density	**Block Load Factor**	**Tonnage per Train**	**Fragmentation Penalty Results**
Export Lines	Very High	Very High	Very High	Very High
Pit to Plant – Iron Ore and Manganese	High	High	High	High
DC-to-DC	High	High	High	High
Freight on Core	High	Medium	High	High
Rural Freight	Low	Low to Medium	Low	Low

This loss of the economies of integration for South Africa would be a loss of R2.4 billion (as the lowest estimate based on overseas case studies) at the design levels of the new required railway for users of the core alone (calculations for the export lines and steelmaking input commodities (iron ore and manganese were not done). An analysis of the cost structures of the current TFR were also done and it seems as if fragmentation charges could, in most cases, be more than the 20% that is the global benchmark (meaning the penalty would, in all likelihood, be more than the R2.4 billion).

Given this information it can be postulated that a vertically and system separated high density shuttle train environment could carry penalties as high as 40% whilst in a lower density required train building environment it could be as low as 20%. This coincides with the view of slight fragmentation of 2PL, siding to siding traffic where freight owners can invest in rolling stock and terminals.

Rail reform option proposed for South Africa

Based on the preceding analysis, the rail reform option proposed for South Africa is premised on a vertically integrated railway and that a new network is developed to exploit opportunities in the growing domestic intermodal segment (Figure 60) (the shaded area reflects funding sources).

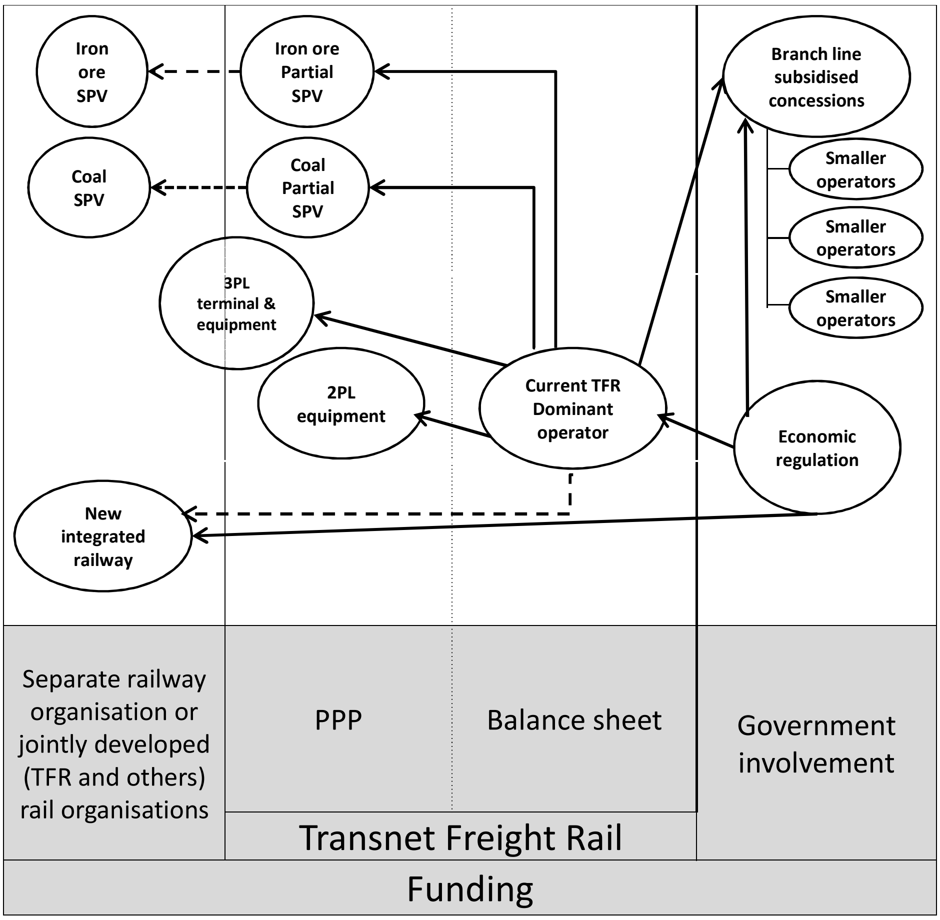

Figure 60: Proposed rail reform option for South Africa

The following salient aspects pertain to this reformed railway:

- The railway remains vertically integrated which enables the benefits of system density and retention of wheel-track technology interface that is essential for the heavy haul lines and economies of scale to be realised.

