OVERVIEW OF SALIENT ECONOMIC FEATURES OF THE MODES OF FREIGHT TRANSPORT FOR USE IN THE FORMULATION OF NATIONAL TRANSPORT POLICY IN SOUTH AFRICA

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Abstract

Defining the economic role of the various modes of freight transport should be one of the basic ingredients of both an economically rational transport policy and the effective functioning of the existing free freight transport market in South Africa. In the interest of the national economy and in the commercial interest of freight carriers, national policy on freight transport should take cognisance of (1) why governments involve themselves in transport, (2) the policy instruments of governments that affect the performance of the freight transport sector, and (3) the salient economic features of the freight transport market that should be considered in the formulation of transport policy. The goal of the research was to compile an overview of these three aspects. The research approach and methodology combine (1) a literature survey; (2) an analysis of the cost structures of freight transport modes; and (3) interviews conducted with specialists in the freight transport industry.

Keywords: Cost Structure, Economic Regulation, Economies of Density, Economies of Scale, Economies of Scope, Modes of Freight Transport

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1 Introduction

During the early 1970s, the general view prevailed that because of economies of scale, the need to protect rail carriers, and the potential for serious market failure, it was in the public interest to regulate freight transport through economic control. However, the operational business requirements of industrialised and trading nations called for liberalisation and reform. These came about from the late 1970s. The new viewpoint that was taking root was that regulatory failures are often more damaging than market failures.

The economic environment in most countries from the late 1970s to the early 1990s was marked by rapid change. This was facilitated and fuelled by two main driving forces: the emergence of freer competition both within domestic borders and internationally, and swift advances in technology.

The emergence of more open market conditions was made possible mainly by the economic deregulation of both freight transport and the marketing of agricultural produce; the privatisation of many utility industries; the globalisation of business activities; and the liberalisation of international trade. In addition to these factors South Africa also benefited by the lifting of trade sanctions. The effect was to make freight transport decision making and the distribution of goods more market-driven. In the interest of the national economy and in the commercial interest of freight carriers, national policy on freight transport should take cognisance of these open market conditions. The goal of the research was to identify the salient economic features of the freight transport market that should be considered in the formulation of such policy.

The research approach combined a literature survey and an analysis of the cost structures and economic features of freight transport operations within each mode of transport. In this paper the results of the research are described qualitatively. Section 2 supplies reasons for government involvement in transport. In Section 3 instruments are identified that governments apply to influence the performance of the freight transport industry. Section 4 provides the intended meaning of cost terminology used in the paper. Salient economic characteristics of the modes of freight transport that national policy makers should be aware of are supplied in Sections 5 to 9. A concluding summary is contained in Section 10.

2 Government as stakeholder in the transport system

Governments apply various mechanisms, deemed to be in the public interest, to intervene in transport. This is because transport is indispensable for sustaining society's welfare and economic development. Governments are to a lesser or greater extent involved in transport as producers, providers or financiers of infrastructure, facilities and services, and as regulators. A diverse range of motives have been advanced for government involvement in transport. These are outlined in the following sections.[9]

2.1 Control of excessive competition

Unrestrained competition may lead to prices being driven down so that total cost coverage is not possible. In reaction to this, an operator may neglect to provide for vehicle replacement, ignore the cost of invested capital or terminate vehicle insurance payments, which can jeopardise the quality of service. Loss-making operators that desperately want to stay in the market may be inclined to avoid essential expenses or to apply dangerous tactics, such as overloading vehicles, not replacing worn tyres when necessary or not conducting routine vehicle maintenance. The more that users fail to recognise lessening standards in safety and quality of service, the more operators may be tempted to cut back even further on safety and service quality to their clients, which ultimately gives rise to instability in the transport market, notably in road freight carriage.[10] The problem is not competition as such, but rather that through a lack of technical control market imperfections may arise or, in the absence of a common freight carrier, that sections of the market may remain inadequately serviced.

2.2 Coordination of transport

Owing to the general inability of vehicle operators to accurately perceive their true transport costs, oversupply of transport capacity may occur, leading to a waste of resources. On the other hand, an overestimation of transport costs could lead to an undersupply of transport services, which could unduly inhibit transport-dependent economic activities if the transport market is not coordinated through government intervention.

2.3 Integration of transport with economic policy

The interaction between land use and transport needs to be coordinated. For example, industrial settlement should be close to where sufficient labour is available and primary production should occur close to the point of origin of resources. This type of coordination may form part of the central government's wider macroeconomic strategies and regional authorities' spatial planning. Investment in transport infrastructure and services will only underpin economic growth and development if the prerequisite factors of production are available. These include, for example, sufficient land, access to raw materials and qualified labour, services and utilities, and entrepreneurs who are able and willing to invest in the service area(s) of such infrastructure. Sometimes these prerequisite ingredients may be present but investment in transport infrastructure and services is the only absent ingredient needed to induce economic growth and development. At other times, transport investment alone may be insufficient to stimulate additional economic growth and development. However, in coordination with non-transport actions, investment in appropriate transport could result in significant economic growth and development. Those other complementary actions could be removing or overcoming limitations of labour force skills and mobility, high business costs, unavailability of utilities and services, non-existence of industrial settlement grants, etc., which require government coordination and support.[11]

2.4 Maintenance of safety, security and order

Conventions and rules of conduct required for sound transport housekeeping need to be in place. Technical regulation and safety measures are needed for safe, secure and orderly use of transport infrastructure and operation of services. Driving on a certain side of the road; not overloading freight vehicles; not driving too fast; and securing dangerous freight are areas where such regulation applies. Defendable conventions on how to deal with the acquisition of right of way for transport infrastructure over private property when it is deemed to be in the public interest and fair remuneration thereof require government guidelines and prescription to enable enforcement.

