QUANTIFYING FREIGHT TRANSPORT VOLUMES IN DEVELOPING REGIONS: LESSONS LEARNT FROM SOUTH AFRICA'S EXPERIENCE DURING THE 20th CENTURY

JH Havenga & WJ Pienaar

ABSTRACT

A number of attempts were made during the 20th century to develop national freight flow information for South Africa. This paper discusses these contributions and attempts to identify the major reasons why the research did not give rise to long-term strategic infrastructure planning. It is important to learn these lessons to avoid making the same mistakes during the critical large-scale infrastructure investments that are unfolding in the first half of the 21st century. The paper starts with an overview of the development of South Africa's surface freight transport infrastructure, and then provides a cross-country comparison of South Africa's key freight indicators. This serves to underscore the importance of a long-term approach to such infrastructure investment.

Keywords: freight, information, South Africa, planning

JEL classification: N01, N17

1. INTRODUCTION

The freight transport infrastructure challenges that South Africa faces at the start of the 21st century – including an investment backlog and limited road-rail collaboration – can be traced back to myopic decisions that were made in the past century (Havenga, Pienaar, and Simpson, 2011). Those decisions were the consequence of the historical absence of a long-term, strategic view of infrastructure planning exacerbated by politically-motivated agendas.

In 1928, and before formal road transport regulation, Frankel (1928, 113) reported:
Instead of the decisions on new railway construction being left to an expert body acting on commercial principles and co-ordinating the expenditure on it with the capital expenditure necessary in other directions, not only is the amount to be spent every year decided mainly by the Minister of Railways and Harbours and the Government, but it appears that even the decision as to which of the proposed lines of railway are to be constructed depends largely on the wishes of the Minister.

Decision-making was hampered by the lack of appropriate information on total surface freight transport flows. According to Smith (1973, 4):
As long ago as 1957, the Minister of Transport indicated that he had given instructions to the National Transport Commission to conduct a survey of all road traffic. As far as can be ascertained, such a survey has never been successfully completed by any Government department.

In an analysis of the South African transport sector in the 1970s, Jones (1999, 186) confirmed that a “detailed picture of modal shares in land transport has been notoriously difficult to construct in South Africa, principally because of the paucity of robust road transport data”.

These challenges led to “a significant lack of co-ordination between the provision of road and rail infrastructure” during the 20th century (Mitchell 2004). Gathering and applying relevant market intelligence is the first crucial step in coordinating a strategic planning process (Havenga and Hobbs 2004). Stigson (2004, 1) also highlights the need to “measur[e] the gap between where we are, and where we want to be” as a core requirement for implementing the World Business Council for Sustainable Development's strategies for freight transport.

There were a however a few notable attempts during the 20th century to develop national freight flow information for South Africa. This paper discusses these contributions and attempts to identify the major reasons why the research did not give rise to long-term strategic infrastructure planning so as to avoid these pitfalls during the critical large-scale infrastructure investments that are unfolding in the first half of the 21st century.
At the outset, an overview of the development of South Africa's surface freight transport infrastructure is provided, culminating in a cross-country comparison of South Africa's key freight indicators. This serves to underscore the importance of a long-term approach to such infrastructure investment.

2. DEVELOPMENT OF SOUTH AFRICA'S SURFACE FREIGHT TRANSPORT INDUSTRY DURING THE 20th CENTURY

The development of South Africa's road and rail transport infrastructure started in earnest when the diamond and gold rush in the latter part of the 19th century was followed by a railway development rush to transport people and goods to and from the new hinterland economic hubs. The political agendas of the then two British colonies (Cape and Natal) and two independent Boer republics (Transvaal and the Orange Free State) significantly influenced development and led to destructive tariff wars amongst the colonial and republic railway administrations. The establishment of the Union of South Africa in 1910 led to these lines being officially connected and the establishment of one national railway organisation. This organisation controlled more than 12,000 route kilometres (60% of today's total). This grew to approximately 22,000 kilometres by the late 1920s. The railway network reached its peak in terms of route length at this stage (Solomon 1983; Jones 2002; Mitchell 2004).
In South Africa the road versus rail debate intensified towards the end of the 1920s as rail was losing customers to the rapidly developing road transport industry.

One of the key reasons for this was the differential tariffing system applied by rail to support the government's economic objectives: low tariffs for mining and agriculture, and high tariffs for industrial goods. This was the first form of cross-subsidisation and the first threat to rail density as higher-value goods sought to move to road transport, because of the inordinately high tariffs charged for rail transportation. The modal shift reduced rail density and applied cost pressures on lower-value commodities (Havenga 2007).

This led to the controversial Motor Carrier Transportation Act of 1930 which restricted the operational freedom of all road freight, except that used by farmers, local authorities and government departments. Permits for transporting isolated categories such as perishable goods could be obtained by road transporters, 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 fast-growing economy. 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 (Mitchell 2006, 1).

The National Transport Policy Study (NTPS) of 1986, which focused on the strategic importance of transport to the economic and social development of the country, identified the need for deregulation and privatisation of transport as a whole. This led to deregulation of the transport industry in 1989 with the scrapping of the road permit system and the focus shifting to the regulation of safety through the Road Freight Quality System (RFQS) (Mitchell 2006, 1), followed in 1989 by the Legal Succession to the South African Transport Services Act when the South African Transport Services was transformed into a public company, Transnet Limited (Van Niekerk 2004). The RFQS was however never implemented and critical investment and maintenance by Transnet was delayed due to its sole shareholder's focus on establishing a democracy in South Africa.

Deregulation was followed by, for the most part, well-researched and visionary policies and strategies by the national Department of Transport (DoT). In 1996 the White Paper on National Transport Policy (NTP), the first transport policy following the country's transition to democracy in 1994, reaffirmed and built on the principles of NTPS.

In 1998, the DoT commissioned the Moving South Africa project (MSA) to translate the 1996 NTP into a long-term strategy to realise the White Paper vision of an integrated land freight transport system that would meet the country's economic and social ideals (DoT 1996, 1998). In 2005, the DoT released the National Freight Logistics Strategy (NFLS), building on the NTP and MSA (DoT 2005) focusing on institutional restructuring and economic regulation with the transport industry. There has, however, been limited implementation of these policies and strategies, due mostly to the fact that South Africa's logistics infrastructure planning is fragmented. Various agencies (such as SANRAL), state-owned enterprises (such as Transnet) and government departments (such as the Department of Transport and the Department of Public Enterprises) owns and/or manages different portions of the country's logistics infrastructure. This inevitably leads to a lack of an integrated vision (Havenga 2011).

This history is mirrored in the growth trends in road and rail freight transport infrastructure in comparison to GDP growth from 1910 until 2005 (Figure 1).
The rail route distance has stagnated since the 1930s (with the exception of building the coal and iron ore export lines in the 1970s). Between 1950 and 1980, paved roads and road and rail rolling stock and motive power increased exponentially to keep pace with the demands of the growing economy and growing international trade. Leading up to and following deregulation of the freight transport industry, the corporatisation of Transnet and political priorities shifting to the “new South Africa”, investment in rail rolling stock declined significantly and this decline has only recently been halted.

The result of the uncoordinated developments is that South Africa's transport productivity is low and its cost of logistics high in international terms. Transport productivity is measured as GDP per ton-kilometre. Total global ton-kilometre data is not available, but extensive desktop research uncovered measurements for 40 countries adding to a total of 13 905 billion ton-kilometre. The total GDP for these countries is $47 trillion (of the world total of approximately $60 trillion, i.e. almost 80% of global GDP, therefore a representative comparison), with an average transport productivity of $3.40 of GDP per ton-kilometre delivered. South Africa's result was $1.15 of GDP per ton-kilometre delivered with only four of the 40 countries being in a worse position.

- Australia (National Road)
- Canada (International Rail, National Road)
- Japan (National Rail, National Road)
- Mexico (International Rail, National Road)
- New Zealand (International Rail, National Road)
- Portugal (National Road)
- Ukraine (International Rail, National Road)
- Wikipedia (2010): Ukraine (Total Rail)
- Bambulyak and Frantzen (2007): Russia (Internation Rail)
- USA DoT (2007): USA data

GDP data was obtained from two sources: USA DoT (2009) and Trading Economics (2008). Logistics costs comparisons were obtained from http://www.nssga.org/government/Reauthorization/14_Section_C.pdf.

Low transport productivity can be caused by many factors, but is mostly a result of poor spatial planning and/or spatial distribution of the economy. Small countries with relatively high GDPs will do well (such as Switzerland, Japan, Denmark, Ireland and the United Kingdom) and sprawling countries with efficient spatial distribution (often with most of the dense production centres at the coast) will also do reasonably well (Norway, Australia and Canada). When transport distances however become inordinately long with many production centres away from the coast, the demand for transport generally increases disproportionately to economic productivity.