- Accounting separation provides a transparent structure for the entrance of alternative partners to the industry in the form of the creation of a special purpose vehicle for the export coal and iron ore lines that would attract investment in these areas. Given the high costs of fragmentation, there are a number of reasons for GFB / coal / iron ore integration or partial SPV:

    - General freight on the coal line
    - Possible manganese on the iron ore line
    - Lower densification of the network
    - Switches in supply points (e.g. coal)
    - Access for junior miners
    - Loss of system density
    - Engineering integration

    (An SPV would be, for example, a joint venture with joint Transnet/LSP/cargo owner ownership, as is quite common with similar ventures in Europe).

- Branch lines are ring fenced and remain within the current TFR but are operated within a subsidy regime (possibly through concessionaires bidding to operate certain lines). Smart practice would be the involvement of development banks in the concessioning process. Economic regulation would be required to ensure the fair treatment of these operators with fair and appropriate access to the core network.. Eventually new smaller operators that are branch line based could be allowed, but economic regulation should be considered.

- The general freight operation serves as the dominant operator on the total network and only operator on the core. However, as accounting separation improves and specific cases for access (where it makes economic sense) can be proved to the regulator, other operators can be allowed on the core, in the longer term. In addition, if branch line operators mature to the extent that they can prove that they will operate certain slots efficiently, access to the core should also be allowed. Performance is improved through improved densification (after ringfencing of branch lines) and careful selection of freight market segments that they will operate.

- This business will utilise its own rolling stock in providing 2PL services for the development of the pit/plant-to-plant or manufacturing segments and may enter into PPP arrangements with customers and others for the creation of additional / specialised rolling stock and loading / offloading equipment. This development will enhance the role of Freight Rail as a 2PL logistics provider. An improved operating model will also be required as a 2PL will have a greater role to play in managing the supply chain which is a prerequisite of this service offering.)

- A focus on the opportunities presented by the growing domestic intermodal can be achieved through PPPs for investment in terminals and rolling stock required to service this 3PL market segment on the current network. The General Freight business role as a dominant operator implies that other smaller branch line railway operators will be able to apply for a licence to operate and request access to the network. Since operations and infrastructure are vertically integrated in this option, government will be required to develop the capacity to ensure that the railway industry is regulated. The development of the long haul DC-to-DC market (where the railway would migrate to the role of a 3PL) is also required to improve densification and cost effectiveness of the core network. This business development requires an intermodal solution and thus a major investment in road-rail wagons, loading/offloading equipment and terminals or logistics hubs. This is a critical undertaking in addressing the nation's freight challenges and it is not possible for Freight Rail to achieve this development without private sector involvement.

- The major difference from the *status quo* is the development of a new railway network (the ideal network defined earlier) to harness future growth. Such a railway could not be funded by Freight Rail / Transnet and it is unlikely that government would be able to finance a network of this extent. The only other means for such a line to be developed would be by the private sector. The private sector is unlikely to fund such an operation if they had ownership of the network only – they would seek to operate this line to ensure a viable investment. This requires the establishment of a new vertically integrated railway. As far as the new network is concerned the investment requirements are substantial with very high technical design challenges. The simple "pipeline" or "conveyor belt" philosophy, exactly as is the case for the export lines, will however make the network extremely competitive. It describes the running of 93 modular 200 wagon train sets hauled by 496 locomotives between 10 to 20 terminals. It will be efficient because of similar technology, a simple and singular operating regime and low operating overheads. This also means no substantial shunting, centralised commercial and maintenance procedures and operating centres. Multiple operators will destroy all of these objectives and increase costs substantially.

- In such an environment government would need to ensure economic regulation of an industry that has multiple operators and more than one infrastructure owner

12. Conclusion

Most efforts around the world to implement rail reform have been informed by gaining colloquial wisdom from each other through case studies. This caused a tug of war between protagonists of vertical integration and vertical separation respectively, and also between privatised and development state models. The theoretical literature follows the same approach. There are too few observations to find statistically significant variables that drive success with regard to the success of any specific institutional form; the key is that there are many creative solutions to be found as hybrids between these extremes. Globally, railways that have made successful changes through rail reform have however reflected benefits, provided that reform is implemented with proper adherence to sound macroeconomic principles, business principles and clear and commonly shared objectives.