This impacts the cost of logistics negatively and confirms the importance of both supply- and demand-side management. Available comparisons between South Africa's logistics costs as percentage of GDP and those of other countries are depicted in Figure 3. (These comparisons are illustrative due to the fact that different methodologies are used within each country, and the methodologies are not publicly available). It does seem, however, that South Africa's logistics cost is high in international terms. The impact of transport infrastructure investment on economic growth is elucidated in the next section and renders the importance of long-term planning self-evident.

3. THE IMPORTANCE OF LONG-TERM STRATEGIC INFRASTRUCTURE PLANNING AND ITS EFFECTS ON ECONOMIC DEVELOPMENT

Long-term planning is therefore essential as an instrument to facilitate and improve short- to medium-term planning and investment decisions, avoiding ad-hoc crisis-driven responses (Singer 1991; FAO 1997; ACIL Tasman 2007). Given the political accountability for national infrastructure spend – leading both to budget determination by politicians concerned about how voters would react to increased spending and by organised interest groups influencing spending for the benefit of their members – more focus is however often given to addressing short term issues (that will impact on political ideals) than on long-term planning (Hilder 2003).

Politicians' constituents will try and influence logistics infrastructure spending in a direction that will benefit certain groups in the short term, or, alternatively, oppose projects where they believe the funds could be better spend. This problem can be solved if the state can play a coordinating role and cooperate with emerging entrepreneurial elements in society (Schirmer 1998). The state has, in this regard (Delius and Schirmer 2000), a difficult role in that it can neither disconnect from the lived experiences of its citizens nor create policy based on false presumptions of the future.

The seeming futility of long-term planning (15 years or more) is often reinforced by economists due to the uncertainty regarding structural and other changes which may occur in the interim period. The results of this state of affairs are "most unfortunate, for it tends to lead to economic policy making which is not sufficiently guided by consideration of long-term strategy", leading to significant opportunity costs of inappropriate decisions (Singer 1991, 325). It is imperative to do both – decision-makers have to "articulate the future strategy and take action on current implementation issues" (Hilder 2003).

The importance of following a long-term plan for infrastructure provision is underscored by the impact of infrastructure spending on economic growth. Research regarding the effect of public infrastructure investment (e.g. investment in roads, ports, rail and airports) on economic growth is relatively new, with initial studies investigating the connection emerging as recently as the late 1980s (Stiff and Smetanin 2010). Aschauer (1989) conducted one of the first empirical studies researching this link and provided empirical evidence of the positive effect of public infrastructure investment on private investment and private output growth, mainly due to improved distribution reducing the cost of trade and access to markets. The shift from public investment to public consumption over the 18-year period studied (1967–1985) at least partially explains the decline in productivity experienced by the G7 industrial economies over the same period (Aschauer 1989, 17).

Démurger's (2001) analysis of the links between infrastructure investment and economic growth in China from 1985 to 1998 confirms that geographical location and infrastructure endowment accounted significantly for observed differences in growth performance across provinces. In a meta-analysis of 76 papers Bom and Ligthart (2008) report the weighted average output elasticity of public capital at 0.08 after correcting for publication bias. Calderón, Moral-Benito and Servén (2011) conducted a comprehensive study on the contribution of infrastructure to aggregate output, covering 88 countries and spanning the years 1960–2000, using a multi-dimensional concept of infrastructure, combining power, transport and telecommunications infrastructure. Their results show a highly statistically significant long-run elasticity of output with respect to the infrastructure index ranging between 0.07 and 0.10.

Turning to investment in transport infrastructure, Lakshmanan and Anderson (2002) report that a careful analysis of the empirical studies in this field "has led to broad acceptance of a positive and modest economic impact of transport infrastructure" (p. 3). According to Jiang (2001), a cost function approach2 shows that public transport infrastructure capital contributes to economic growth over time, with elasticities ranging between 0.07 and 0.22. In an extensive analysis of 18 OECD countries for the period of 1870–2009, Farhadi (2011) demonstrates that an increase in transport investment has an indirect and significant effect on long-run economic growth by raising labour productivity, with transport infrastructure contributing 0.09 percentage points to growth during the period. In a detailed historical analysis spanning 106 years, Fedderke, Perkins, and Luiz (2006) demonstrate that the impact of infrastructure investment on economic growth in South Africa was both strong and statistically significant.

Jiang (2001) argues that, given the wide-ranging results of these studies, two sets of policies that relates to both current realities and the future vision should simultaneously receive attention. As far as current realities are concerned, service quality and its impact on the potential utilisation of existing transportation infrastructure plays a role. A successful future vision would require transportation infrastructure capital that will promote growth and the spatial distribution of economic activities.

Goodwin (2000) however cautions that there are not necessarily automatic large-scale economic or employment benefits to be derived from public investment in transport infrastructure. The specific local circumstances and the nature of the transport investment determine the economic impact. Often, transport infrastructure investments are "ill-conceived attempts to cater for traffic growth rather than efforts to improve transport" (Goodwin 2000: 7). Lakshmanan and Anderson (2002) also argue that the benefits accruing from an infrastructure investment is context dependent and that economic assessments must incorporate a broader range of interrelationships and data than is typical in current practice.

Laaksonen (1999), Yevdokimov (2000) and Brown and Hatch (2002) refer for instance to the benefits of intermodal transport as a general purpose technology (GPT) typically characterised by statistically significant spillover effects to other areas of the economy. According to Yevdokimov (2000) a once-off 10% increase both in the frequency of transport and transport network expansion due to intermodal transport resulted in a permanent increase in annual economic growth, reaching a peak of 3% per annum after 15 years and settling over the long-term at a 0.4% increase in economic growth per annum.

Therefore, investment in context-appropriate transport infrastructure should facilitate economic growth. To determine this investment, strategic planning supported by a maintained market intelligence database, is critical. In this regard, Singer (1991, 328) emphasises the importance of quantifying and forecasting the variables that will impact on the long-term framework, despite the pitfalls of forecasting since "informed guesstimates are superior to no knowledge whatsoever" (Olgaard and Rasmussen 1969, cited in Singer 1991, 331). Lakshmanan and Anderson (2002), in turn, accentuate the need for performance-based indicators to track performance of the macro-logistics system against the long term framework.

In order to build this market intelligence database, Bogetić and Fedderke (2006) and Pienaar (2005, 2008, 2010) recommend a deeper analysis of the transport sector to develop a more nuanced picture of the different surface freight transport modes. The attempts in South Africa during the 20th century to develop such a modal view are critiqued in the next section.

4. QUANTIFICATION OF FREIGHT TRANSPORT VOLUMES IN SOUTH AFRICA

The main research contributions to the development of freight flows in South Africa during the 20th century were those of Verburgh (1958), Smith (1973) and Hamilton (1983, 1986), and to a lesser extent (because of little supporting references) those of Van der Veer (1982), Kennedy (1984) and Pretorius (1991).

There are essentially three methodologies available for quantifying freight volumes: questionnaire-based surveys, truck movement observations and gravity modelling. The first underperforms notoriously except in countries with mandatory filing, such as the USA. Mandatory filing uses the same methodology as surveys, but participants are forced to submit answers.

The second is the most cost-effective option, but provides little commodity visibility. The third method has the potential to provide the most comprehensive information, but only if it is done in detail and is adequately funded. All of the contributions that will be discussed in this paper followed a supply-side survey approach, i.e. distributing questionnaires to road freight transport service providers.
Before discussing these contributions, it is important to define the following concepts:

- **Transportable GDP** is defined as that portion of GDP that produces a physical component requiring transportation from point of origin to point of production or consumption, specifically the agricultural, mining and manufacturing subsectors of GDP (i.e. the primary and secondary sectors of the economy).

- The absence of a time series for road data necessitates the use of a **proxy for rail market share** to enable the analysis of trends in modal market share. This proxy is calculated as rail data as a percentage of transportable GDP (the figures for tons transported by rail are available from the national rail operator dating from 1910). The comparison is not a precise measurement of market share, but remains a good approximation of modal shift in the absence of other data. A decrease in this ratio implies a decrease in rail market share and an increase in road market share.

- **Surface freight transport** is that portion of total freight transport that is transported by road and rail.

- Road transport can be subdivided into **ancillary road transport**, which refers to the provision of road transport services by freight owners themselves, and **road transport for reward**, which refers to the outsourcing of the function by freight owners to road transport companies.

- A **ton-kilometre** is the standard unit of measuring freight transport and is the product of tons and distance travelled. (Empty running, i.e. what is sometimes is referred to as gross ton-kilometre, is not included.)

4.1 Verburgh's 1958 research

Verburgh (1958) pioneered detailed studies of road transportation volumes in South Africa. The primary goal of Verburgh's work was to shed light on the balance between the supply of transport infrastructure and the demand for that infrastructure (this goal was not reached). Verburgh's survey methods were based on a special study of the Transportation and Communications Commission of the United Nations Organisation. This study suggested that in most countries the technique of sampling and limited-period questioning provided the best method to obtain road transport performance figures.

Verburgh and his team at the Bureau for Economic Research at the University of Stellenbosch drew a sample of both ancillary and for-reward road transport service providers to develop an understanding of the industry. Verburgh's work included defining capacity in terms of equipment for road and rail and defining the 'safe' domains for rail and road in two categories.

These are fragile, urgent and perishable for road, and bulk long-haul for rail. In his analysis, Verburgh expressed satisfaction with the growth of 78% in tons transported by rail in the period 1937–1956, which he attributed to the growth in intercity transport. A retrospective analysis of Verburgh's data, however, highlights disconcerting trends that were not commented on. Verburgh's rail tons as a percentage of transportable GDP (which was available in 1958, but not utilised in this fashion) is illustrated in Figure 5 (the rail market share proxy defined earlier).

The time series points to several interesting developments and resulting structural challenges in transport during the period under review:

- Rail's share of agricultural traffic increased. This sector was the most heavily subsidised, the most difficult to transport (because of the many collection points) and one of the most difficult to invest in as far as transport equipment is concerned (since the traffic is seasonal and the equipment is therefore not utilised throughout the year – hence there are even more fixed costs than incurred by road). It is also cyclical, thereby exacerbating all these challenges. In addition, the sector reaches equilibrium points, where neither imports nor exports of commodities are necessary, directly influencing the share of transport versus production. The issue of agricultural market share and the development of branch lines were political ones. This did not change until the 1980s as South Africa and Transnet were preparing for change.

- Rail's share of mining-sector transport remained static. As most mining commodities are transported over long distances from fixed points of extraction to fixed production plants or harbours, this is by nature rail's bread-and-butter transport.

- Rail's share of manufacturing-sector transport declined by one-fifth. This could be partly attributed to structural changes, such as shifts in production and consumption away from the rail network, or to changes in parcel sizes. However, it is hypothesised that cross-subsidisation within rail contributed significantly to this phenomenon. In response to the government's economic development agenda for rural areas, the practice was to use the returns from the more profitable transport of manufactured goods to subsidise low-value commodity transport, which resulted in a decline in manufacturing transport due to insufficient investment in manufacturing-transport requirements.

Verburgh's data indicated the growth in road operational capacity compared with rail operational capacity, i.e. wagon and truck populations,3 but Verburgh did not comment on the fact that rail wagon volumes were growing more slowly than the commercial road vehicle population. In addition, rail's infrastructure that carries 180 million tons currently were already installed in 1956 and was, therefore, able to carry significantly more than the 64 million tons that Verburgh reported for 1958. This implies that, in an “administered” tariff environment, at least some of the freight that shifted to road could have attracted lower tariffs on rail because of the high fixed cost component of rail infrastructure.

Verburgh (1958, 36) reported on exemptions that were granted to road operators, allowing long-haul operations. The longer-term impact of long-haul road traffic in terms of road infrastructure investment and maintenance was not questioned. It also resulted in railway tariffs that remained unnaturally high owing to high fixed cost distributed over lower volumes, making the system more vulnerable than it should have been when deregulation finally occurred. Moreover, the high tariffs created a false sense of security in the narrow gauge, which has created undue investment challenges today.4
The surface freight transport market share calculated from Verburgh's statistics is shown in Table 1.

The dominance of rail in ton-kilometre terms is evident. The significant difference between rail's ton and ton-kilometre market share indicates that long-distance transport was on rail. If this is transposed to average transport distance, the figure for rail is 427 km, for road for reward 29 km and for road ancillary 17 km. Average transport distances are in balance with a “pipe and feeder” system, whereby railways are the pipe, fed over shorter distances by road transport for reward and very short distances by freight owners’ own ancillary transport systems.

Yet Figure 2 shows that the downward trend in rail's transport of manufactured goods was already visible – although no mention of this is made in the research. The excess capacity on rail at that time, and the assumption that the expected growth in manufacturing production would be better served by road transport, negated the need for an understanding of balancing the transport modes. By not following through on a wider modal-balancing approach, Verburgh's study did not succeed in providing long-term infrastructure planning frameworks. At the same time, though, Verburgh's work was the first and last attempt in the history of macro-economic freight transport measurement in South Africa that attempted to develop a detailed strategic perspective.

4.2 Smith's 1971 research

The next study that attempted to quantify freight transport was conducted in 1971 by Smith (1973). Smith (1973, 1) cites difficulties at the Department of Statistics, a high percentage of transport-business mortalities and the “stringent limitations” of the effects of the 1930 Act, which regulated road freight transport, as the core issues that led to his study. Like Verburgh's work of 1958, Smith's was based on 329 returned questionnaires (Verburgh based his on 403) from a sample of 4 000 out of the estimated 12 000 road hauliers, which resulted in a response rate of 8% (Verburgh's was 16%).

Smith's study is silent on many of the ancillary, or freight-owner, transport statistics that Verburgh did report on, but it is possible to reconstruct some trends and data from his base data. Creating the same core statistics that were produced from Verburgh's data (a comparison that Smith – although referring to Verburgh extensively – interestingly did not do) enables an analysis of modal shifts in the intervening years.

The data presented in Table 2 show that in the 14 years between the two surveys, tons transported more than doubled and ton-kilometres almost doubled. Rail market share in tons declined markedly, and in ton-kilometre terms both road for reward and ancillary road market share doubled, as illustrated in Table 3.

The growth in average transport distances shown in Table 4 compared with the faster growth in tons transported versus ton-kilometres delivered is counter-intuitive. This is, however, a direct result of the changing structure of the market, whereby specialisation requires longer transport for the same level of output. Economic performance in terms of gross domestic product per ton transported deteriorated, compared with 1957, but in terms of ton-kilometres delivered the performance improved, as shown in Table 5.

The rising trend in economic performance per ton-kilometre as opposed to a declining trend in performance per ton is an interesting phenomenon, because even when the average transport distance for all modes increased, the average transport distance in the economy decreased from 141 km to 108 km. This is a feature of urbanisation, but could also be a lead indicator of specialisation, following urbanisation, in a multi-metropole economy that should predict corridor formation.

Smith did not attempt the same level or depth of economic analysis as Verburgh and no further clarification of his interpretations are possible, as he did not elaborate on many of the salient issues that his research could have uncovered. A closer analysis of the data pointed to an increase in road activity compared with rail; especially as “rail-captured” traffic picked up and the increase in exemption applications by road transport operators and freight owners indicated that manufacturing transport was continuing its shift to road transport.

4.3 Van der Veer's 1982 research

In 1982 Van der Veer developed market share statistics for the period from 1971/72 to 1980/81 (Jones 1999).5 The research yielded interesting performance figures for rail in this period, namely that tons transported increased by 50% and ton-kilometres by 63%. Rail's average transport distance increased, mainly owing to the commissioning of the export lines and an increase in cross-border traffic. What Jones (1999, 181) picked up, however, was that high-rated (i.e. manufacturing) traffic's contribution to tons transported by rail decreased from around 18% in the beginning of the 1970s to 12% at the end of that decade.

Rail's revenue share of this traffic declined from around 50% to about 40% during the same period. The question arises whether this is because of changes in the market structure or rail market share changes. For the only available time series of rail market share, Verburgh's data are extended by using statistics obtained from Transnet Freight Rail to the end of the 1970s, as depicted in Figure 6.

The flattening of rail's manufacturing “market share” is visible in the 1970s, i.e. the correlation between rail's actual performance and market share by proxy seems to be in place. Rail's manufacturing market share, however, remained low. Jones (1999) discussed the rate problem as a potential cause of this, i.e. the railway's assumption that high-value rail cargo (mostly manufactured goods) was price-inelastic and higher rates charged for the high-value cargo could be used to cross-subsidise the transport of agricultural commodities. The assumption was not correct and shippers of manufactured commodities continued to seek alternative transport arrangements.