The objective of this research was therefore to define, from basic principles, the manner in which South Africa's railway should develop in order to address the country's freight challenges and contribute to the fulfilment of national objectives in the context of a development state. The recommendations sought to consider the country's freight transport requirements and not to address the specific challenges of the current railway.

This work is based on a market research led approach and borrows from clear strategic management principles:

1. Identify the market in which the business operates;
2. Segment it clearly;
3. Determine which segments should be targeted based on the match with the firm's value proposition;
4. Determine investment requirements and develop a business case; and
5. Finally, structure the business to deliver the business case (structure follows strategy) and determine governance rules (regulation).

The universality of these principles in much more than just the management discipline was proven in that it enabled the objective definition of an ideal freight rail system for South Africa, the market segments this railway should target and what its investment priorities should be. This culminated in the proposal of a feasible rail reform option for South Africa in the context of the country's unique challenges.

The recommendation for South Africa centres around a core dense rail network that is shared by key freight flows. The core network represents a significant shift of traffic from road to rail through the development of the plant-to-plant/ manufacturing business and, more importantly, rail's entry into the long distance, DC-to-DC intermodal market. This will require significant investment, and most likely the development of a new network, necessitating a degree of private sector participation. The development of a core network presupposes the separation of low density branch lines from this core. The technology deployed on heavy haul export lines require that these businesses remain vertically integrated. An immediate imperative (regardless of the chosen permutation with greater or lesser state and private sector participation) requires an accounting separation of infrastructure and operations, although above and below track operations remain integrated.

The focus of this research was on the rail freight system. It is however imperative that whatever the optimal option for freight on rail is deemed to be, the final business case must also make provision for passenger rail requirements, which in certain instances will share the rail network with freight.

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14. Annexure A – Characteristics of freight market sub segments

1. Export Mining: Pit to Port – Iron Ore

Geographical Flow

Defining Characteristics	Measures / Attributes
Product	Dry Bulk
Nature of Terminal	Heaps
Tons per terminal ('000)	7 815
Density	31
Volume (mt)	31.0
Uniformity	High
Income (or Cost) (Rbn)	1.4
Average transport distance	919
Current Rail Market share	100%

Current TFR service type

- "Conveyor belt" like in nature
- Single / Few Customers
- Virtually a single commodity line
- Highly customised and efficient train designs
- Dedicated rolling stock
- Only 1 wagon type for all iron ore
- Two Loading and one offloading points (Siding to Siding)
- Simple empty wagon distribution
- Stock pile to stock pile

TFR in collaboration with Transnet port authority, port operations and customers operates a vertically integrated service which is dense and efficient. Alternative sources of funding would have to be sought for further expansion beyond 47mt, etc.
Contributes to national policy objective of supporting exports, shifting freight traffic from road to rail and reducing the cost of logistics thus contributing positively to national competitiveness

Defining Characteristics	Measures / Attributes
Customer service requirement	Continuous throughput efficiency to accommodate volume growth
Current installed asset utilisation	47 - 50mt
Current operational asset utilisation	45mt
Logistics complexity	Simple

Density	**Line**	High
	Terminal	High
	System	Potentially stand alone
Uniformity		High
Genetic Technology		Standardised Heavy haul

2. Export Mining: Pit to Port – Coal

<table>
<tr><th>Geographical Flow</th><th>Defining Characteristics</th><th>Measures / Attributes</th></tr>
<tr><td rowspan="9"></td><td>Product</td><td>Coal</td></tr>
<tr><td>Nature of Terminal</td><td>Heaps</td></tr>
<tr><td>Tons per terminal (‘000)</td><td>3 284</td></tr>
<tr><td>Density</td><td>62</td></tr>
<tr><td>Volume (mt)</td><td>61.9</td></tr>
<tr><td>Uniformity</td><td>High</td></tr>
<tr><td>Income (or Cost) (Rbn)</td><td>2.7</td></tr>
<tr><td>Average transport distance</td><td>484</td></tr>
<tr><td>Current Rail Market share</td><td>100%</td></tr>
<tr><td rowspan="4">Current TFR service type
• “Conveyor belt” in nature
• Customer base : 20-25 customers
• Stockpile to stockpile service
• Competition for slots
• Competition on feeder lines and at loading points with GFB traffic
• Customised and efficient train designs
• Dedicated rolling stock
• Only 2 wagon types for export coal
• ± 40 Loading and 1 offloading points (Siding to Siding)
• Fairly simple empty wagon distribution