4.4 Kennedy's 1984 research

By the beginning of the 1980s, rail's cross-subsidisation approach was severely distorting the market. The advent of the age of logistics and total cost of ownership made this approach untenable. Yet the understanding of the changing market structure was still limited. Kennedy (1984, 19) quotes a road transport board official who maintained that “if a company needs road transport to stay in business, it is a marginal firm and probably should not be in business anyway”.

This view ignores the value of road transport and concentrates on minimum transport costs to the detriment of other logistics functions, such as flexibility, reliability, goods security and road transport's capability of providing a door-to-door service.

Kennedy (1984, 57) did a detailed analysis of road and rail costs in 1984. The purpose of his work was not to quantify freight volumes. However, it is included here not only to highlight some of the pertinent conclusions of his work, but also to point out the misconception that still existed regarding modal balance.

Kennedy highlighted two of the reasons for road transport regulation, i.e. to protect the railway's traffic base (economic), and delay the deterioration of the road network (technical). He emphasised that the railways had not been balancing their books during preceding years (because of cross-subsidisation within rail and from other modes within the then South African Transport Services). According to Kennedy, therefore, the transport system was not working. He suggested that road levies charged at true usage costs would protect the road network (and by implication the rail network would be accountable for its true usage cost).

Kennedy's work on costs was extensive, but he did not consider the impact of externalities. He also made a questionable comment on the resultant traffic loss of the railways (if full deregulation occurs and full costs are charged to both the railways and road). The comment refers to the loss of income of the railways and the consequent effect on the railways’ cost base:

A very short time after such traffic losses, several days or weeks, there will be likely to be very little cost reduction, apart from reduced energy usage and damage inflicted upon the track structure. After several months, if the traffic reductions are significant on certain routes, the scheduling of trains, assignment of motive power and the organisation of yard and station forces can be adjusted to meet the new traffic levels (Kennedy 1984, 100).

Kennedy ignored the fact that most rail costs are fixed over the medium to long-term (they are sunk to some extent) and that all railways require high densities to be profitable. He does not consider intermodality (which by this time was an established technology internationally) and future freight levels, which could possibly change the income structure of a railway over dense long-haul corridors.

4.5 Hamilton's 1985 research

In 1985 Hamilton repeated Verburgh's methodology in response to a request from the South African Transport Services (which was then the operator of South Africa's railway) (Hamilton 1986, 1). Hamilton stated that the survey was needed to define the extent of the road haulage industry to enable infrastructure planning. His objectives were to determine origin-destination data by commodity and the modal structure of all surface freight in South Africa (excluding finally consumed product). Hamilton (1986, 3) mentioned in passing why some of the conclusions of the first survey he conducted in 1983 were suspect, namely:

- that fleet sizes were used as a sampling unit rather than vehicle types, and that the number of operators per fleet size was difficult to establish; and
- that vehicles with a gross mass of less than 5 tons are often registered as utility vehicles or in the name of private persons or other non-transport bodies, such as municipalities, statutory bodies or vehicle dealers – which would lead to under-sampling and, therefore, undercounting.

Hamilton's approach is once again to survey road-for-reward and ancillary operators with a questionnaire, which means that the basic supply-side approach did not change from Verburgh and Smith. He achieves a higher response rate of 13.5% (because of a shorter questionnaire and follow-up interviews), but this response rate represents only 113 satisfactorily completed questionnaires (Hamilton 1986, 7).

The modal performance data arising from Hamilton's survey are compared with Verburgh's and Smith's market shares in Table 6. The modal market share can also be expressed in percentage terms (refer to Table 7).[7] From the available data, average transport distances can also be calculated (see Table 8). These data show a significant (and concerning) increase in the average transport distances of road for reward, which was not commented on or explained by Hamilton.

The results of the 1985 study seem to indicate a halt in the deterioration of the railways' performance, apparently confirmed by an improvement in market share. However, if the approximately 40–50 million tons transported on the export lines at that stage (the export lines had begun functioning since the 1971 survey) are taken into account, as well as the natural growth in other mining commodities, this is not the case and rail market share remained flat at best.

In fact, at this stage the Verburgh data sets of 1958 could be considered again and extended by using statistics obtained from Transnet Freight Rail up to 1985 to get a better picture of market share by proxy for the three transportable economic sectors (see Figure 7). These figures do point towards a flattening of the downward trend of rail performance since 1957 during the 1970s and early 1980s, and, therefore, seem to correspond well with Hamilton's data.

A comparison of transport's economic performance over time is provided in Table 9. The trend from 1957 to 1971 was reversed from 1971 to 1985. GDP per ton improved, but deteriorated per ton-kilometre. This is attributable to the building and commissioning of mass, low-value export systems, which are “ton-kilometre-hungry”.

As with previous surveys, no strategic deductions or strategic infrastructure suggestions were made. He did request the co-operation of associations such as the Public Carriers Association and Association for Private Transport Owners, which was once again lacking during the research. In spite of this, Hamilton believed that the study would be repeated often (Hamilton 1986, 28).

4.6 Pretorius’ research (1985–1990)

In the late 1980s, the Research Unit for Transport Economic and Physical Distribution Studies of the then Rand Afrikaans University (now the University of Johannesburg) developed a database to fill the gap for “reliable information relating to the macro- as well as the micro-economic aspects of freight transport activities” (Pretorius 1991, 1). The report provided the first reference to macro-economic transport issues; it was extensive and provided some forecasts and developed indicators.

The sample on which the surveys were based was initially extensive – close to 40 000 in 1985 1986 and 1987 – but was reduced to below 10 000 in 1988 1989 and 1990 after more knowledge about the composition of the population was obtained. The stratified random sample considered population, gross geographical product and commercial-vehicle population. Unfortunately, two important transport performance parameters were missing, i.e. ton-kilometres and origin-destination pairs. The results for tons on a macro-level are shown in Table 10.

The only known data for this time period were tons transported by rail, and Pretorius (1991, 31) provided the sample's response and then compared this with actual tons transported by rail, but never discussed the dissimilarities between the two data sets (which were quite extensive). It seems that the deterioration in the sample size did not influence the reliability of the data very much because the performance of rail, as reported by the sample, undercounted its actual performance by 12% on average. (Pretorius did not provide this analysis.) The difference is illustrated in Table 11.

The modal time series as extended by Pretorius’ work is provided in Table 12. If Pretorius’ rail data are replaced with actual data, and if road transport data are ‘normalised’ with the 12% undercounting observation for rail, the following picture emerges (see Table 13). One could quote Pretorius’ data to say that on the eve of deregulation the economy required around 700 to 800 million tons of freight transport, with ancillary road accounting for about 50% of the share, and road for reward and rail approximately 25% each.

Pretorius’ surveys continued for a few years and were then discontinued. It is assumed that the lack of strategic context, lack of funding and lack of interest from the DoT contributed to the survey's demise.

A researcher at the University of Johannesburg, Bierman (2006, 12), repeated Pretorius' work once in 2006 using the same methodology, and recent indications are that the University of Johannesburg aims to repeat the survey again.

5. CONCLUSIONS

The historical analysis of South Africa's freight transport infrastructure development and the endeavours to quantify freight transport flows analysed in this article point to fundamental principles that, if applied, could facilitate the integrated development of freight transport infrastructure in developing regions. The key enabler is a single national point of accountability for collaborative freight infrastructure development. The mandate of this entity starts with the development of a shared vision for the freight transport industry and investment and incentivisation against this vision. This is, however, only possible if appropriate market intelligence is developed, maintained and interpreted, and corrective action is taken when required. Such market intelligence includes:

1. Tracking of modal balance:

- Track trends in market share and interrogate noticeable shifts.
- Within each mode, track and understand the differences between the different types of capacity per mode (installed, maintained and operational), as well as the utilisation of operational capacity.
- Understand trade-off decisions between modes and the short term and long-term impact of such decisions.
- If surveys need to be done, the cooperation of major transport agencies should be incentivised as this is critical to facilitate a sufficient number of responses.

2. Forecasting and scenario development:

- Understand the impact of structural changes in the economy on demand for transport – now and in future.
- Understand the impact of structural changes in the global and domestic transport industry (such as a global move towards intermodality) and the impact on investment requirements.
- Model the impact of government policies (e.g. cross-subsidisation) on long-term system sustainability.

3. Developing and tracking key macroeconomic indicators such as GDP per ton-kilometre and logistics costs as percentage of GDP to track the competitiveness of transport in serving the economy.

Especially at the outset, the cost and time required to develop this information could be prohibitive. It is however still critical to use proxies for these analyses (such as cross-border data or shifts in GDP) so that the most informed investment decisions can be made.

There are essentially three methodologies available for quantifying freight volumes: questionnaire-based surveys, truck movement observations and gravity modelling. The research discussed in this article is all based on surveys, and all the surveys had a very low response rate. This is one of the key challenges with survey-based research, especially when there is no legal or other incentive to complete the questionnaire and is one of the core reasons why the majority of current research efforts (mentioned below) are based on truck movement observations and gravity modelling.

The latest research efforts in South Africa are applying the above-mentioned lessons in an effort to inform long-term collaborative infrastructure planning. These research efforts started in the mid-1990s and culminated in the annual State of Logistics Survey, which has been published since 2004 (CSIR, University of Stellenbosch, and Imperial Logistics 2010) and the annual Transnet Freight Demand Model research (Havenga, Simpson, and Fourie 2011), which started in 2005 and uses traffic counts and gravity modelling. The application of these lessons by other developing regions could fast-track the development of appropriate freight transport infrastructure and enable the circumvention of some of the challenges faced when a freight transport network is developed without this intelligence.

The research in this article served a dual purpose in this regard. A historical view on freight modal market share and volumes in South Africa (given the quality concerns identified and analysed) contributes towards the understanding of long term trends. This is important given the long term nature of infrastructure spending that was argued. At the same time, deficiencies in measuring are identified in such a way that future researchers can improve volume and market share calculations to enable effective infrastructure spending.

Notes

[2]The cost function specifies an economically efficient use of resources, i.e. the firm chooses the least cost combination of inputs to produce a given output (as opposed to the production function which specifies a technically efficient use of labour and capital necessary to produce output, i.e. no resources are wasted) (Thompson n.d.).

[3]The capacity of a transport system can be explained in terms of three classes, i.e. installed, maintained and operational. Installed capacity is the initial fixed investment, and can only be improved in leaps; maintained capacity is a view of the annual level of maintenance of this installed capacity, and can also only be improved in leaps if the maintenance schedule deteriorated; operational capacity is the real capacity available on the fixed infrastructure, given current levels of employees, systems, motive power and carrying capacity.

[4]The carrying capacity of railway wagons – which remains the biggest driver of marginal costs and means that larger carrying capacities decrease costs – increases with a wider gauge. (In 1870, the unfortunate decision was made to narrow South Africa's gauge in order to permit the railway to cross the mountains north of Wellington more cost-effectively.) In most cases, this capacity can at least be doubled with a wider gauge. Compared with Europe, which has a wider gauge but half of South Africa's road truck carrying capacity limits, a significant marginal cost component of South Africa's rail system today has an installed backlog by a factor of four – a result of the absence of such reasoning by many researchers of the day.

[5]Van der Veer's original research was not available. An analysis of his research conducted by Jones in 1999 is used as the basis for this discussion. The years used by Van der Veer corresponded to the rail operator's financial years as this was the periods in which rail data was published.

[6]Hamilton conducted his first study in 1983. The study produced erratic results due to a very low response rate and is not discussed here. For an analysis of this study refer to Havenga 2007, 94.

[7]Rail ton-kilometre market share deteriorated despite the introduction of the ring-fenced bulk export lines. The reason for this was that the average transport distance of the coal line is 650 km and the iron ore line 850 km. Traffic being lost at that stage was mostly the 1500 km between Johannesburg and Cape Town and the 600 km between Johannesburg and Durban.

TABLES

Table 1: Modal performance and market share in 1957*								
	Tons				**Ton-kilometres**			
	Rail	**Road for reward**	**Road ancillary**	***Total***	**Rail**	**Road for reward**	**Road ancillary**	***Total***
Millions	75	67	113	*255*	32 000	1 955	1 960	*35 915*
% share	29	26	44	*100*	89	5	5	*100*
*Calculated from Verburgh's distribution of vehicles per firm type (1958, 21), average distance loaded per annum (217) and ton-miles per vehicle (168).								

Table 2: Modal performance shifts between 1957 and 1971*								
	Million tons				**Million ton-kilometres**			
	Rail	**Road for reward**	**Road ancillary**	***Total***	**Rail**	**Road for reward**	**Road ancillary**	***Total***
Verburgh – 1957	75	67	113	*255*	32 000	1 955	1 960	*35 915*
Smith – 1971	100	245	279	*624*	53 000	7 850	6 387	*67 237*
CAGR**	2%	10%	7%	*7%*	4%	10%	9%	*5%*
*Ancillary transport statistics calculated from average distance and tons per vehicle per annum, per industry group and vehicle fleet composition from growth rates in commercial vehicles, NAAMSA, and certificates issued (Smith, 1973: 5, 139–140, 144–145).								
**CAGR = Compound annual growth rate.								

Table 3: Modal market share shifts between 1957 and 1971								
	Tons (% market share)				**Tonkilometres (% market share)**			
	Rail	**Road for reward**	**Road ancillary**	**Total**	**Rail**	**Road for reward**	**Road ancillary**	**Total**
Verburgh – 1957	29	26	44	100	89	5	5	100
Smith – 1971	16	39	45	100	79	12	9	100

Table 4: Average transport distance (ATD) shifts between 1957 and 1971			
	ATD (km)		
	Rail	**Road for reward**	**Road ancillary**
Verburgh – 1957	427	29	17
Smith – 1971	530	32	23

Table 5: Economic performance related to transport input (constant 1995 prices)		
Year	**GDP per ton**	**GDP per ton-km**
Verburgh – 1957	R659	R4,68
Smith – 1971	R542	R5,03

Table 6: Modal performance based on main surveys done up to 1985*								
	Million tons				**Million ton-kilometres**			
	Rail	**Road for reward**	**Road ancillary**	***Total***	**Rail**	**Road for reward**	**Road ancillary**	***Total***
Verburgh – 1957	75	67	113	*255*	32 000	1 955	1 960	*35 915*
Smith – 1971	100	245	279	*624*	53 000	7 850	6 387	*67 237*
Hamilton – 1985	170	263	241	*674*	91 861	31 297	14 219	*137 377*
* Hamilton split tons between road for reward and road ancillary, but not tonkilometres. Based on previous studies' split between the ATD of these two categories, a rough estimate of the tonkilometre split was possible.								

Table 7: Modal market share shifts based on main surveys done up to 1985								
	Tons (% market share)				**Tonkilometres (% market share)**			
	Rail	**Road for reward**	**Road ancillary**	**Total**	**Rail**	**Road for reward**	**Road ancillary**	**Total**
Verburgh – 1957	29	26	44	100	89	5	5	100
Smith – 1971	16	39	45	100	79	12	9	100
Hamilton – 1985	25	39	36	100	67	23	10	100

Table 8: Changes in average transport distance based on main surveys done up to 1985			
	ATD (km)		
	Rail	**Road for reward**	**Road ancillary**
Verburgh – 1957	427	29	17
Smith – 1971	530	32	23
Hamilton – 1985	540	119	59

Table 9: Economic performance related to transport input*			
Year	**GDP per ton**	**GDP per ton-km**	**ATD**
Verburgh – 1957	R659	R4,68	141
Smith – 1971	R542	R5,03	108
Hamilton – 1985	R717	R3,52	204
*Van der Veer's data is not included as his research did not included a tonkilometre calculation			

Table 10: Pretorius's modal performance data 1985–1990 (Pretorius 1991: Appendix 2)				
	Million tons			
	Rail	**Road for reward**	**Road ancillary**	**Total**
1985	176	239	363	778
1986	131	220	412	763
1987	157	199	437	793
1988	187	168	414	769
1989	155	134	382	671
1990	164	131	353	648

Table 11: Undercounting of rail performance in Pretorius's sample*				
	Rail – Pretorius (million tons)	**Rail – actual (million tons)**	**Difference (million tons)**	**Difference (%)**
1985	176	182	6	3
1986	131	178	47	26
1987	157	188	31	16
1988	187	187	0	0
1989	155	179	24	13
1990	164	184	20	11
*Actual rail data from Transnet Freight Rail (TFR)				

Table 12: Modal performance 1957–1990 based on all available sources				
	Million tons			
	Rail	**Road for reward**	**Road ancillary**	**Total**
Verburgh – 1957	75	67	113	255
Smith – 1971	100	245	279	624
Hamilton – 1985	170	263	241	674
Pretorius – 1985	176	239	363	778
Pretorius – 1986	131	220	412	763
Pretorius – 1987	157	199	437	793
Pretorius – 1988	187	168	414	769
Pretorius – 1989	155	134	382	671
Pretorius – 1990	164	131	353	648