TFR in collaboration with Transnet port authority, port operations and customers operates a vertically integrated service which is dense and efficient. Alternative sources of funding would have to be sought for further expansion beyond 81mt, etc.
Contributes to national policy objective of supporting exports, shifting freight traffic from road to rail and reducing the cost of logistics thus contributing positively to national competitiveness</td><td>Additional Customer service requirement</td><td>Continuous throughput efficiency to accommodate volume growth</td></tr>
<tr><td>Current installed asset utilisation</td><td>71mt</td></tr>
<tr><td>Current operational asset utilisation</td><td>63mt</td></tr>
<tr><td>Logistics complexity</td><td>Simple</td></tr>
</table>

<table>
<tr><td rowspan="3">Density</td><td>Line</td><td>High</td></tr>
<tr><td>Terminal</td><td>High</td></tr>
<tr><td>System</td><td>Potentially stand alone</td></tr>
<tr><td colspan="2">Uniformity</td><td>High</td></tr>
<tr><td colspan="2">Genetic Technology</td><td>Standardised Heavy haul</td></tr>
</table>

3. Export Mining: Pit to Port – Manganese

Geographical Flow	Defining Characteristics	Measures / Attributes
	Product	Manganese
	Nature of Terminal	Heaps
	Tons per terminal ('000)	1 163
	Density	3.8
	Volume (mt)	3.5
	Uniformity	High
	Income (or Cost) (Rbn)	0.5
	Average transport distance	831
	Current Rail Market share	100%
TFR Current Service Offering • Efficient train designs • Competes with other flows over some segments • Largely ring-fenced wagons • Few Origin – Destination (OD) pairs • Fairly simple empty wagon distribution • Often stockpile to stockpile(Siding to Siding) service	Additional Customer service requirement	Continuous throughput efficiency to accommodate volume growth
	Current installed asset utilisation	5mt
	Current operational asset utilisation	4.3mt
	Logistics complexity	Simple

Density	**Line**	High
	Terminal	High
	System	Shared with other flows (especially on NatCor)
Uniformity		High
Genetic Technology		Standardised Heavy haul

4. Export Mining: Pit to Port – Other Mining Exports

<table>
<tr><th>Geographical Flow</th><th>Defining Characteristics</th><th>Measures / Attributes</th></tr>
<tr><td rowspan="9"></td><td>Product</td><td>Various mining products</td></tr>
<tr><td>Nature of Terminal</td><td>Heaps</td></tr>
<tr><td>Tons per terminal ('000)</td><td>61</td></tr>
<tr><td>Density</td><td>1.3</td></tr>
<tr><td>Volume (mt)</td><td>12.3</td></tr>
<tr><td>Uniformity</td><td>High</td></tr>
<tr><td>Income (or Cost) (Rbn)</td><td>3.7</td></tr>
<tr><td>Average transport distance</td><td>682</td></tr>
<tr><td>Current Rail Market share</td><td>53%</td></tr>
<tr><td>TFR Current Service Offering
• Efficient train designs
• Competes with other flows over some segments
• Largely ring-fenced wagons
• Few Origin – Destination (OD) pairs
• Fairly simple empty wagon distribution
• Often stockpile to stockpile(Siding to Siding) service

Some (±25%) of mining export products (e.g. crude and natural gas, coal, chrome, titanium, magnetite) conveyed over shorter distances (less than 500km) not always suited for transport by rail</td><td>Logistics complexity</td><td>Simple</td></tr>
</table>

<table>
<tr><td rowspan="3">Density</td><td>Line</td><td>Medium</td></tr>
<tr><td>Terminal</td><td>Medium</td></tr>
<tr><td>System</td><td>Shared systems</td></tr>
<tr><td colspan="2">Uniformity</td><td>High</td></tr>
<tr><td colspan="2">Genetic Technology</td><td>Light Axle load, Low speed</td></tr>
</table>

5. Domestic Mining: Pit to Plant – Iron Ore

Geographical Flow	Defining Characteristics	Measures / Attributes
	Product	Iron Ore
	Nature of Terminal	Heaps to siding
	Tons per terminal ('000)	860
	Density	2.2
	Volume (mt)	13.6
	Uniformity	High
	Income (or Cost) (Rbn)	0.38
	Average transport distance	550
	Current Rail Market share	100%
TFR Current Service Offering • Efficient train designs • Competes with other flows over some segments • Largely ring-fenced wagons • Few Origin – Destination (OD) pairs • More complex empty wagon distribution (including optimisation of empty leg) • Often stockpile to stockpile(Siding to Siding) service	Additional Customer service requirement	Supply chain integration with steel manufacturing process
	Logistics complexity	Medium