Table 13: Modal performance: Pretorius' data normalised				
	Million tons			
	Rail - actual	**Road for reward**	**Road ancillary**	**Total**
Verburgh – 1957	75	67	113	255
Smith – 1971	100	245	279	624
Hamilton – 1985	170	263	241	674
Pretorius – 1985	182	272	414	868
Pretorius – 1986	178	251	470	899
Pretorius – 1987	188	227	498	913
Pretorius – 1988	187	192	472	851
Pretorius – 1989	179	153	435	767
Pretorius – 1990	184	149	402	735

FIGURES

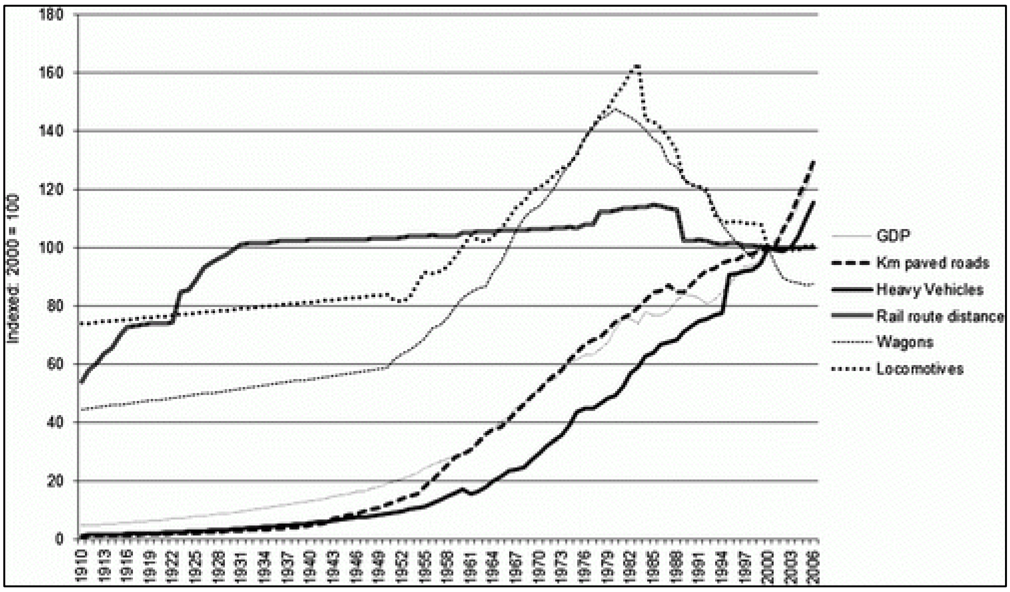

Figure 1: Historical development of South Africa's road and rail transport infrastructure
Source: Road data from eNatis 2011; rail data from Transnet Freight Rail 2011.

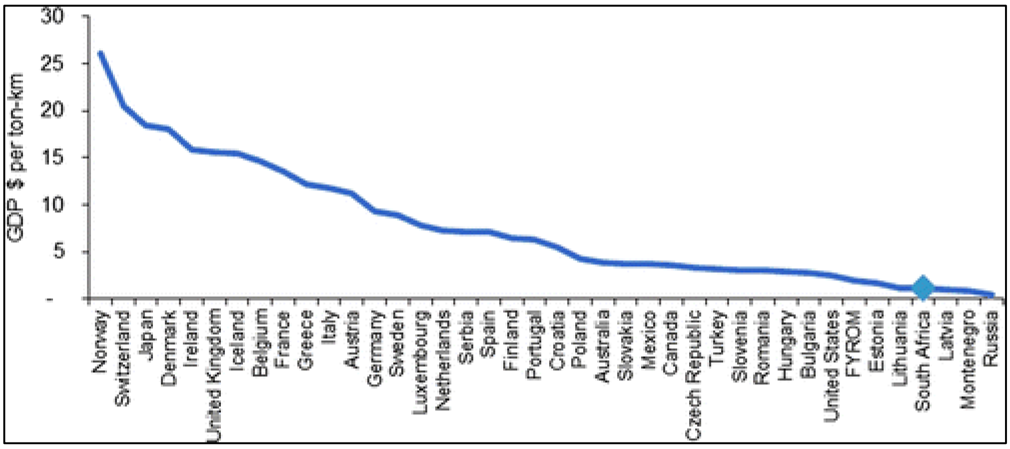

Figure 2: GDP dollars per ton-kilometre – global comparison*
*For ton-kilometre data the main sources were OECD (2010) and Eurostat (2009). For countries not available in these sources, the following sources were used:
Trading Economics (2010):

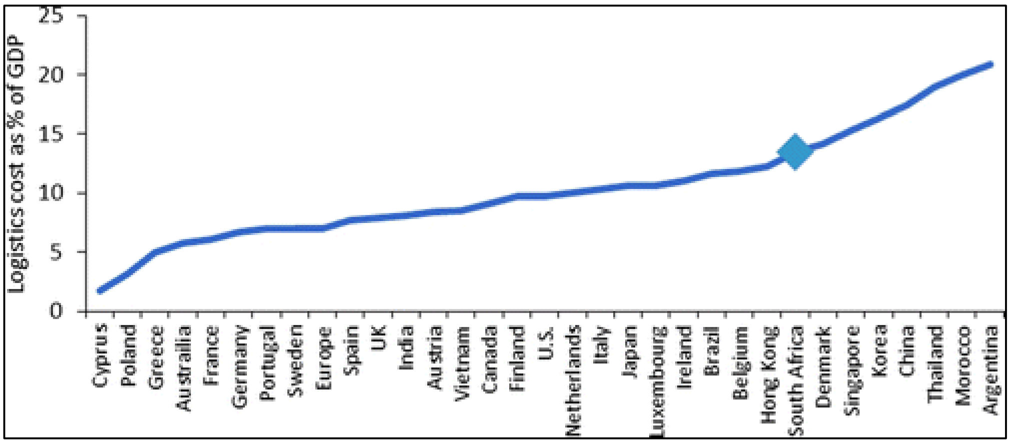

Figure 3: Global logistics costs as percentage of GDP comparisons

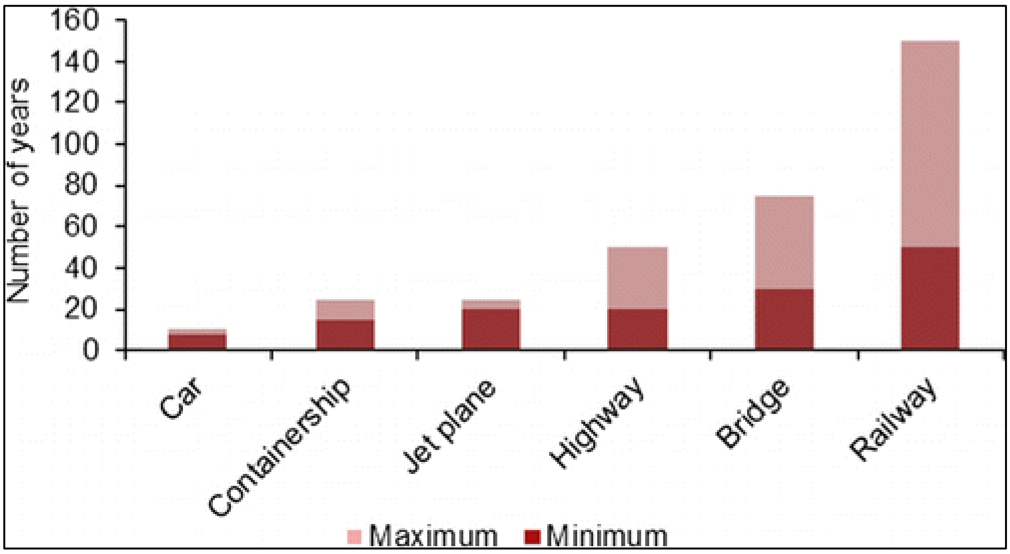

Figure 4: Lifespan of major transport assets (WWF 2006)