Density	**Line**	High
	Terminal	High
	System	Shared system
Uniformity		High
Genetic Technology		Standardised Heavy haul

6. Domestic Mining: Pit to Plant – Coal

Geographical Flow	Defining Characteristics	Measures / Attributes
	Product	Coal
	Nature of Terminal	Heaps to Siding
	Tons per terminal ('000)	246
	Density	0.7
	Volume (mt)	8.0
	Uniformity	High
	Income (or Cost) (Rbn)	1.5
	Average transport distance	867
	Current Rail Market share	52%
TFR Current Service Offering • Efficient train designs • Many small consignments – Less Than Trainload traffic • Competes with other flows over all segments • Many Origin – Destination (OD) pairs • Very complex empty wagon distribution (including optimisation of empty leg) • Often stockpile to stockpile(Siding to Siding) service	Additional Customer service requirement	Supply chain integration with heavy industry such as steel and cement manufacturing processes
	Logistics complexity	Medium

Density	**Line**	High
	Terminal	High
	System	Shared system
Uniformity		High
Genetic Technology		Standardised Heavy haul

7. Domestic Mining: Pit to Plant – Manganese

Geographical Flow	**Defining Characteristics**	**Measures / Attributes**
	Product	Manganese
	Nature of Terminal	Heap to siding
	Tons per terminal ('000)	122
	Density	0.7
	Volume (mt)	2.1
	Uniformity	High
	Income (or Cost) (Rbn)	0.2
	Average transport distance	584
	Current Rail Market share	97%
TFR Current Service Offering • Efficient train designs • Competes with other flows over some segments • Largely ring-fenced wagons • Few Origin – Destination (OD) pairs • More complex empty wagon distribution (including optimisation of empty leg) • Often stockpile to stockpile(Siding to Siding) service	Additional Customer service requirement	Supply chain integration with steel manufacturing process
	Logistics complexity	Medium

Density	**Line**	High
	Terminal	High
	System	Shared system
Uniformity		High
Genetic Technology		Standardised Heavy haul

8. Domestic Mining: Pit to Plant – Domestic Mining

Geographical Flow	Defining Characteristics	Measures / Attributes
	Product	Mining products
	Nature of Terminal	Heaps to siding
	Tons per terminal ('000)	39
	Density	2.0
	Volume (mt)	77
	Uniformity	High
	Income (or Cost) (Rbn)	14.4
	Average transport distance	359
	Current Rail Market share	12%
TFR Current Service Offering • Efficient train designs • Competes with other flows over some segments • Largely ring-fenced wagons • Few Origin – Destination (OD) pairs • More complex empty wagon distribution (including optimisation of empty leg) • Often stockpile to stockpile(Siding to Siding) service Almost 80% of this traffic conveyed over distances of <500km	Additional Customer service requirement	Supply chain integration with manufacturing processes
	Logistics complexity	Medium

Density	**Line**	Medium
	Terminal	Medium
	System	Shared system
Uniformity		High
Genetic Technology		Low speed, Low axle load

9. Intermediate Manufacturing: Plant to Plant / DC – Long Distance

Geographical Flow	Defining Characteristics	Measures / Attributes
	Product	Heavy break bulk
	Nature of Terminal	Siding to Siding
	Tons per terminal ('000)	10
	Density	3.7
	Volume (mt)	103
	Uniformity	Low (Mixed traffic)
	Income (or Cost) (Rbn)	32.3
	Average transport distance	594
	Current Rail Market share	17%
TFR Current Service Offering • Efficient train designs • Competes with other flows over all segments • Assets shared – not ringfenced • Many (±4000) Origin – Destination (OD) pairs • Very complex empty wagon distribution (including optimisation of empty leg) Significant portion of this type of traffic is transported over distances >500km Typical 2PL business – mostly just client and supplier, no intermediary players	Degree of route overlap	High
	Additional Customer service requirement	Efficiency and reliability. Need for information on consignments
	Logistics complexity	Varied and high

Density	**Line**	Medium
	Terminal	Low
	System	Large Shared system
Uniformity		Low
Genetic Technology		Medium speed, High axle load

10. Immediate Manufacturing: Plant to Plant / DC – Short Distance

Geographical Flow	Defining Characteristics	Measures / Attributes
	Product	Heavy break bulk
	Nature of Terminal	Siding to Siding
	Tons per terminal ('000)	8
	Density	1.2
	Volume (mt)	55.1
	Uniformity	Low (mixed traffic)
	Income (or Cost) (Rbn)	1.9
	Average transport distance	57
	Current Rail Market share	6%
TFR Current Service Offering • Not rail friendly except if there are highly utilised sidings at both ends	Additional Customer service requirement	Door to door delivery
	Logistics complexity	High

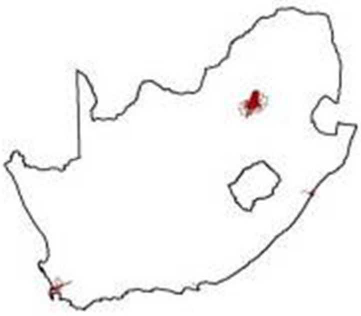
Density	**Line**	Low
	Terminal	Low
	System	Shared system clustered around metropolitan areas
Uniformity		Low
Genetic Technology		Medium speed, Low axle load

11. Finished Palletised Goods: DC to DC – Long Distance

<table>
<tr><th>Geographical Flow</th><th>Defining Characteristics</th><th>Measures / Attributes</th></tr>
<tr><td rowspan="9"></td><td>Product</td><td>Palletised</td></tr>
<tr><td>Nature of Terminal</td><td>DC in a logistics hub</td></tr>
<tr><td>Tons per terminal ('000)</td><td>30</td></tr>
<tr><td>Density</td><td>5.5</td></tr>
<tr><td>Volume (mt)</td><td>23.3</td></tr>
<tr><td>Uniformity</td><td>High (all pallets)</td></tr>
<tr><td>Income (or Cost) (Rbn)</td><td>19.0</td></tr>
<tr><td>Average transport distance</td><td>772</td></tr>
<tr><td>Current Rail Market share</td><td>3%</td></tr>
<tr><td rowspan="2">TFR Current Service Offering
• Insignificant penetration of this market by rail
• Investment would be required in terminals / hubs as well as road –rail rolling stock
• Typically 3PL type business. TFR to make choices regarding future involvement in this market segment</td><td>Additional Customer service requirement</td><td>Freight consolidation at logistics hub</td></tr>
<tr><td>Logistics complexity</td><td>High</td></tr>
</table>

<table>
<tr><td rowspan="3">Density</td><td>Line</td><td>High</td></tr>
<tr><td>Terminal</td><td>High</td></tr>
<tr><td>System</td><td>Large Shared system</td></tr>
<tr><td colspan="2">Uniformity</td><td>High</td></tr>
<tr><td colspan="2">Genetic Technology</td><td>High speed, light axle load</td></tr>
</table>

12. Finished Palletised Goods: DC to DC – Short Distance

Geographical Flow	Defining Characteristics	Measures / Attributes
	Product	Palletised
	Nature of Terminal	DC in a logistics hub
	Tons per terminal ('000)	21.7
	Density	1.2
	Volume (mt)	9.2
	Uniformity	High (All pallets)
	Income (or Cost) (Rbn)	1.1
	Average transport distance	56
	Current Rail Market share	3%
TFR Current Service Offering • Insignificant penetration of this market by rail • Rail unlikely to target inroads in this market	Additional Customer service requirement	JIT, Door to door, high number of drops per day
	Logistics complexity	Very high

Density	**Line**	Low
	Terminal	High
	System	Shared system clustered around metropolitan areas
Uniformity		High
Genetic Technology		Medium speed, Low axle load

13. Rural: Rural Agricultural: Extraction

<table>
<tr><th>Geographical Flow</th><th>Defining Characteristics</th><th>Measures / Attributes</th></tr>
<tr><td rowspan="9"></td><td>Product</td><td>Dry and Liquid Bulk</td></tr>
<tr><td>Nature of Terminal</td><td>Silo to hub or siding</td></tr>
<tr><td>Tons per terminal ('000)</td><td>5</td></tr>
<tr><td>Density</td><td>1.3</td></tr>
<tr><td>Volume (mt)</td><td>12.9</td></tr>
<tr><td>Uniformity</td><td>Medium</td></tr>
<tr><td>Income (or Cost) (Rb)</td><td>5.7</td></tr>
<tr><td>Average transport distance</td><td>565</td></tr>
<tr><td>Current Rail Market share</td><td>18%</td></tr>
<tr><td rowspan="2">TFR Current Service Offering
• Too many Infra points
• Train Designs not well executed
• Overly complex
• Large number of OD pairs
• Outdated, non-standard wagon fleet consisting of more than 50 different wagon groups
• Complex empty wagon distribution
• Often seasonal traffic
• Often conveyed on Branch lines</td><td>Additional Customer service requirement</td><td>Seasonal capacity; Integration into food processing business</td></tr>
<tr><td>Logistics complexity</td><td>High</td></tr>
</table>