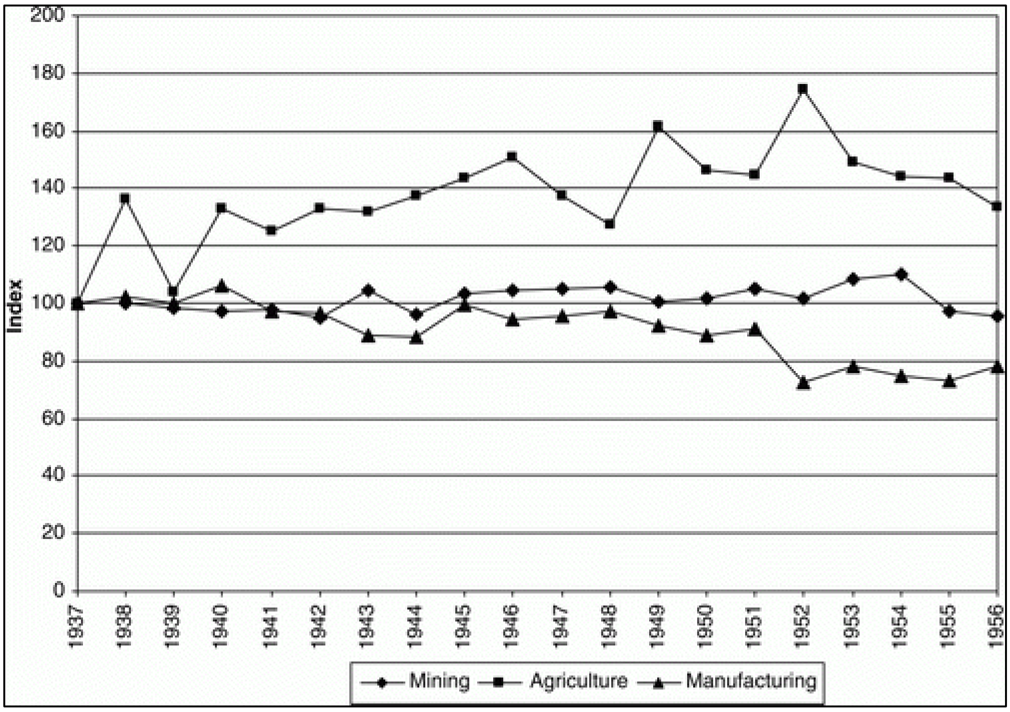

Figure 5: Verburgh's (1958) rail tons transported as a percentage of transportable GDP

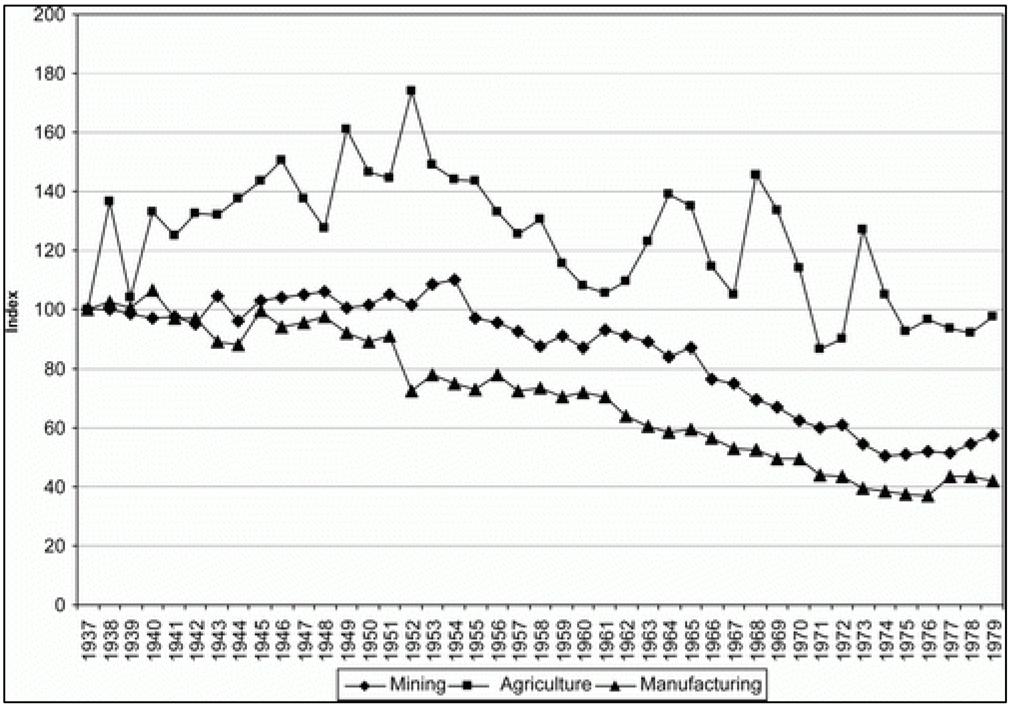

Figure 6: Rail tons transported as a percentage of transportable GDP
Sources: Rail tons up to 1956 from Verburgh (1958), rail tons from 1957 onwards from Transnet Freight Rail (2011).

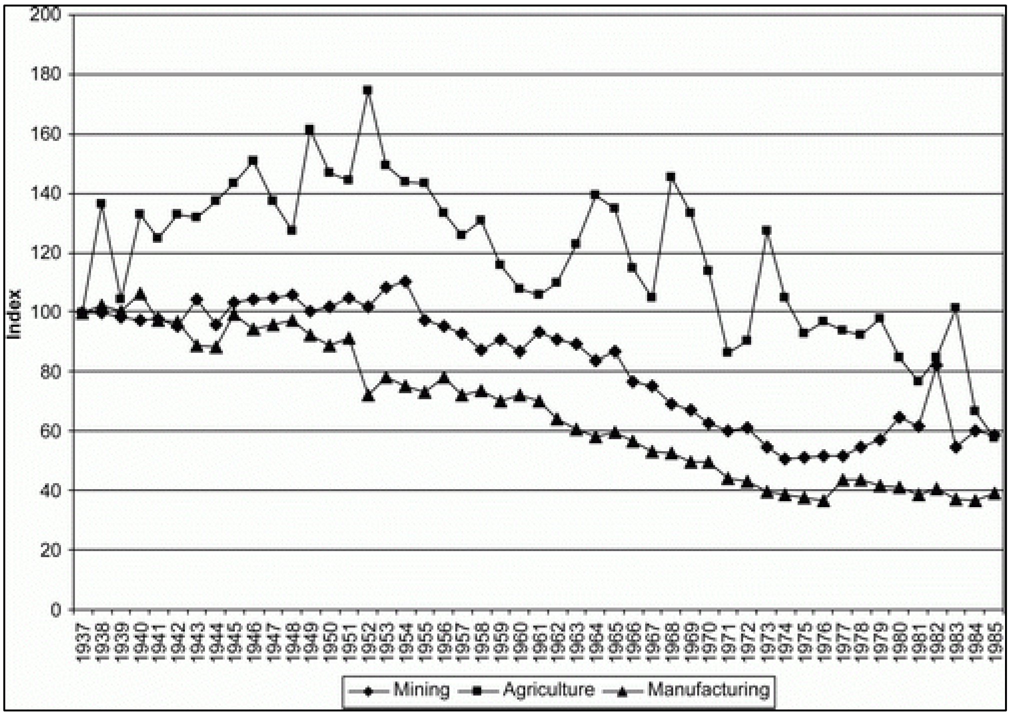

Figure 7: Extrapolation of Verburgh's original 1958 data sets
Sources: Rail tons up to 1956 from Verburgh (1958), rail tons from 1957 onwards from Transnet Freight Rail (2011).

REFERENCES

1. ACIL Tasman. 2007. Underpinning regional development with infrastructure – Best practice for infrastructure planning and allocation of infrastructure funds. Report prepared for the Western Australian Regional Development Council. http://rdl.wa.gov.au/publications/Documents/Underpining%20Regional%20Development%20with%20Infrastructure.pdf .
2. Aschauer, D.A. 1989. Public investment and productivity growth in the Group of Seven. Federal Reserve Bank of Chicago. Economic Perspectives Sep: 17–25. http://www.chicagofed.org/digital_assets/publications/economic_perspectives/1989/ep_sep_oct1989_part3_aschauer.pdf .
3. Bierman, N. 2006. The role and characteristics of private (not for reward) road transport operators in the South African freight mark . MCom diss, University of Johannesburg.
4. Bogetić, Z., and J. Fedderke. 2006. International benchmarking of South Africa's infrastructure performance. *Journal of Development Perspectives* 2, no. 1: 7 – 31.
5. Bom, P.R.D., and J.E. Ligthart. 2008. How productive is public capital? A meta-analysis. CESifo Working Paper no. 2206. http://www.cesifo-group.de/portal/pls/portal/docs/1/1187266.PDF .
6. Brown, T.R. , and A.B. Hatch. 2002. The value of rail intermodal to the US economy. The American Association of State Highway and Transportation Officials: Special Committee on Intermodal Transportation and Economic Expansion. http://intermodal.transportation.org/Documents/brown.pdf .
7. Calderón, C., E. Moral-Benito , and L. Servén. 2011. Is infrastructure capital productive? A dynamic heterogeneous approach . Documento de trabajo no. 1103. Banco de España.
8. CSIR, University of Stellenbosch, and Imperial Logistics. 2010. Annual State of Logistics Surveys (1st to 7th) . www.csir.co.za/sol .
9. Delius, P., and S. Schirmer. Historical research and policy making in South Africa. *African Studies* 59, 1: 5 – 12 doi: 10.1080/713650977.
10. Démurger, S. 2001. Infrastructure development and economic growth: An explanation for regional disparities in China?. *Journal of Comparative Economics*, 29: 95–117. doi:10.1006/jcec.2000.1693.
11. DoT (National Department of Transport, South Africa). 1996. White paper on national transport policy. Pretoria: Department of Transport.
12. DoT. 1998. *Moving South Africa: A transport strategy for 2020*. Pretoria: Department of Transport.
13. DoT. 2005. *National freight logistics strategy*. Pretoria: Department of Transport.
14. eNATIS (electronic National Traffic Information System). 2011. www.enatis.com .
15. Eurostat. 2009. International Transport Forum. National Statistics (CH): 1990–2009 estimates.
16. FAO. 1997. Management of agricultural research: A training manual. Module 2: Research planning. Food and Agriculture Organisation of the United Nations. http://www.fao.org/docrep/W7502E/w7502e03.htm .
17. Farhadi, M. 2011. Transport infrastructure and long-run economic growth in OECD countries. 40th Australian Conference of Economists Canberra. 11–14 July 2011. http://ace2011.org.au/ACE2011/Documents/Abstract_Minoo%20Farhadi.pdf .