<table>
<tr><td rowspan="3">Density</td><td>Line</td><td>Low</td></tr>
<tr><td>Terminal</td><td>Medium</td></tr>
<tr><td>System</td><td>Shared system diverge</td></tr>
<tr><td colspan="2">Uniformity</td><td>High</td></tr>
<tr><td colspan="2">Genetic Technology</td><td>Medium speed, medium axle load</td></tr>
</table>

14. Rural: Rural Agricultural: Manufacturing Delivery

Geographical Flow	Defining Characteristics	Measures / Attributes
	Product	Palletised
	Nature of Terminal	DC and Hub to rural hub
	Tons per terminal ('000)	10
	Density	1.3
	Volume (mt)	17.0
	Uniformity	High (Pallets)
	Income (or Cost) (Rb)	13.1
	Average transport distance	669
	Current Rail Market share	1%
TFR Current Service Offering • Too many Infra points • Train Designs not well executed • Overly complex • Large number of OD pairs • Outdated, non-standard wagon fleet consisting of more than 50 different wagon groups • Complex empty wagon distribution • Often conveyed on Branch lines	Additional Customer service requirement	Freight consolidation at logistics hub
	Logistics complexity	High

Density	**Line**	Low
	Terminal	Low
	System	Diverged
Uniformity		Medium
Genetic Technology		Medium speed, Low axle load

15. Rural: Rural Interchanges

<table>
<tr><th>Geographical Flow</th><th>Defining Characteristics</th><th>Measures / Attributes</th></tr>
<tr><td rowspan="10"></td><td>Product</td><td>Farm produce</td></tr>
<tr><td>Nature of Terminal</td><td>Rural hub to rural hub</td></tr>
<tr><td>Tons per terminal ('000)</td><td>7</td></tr>
<tr><td>Density</td><td>4.2</td></tr>
<tr><td>Volume (mt)</td><td>39</td></tr>
<tr><td>Uniformity</td><td>Low</td></tr>
<tr><td>Income (or Cost) (Rb)</td><td>11.4</td></tr>
<tr><td>Average transport distance</td><td>364</td></tr>
<tr><td>Current Rail Market share</td><td>5%</td></tr>
<tr><td></td><td></td></tr>
<tr><td rowspan="2">TFR Current Service Offering
• Too many Infra points
• Train Designs not well executed
• Overly complex
• Large number of OD pairs
• Outdated, non-standard wagon fleet consisting of more than 50 different wagon groups
• Complex empty wagon distribution
• Often conveyed on Branch lines and even more than one branch line</td><td>Additional Customer service requirement</td><td>Seasonal capacity; Integration into food processing business Freight consolidation at logistics hub</td></tr>
<tr><td>Logistics complexity</td><td>High</td></tr>
</table>

<table>
<tr><td rowspan="3">Density</td><td>Line</td><td>Low</td></tr>
<tr><td>Terminal</td><td>Low</td></tr>
<tr><td>System</td><td>Diverging</td></tr>
<tr><td colspan="2">Uniformity</td><td>Low</td></tr>
<tr><td colspan="2">Genetic Technology</td><td>Medium speed, Low axle load</td></tr>
</table>

15. Annexure B – Description of cargo types

Cargo Types	Description
Agricultural dry bulk	Dry bulk with many OD's with dedicated intermediate terminals
Heavy break bulk	Break bulk with less volume, less fragile and not palletized
Light break bulk	Break bulk that is more expensive, more valuable, easier to break, has own dedicated package type and volume to weight ratio higher
Liquid bulk	Bulk transported by tankers and pipelines
Mining dry bulk	Dry bulk that has dedicated terminals, few OD's
Open skip bulk	Transporting of sand, waste and mining products over short distance. Everywhere to everywhere. Lowest possible value transported in bulk
Palletized	Palletized break bulk, packaged in such a way that it can be put on pallets
Refrigerated	Perishables, requiring cold storage
Ro-ro	Roll onto something by its own means

Cargo Type	Commodity	Total_Tonkm
Agricultural dry bulk	OTHER AGRICULTURE	5 062 583 819
	WHEAT	4 649 446 736
	MAIZE	4 216 272 046
	SUGAR CANE	1 382 159 433
	GRAIN SORGHUM	861 053 169
	SUNFLOWER SEED	355 630 975
	BARLEY	250 474 509
	SOYA BEANS	157 271 859
Heavy break bulk	INDUSTRIAL CHEMICALS	37 466 945 755
	OTHER MANUFACTURING INDUSTRIES	16 152 151 411
	FERTILIZERS AND PESTICIDES	11 608 374 019
	PAPER & PAPER PRODUCTS	11 374 472 837
	OTHER CHEMICALS	11 288 049 805
	MACHINERY AND EQUIPMENT	9 856 482 043
	WOOD AND WOOD PRODUCTS	7 116 927 748
	NON-METALLIC MINERAL PRODUCTS	6 541 495 421
	CEMENT	5 594 000 681
	OTHER IRON AND STEEL BASIC INDUSTRIES	3 676 875 800
	RUBBER PRODUCTS	3 322 401 728
	METAL PRODUCTS EXCLUDING MACHINERY	2 996 024 853
	BRICKS	1 805 848 284
	NON-FERROUS METAL BASIC INDUSTRIES	1 686 881 283
	PRINTING AND PUBLISHING	538 311 009
Light break bulk	TEXTILES, CLOTHING, LEATHER PRODUCTS AND FOOTWEAR	19 522 742 622
	FURNITURE	4 817 577 568
	ELECTRICAL MACHINERY	2 483 711 552
	COTTON	47 162 608
Liquid bulk	CRUDE PETROLEUM & NATURAL GAS	12 043 184 775
	PETROLEUM REFINERIES AND PRODUCTS OF PETROLEUM/COAL	11 977 797 357
	AVIATION FUEL	1 239 699 783
	WATER SUPPLY	752 837 133
	METHANE-RICH GAS	480 026 305
Mining dry bulk	COAL MINING	54 119 484 819
	IRON ORE (HEMATITE)	38 014 473 038
	OTHER NON-FERROUS METAL MINING	4 948 903 533
	MANGANESE	4 690 130 839
	OTHER NON-METALLIC MINERAL MINING	3 183 750 052
	CHROME	2 093 472 169
	MAGNETITE	1 620 024 883
	FERROCHROME	1 544 096 021
	FERROMANGANESE	739 781 286
	ZINC	169 997 968
	TITANIUM	155 053 668
	COPPER	72 580 124
Open skip bulk	OTHER MINING	8 819 238 409
	MINING OF CHEMICAL & FERTILIZER MINERALS	7 950 468 113
	STONE QUARRYING, CLAY & SAND-PITS: LIMESTONE & LIME WORKS	6 316 815 962
	STONE QUARRYING, CLAY & SAND-PITS: OTHER	4 171 086 279
	STONE QUARRYING, CLAY & SAND-PITS: GRANITE	1 531 976 163
Palletized	FOOD AND FOOD PROCESSING	41 609 941 277
	BEVERAGES	14 241 294 814
	MOTOR VEHICLE PARTS AND ACCESSORIES	3 647 483 208
	PHARMACEUTICAL, DETERGENTS AND TOILETRIES	3 052 192 849
	TOBACCO PRODUCTS	775 352 126
Refrigerated	VEGETABLES	3 770 908 903
	CITRUS	2 474 137 152
	DAIRY	2 291 066 597
	POULTRY PRODUCTS	1 356 123 921
	DECIDUOUS FRUIT	1 121 041 308
	LIVESTOCK (SLAUGHTERED)	963 698 556
	VITICULTURE	707 064 138
	SUBTROPICAL FRUIT	610 998 278
Ro-ro	MOTOR VEHICLES	13 652 575 691
	TRANSPORT EQUIPMENT	1 775 495 227

Cargo Type	Commodity	Total_Tonkm
Agricultural dry bulk	OTHER AGRICULTURE	5 062 583 819
	WHEAT	4 649 446 736
	MAIZE	4 216 272 046
	SUGAR CANE	1 382 159 433
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