18. Fedderke, J., Perkins, P. and Luiz, J. 2006. Infrastructural investment in long-run economic growth: South Africa 1875–2001. *World Development*, 34(6): 1037–59. doi:10.1016/j.worlddev.2005.11.004.
19. Frankel, S.H. 1928. *The railway policy of South Africa: An analysis of the effects of railway rates, finance and management on the economic development of the Union*, Johannesburg: Hortors.
20. Goodwin , F. 2000. Transport, infrastructure and the economy: Why new roads can harm the economy, local employment, and offer bad value to European taxpayers. European Federation for Transport and Environment. http://www.transportenvironment.org/Publications/prep_hand_out/lid/35 .
21. Hamilton, C.C. 1983. *Die Suid-Afrikaanse goederevervoermark*, Pretoria: Nasionale Instituut vir Vervoer- en Padnavorsing, WNNR.
22. Hamilton, C.C. 1986. *The estimated market share of public and ancillary road carriers in a specifically defined South African goods transport market*, Pretoria: National Institute for Transport and Road Research, CSIR.
23. Havenga, J.H. 2007. The development and application of a freight transport flow model for South Africa. DPhil diss, University of Stellenbosch.
24. Havenga, J.H. 2011. Trade facilitation through logistics performance: The enabling role of national government. *Journal of Transport and Supply Chain Management*, 5(1): 123–48.
25. Havenga, J.H. and Hobbs, I.E. 2004. *A practical guide to strategy: Making strategic thinking, development and implementation accessible*, Stellenbosch: Sun Press.
26. Havenga, J.H., Pienaar, W.J. and Simpson, Z. 2011. A case for measuring logistics costs on a national level: A South African application. *Corporate Ownership and Control*, 8(3): 622–31.
27. Havenga, J.H., Simpson, Z. and Fourie, P. 2011. *Unpublished freight transport demand model developed for Transnet*, Durbanville: Growth and Intelligence Network.
28. Hilder, C. 2003. Why Australia needs a long-term national infrastructure strategy. *Public Infrastructure Bulletin* 1, no. 1 : http://epublications.bond.edu.au/pib/vol1/iss1/2 .
29. Jiang, B. 2001. A review of studies on the relationship between transport infrastructure investments and economic growth. Research conducted for the Canada Transportation Act Review. http://www.reviewcta-examenltc.gc.ca/CTAReview/CTAReview/english/reports/jiang.pdf .
30. Jones, T. 1999. The South African transport sector in the 1970s. *South African Journal of Economic History*, 14: 162–94. doi:10.1080/10113439909511115.
31. Jones, T. 2002. “The freight transport sector, 1970–2000”. In *The decline of the South African economy*, Edited by: Jones, S. 143–64. Cheltenham: Edward Elgar.
32. Kennedy, T.L. 1984. *Road and rail transport and distribution costs: A modal choice model*, Pretoria: National Institute for Transport and Road Research, CSIR.
33. Laaksonen, S. 1999. Employment and technology: Results of recent econometric research . In IPTS-ESTO Techno-Economic Analysis Report , J. Lievonen and J.C. Císcar . June 1999 European Commission.
34. Lakshmanan, T.R. and Anderson, W.P. 2002. *Transportation infrastructure, freight services and economic growth: A synopsis of a white paper*, Washington: The US Department of Transportation, Federal Highway Administration.

35. Mitchell, M. 2004. The history of transport infrastructure in South Africa during the past 50 years. Unpublished report prepared for the Development Bank of South Africa.. Pretoria.
36. Mitchell, M. 2006 . Confronting land freight challenges in South Africa. www.sarf.org.za/news/30_Land%20freight%20issues%20web.doc .
37. OECD. 2010. International Transport Forum: Key Transport Statistics Trading Economics.
38. Perkins, P., Fedderke, J. and Luiz, J. 2005. An analysis of economic infrastructure investment in South Africa. *South African Journal of Economics*, 73(2): 211–28. doi:10.1111/j.1813-6982.2005.00014.x.
39. Pienaar, W.J. 2005. Estimation of increased regional income that emanates from economically justified road construction projects. *South African Journal for Science and Technology*, 24(4): 108–17.
40. Pienaar, W.J. 2008. Economic evaluation of the proposed road between Gobabis and Grootfontein, Namibia. *South African Journal of Economics*, 76(4): 667–84. doi:10.1111/j.1813-6982.2008.00220.x.
41. Pienaar, W.J. 2010. The regulation of commercial petroleum pipeline operations: A South African example. *Corporate Ownership and Control*, 7(3): 188–92.
42. Pretorius, W.P. 1991. *Freight transport data bank report*, 2nd ed, Johannesburg: Research Unit for Transport Economic and Physical Distribution Studies, Rand Afrikaans University.
43. Schirmer, S. 1998. Towards a new interpretation of the history of economic growth. South African Journal of Economic History 13 (September 1998): 75 – 101.
44. Singer, M. 1991. Issues in long-term planning for economic development. In *Theoretical foundations of development planning: volume 1*, S.B. Dahiya, 326 – 46. New Delhi: Concept.
45. Smith, W.J.J. 1973. *A quantitative study of road hauliers and ancillary road transport users in the Republic of South Africa*, Johannesburg: Rand Afrikaans University.
46. Solomon, V.E. 1983. Transport. In *Economic history of South Africa* , F.L. Coleman , 89 – 124. Pretoria : Haum Educational.
47. Statistics South Africa. 2011. Land transport survey. http://www.statssa.gov.za/publications/statspastfuture.asp?PPN=P7162&SCH=4694
48. Stiff, D. and Smetanin, P. 2010. *Public infrastructure underinvestment: The risk to Canada's economic growth*, New York: RiskAnalytica.
49. Stigson, B. 2004. *Mobility 2030: Meeting the challenges of sustainability*, Geneva: World Business Council for Sustainable Development.
50. Thompson, F. n.d . Cost and production . Willamette University , Oregon. http://www.willamette.edu/~fthompso/ManEX/Sem119-Costs/Cost.html (accessed 25 November 2011) .
51. Trading Economics 2008 Available at http://www.tradingeconomics.com (accessed 27 November 2012).
52. Trading Economics 2010 Available at http://www.tradingeconomics.com (accessed 27 November 2012).
53. Transnet Freight Rail. 2011. *Historical rail data obtained from Transnet Freight Rail*. Johannesburg: Transnet Limited.
54. United States of America, Department of Transportation (USA DoT) 2007 1990–2007 estimates.
55. United States of America, Department of Transportation (USA DoT) 2009 Research and Innovative Technology Administration. Bureau of Transport Statistics.

56. Van der Veer, G.D. 1982. The role of rail transport in the total transport scene. In Freight transport. Proceedings of the Annual Transportation Conference Pretoria.
57. Van Niekerk, H.C. 2004. *Class notes (Port Economics)*, Stellenbosch: University of Stellenbosch.
58. Verburgh, C. 1958. Road transport of goods in South Africa. Bureau for Economic Research, Faculty of Commerce, University of Stellenbosch.
59. WWF (World Wildlife Fund). 2006. Living planet report. Gland: WWF International.
60. Yevdokimov, Y.V. 2000. Measuring economic benefits of intermodal transportation. *Transportation Law Journal* 27, no. 3 : 439 – 52.