2.5 Provision of costly infrastructure

Certain infrastructure developments, which are usually a prerequisite for effective logistics service and economic growth and development (for example, seaports, airports and railway lines dedicated to heavy bulk commodity carriage) involve high investment costs, long periods for recouping capital costs and high levels of risk. The consequence is that such developments are provided by government, or that government creates a supportive framework within which private investment in such infrastructure ventures can take place remuneratively, with government as partial financier and private enterprise as producer.

[9] Button, K. J. 2010: 464,465; Cowie, J. 2010: 226-245; Pienaar, W.J. 2007: 273, 274.
[10] Pretorius, J. 1997:8-1, 8-2.
[11] Pienaar, W.J. 2008: 676.

2.6 Provision of public goods

Certain types of infrastructure cannot be supplied through private investment at an acceptable profit in the absence of government intervention, or if an effective means for collecting income from users is not readily available to private investors. Examples are certain transport infrastructure components, for example, uncongested roads, street lighting and lighthouses along shipping lanes, which are deemed to possess a measure of public good characteristics. These characteristics are, firstly, non-excludability, whereby use cannot be withheld from non-payers, rendering pricing through market forces elusive, and, secondly, non-rivalry, whereby one person's use does not diminish that of others (e.g. after usage of uncongested road space it is immediately available for the following user, i.e. the road space does not deplete). Non-excludability makes it difficult, if not impossible, to enforce payment and is to a certain extent a technological phenomenon. Non-rivalry implies the absence of scarcity, which means the price mechanism has no function to ration demand and/or supply in order to clear the market. Consequently, it is not possible to determine an effective price. The measure to which such infrastructure can be provided efficiently and priced effectively is dependent on government intervention, such as the institution of acceptable road tolling and workable traffic control measures (e.g. to temporarily prohibit street access by freight vehicles during times when their presence is deemed undesirable, or to spatially limit heavy-goods-vehicle movement to certain road lanes to permit segregation of traffic according to speed for safety reasons).

2.7 Recovery of the true resource cost of transport inputs

The market mechanism may fail to reflect the scarcity value of exhaustible resources, such as petroleum. Governments may, therefore, steer transport decision makers away from over-utilisation of such resources through pricing tactics. One example of such tactics is indirect taxes built into the price of certain fuels.

2.8 Regulation of harmful conduct and externalities

Transport activities may impose costs and hardship on others not party to the transport activity. Examples are pollution caused by freight vehicles, and third-party and public liability caused by accidents (such as pain, suffering and loss of income). These social costs are often excluded in transport decision making. In an attempt to curb the detrimental effect of such market failures the need arises for governments to apply social justice and 'internalise' these externalities through legislative measures.

2.9 Restraint of monopoly power

Owing to the large investment as an absolute amount often involved in indivisible and durable equipment and infrastructure, and the high ratio of fixed costs that in certain cases occur in freight transport, notably pipeline and rail transport, the breakeven point between revenue and cost can occur at a high level of output. This means that a large volume of freight services must be sold before a profit is realised. This may imply that to fully reap the benefits of economies of scale there is room for only one incumbent service provider in the market, i.e. a natural monopoly. Measures to prevent transport monopolies were previously particularly related to rail transport and were applied to reduce the potential for exploitation. In industrialised countries, technical advances within other modes of transport and the economic deregulation of the freight transport industry have reduced the potential for monopolistic exploitation. Nowadays, more pertinent is the potential for cartel formation, the process by which a small number of operators (i.e. an oligopoly) dominate a market segment through collusion.

2.10 Social support

Social criteria may be needed to guide transport resource allocation in order to afford all spheres of society mobility and access to economic activities. Corrective measures may be necessary when groups in society are too indigent to afford participation in transport or lack adequate transport infrastructure and/or services.

3 Policy instruments of governments that affect the performance of the freight transport sector

A set of nine instruments can be identified that governments apply to influence the performance of the freight transport industry: Legislation; Direct supply; Fiscal measures; Monetary measures; Moral appeal and persuasion; Policies relating to strategic commodities; Procurement policy; Provision of information; Research and development

3.1 Legislation

Governments exert statutory control over transport on three levels.[12] First, in the broadest sense, this covers the laws that govern the conduct of all legal subjects (for example, human behaviour and the activities of business). From this point of view, all business is regulated, since it is subject to the rules of conduct prescribed by the state.

Second, governments impose (a) general industrial and business legislation in order to deal with market imperfection and failure (governing aspects

[12] Pegrum, D. F. 1973: 243.

such as restrictive and unfair business practices and mergers); and (b) consumer-protection legislation (including areas like advertising). These embrace all forms of activity in the economy and not just transport.[13]

Third, legislation may be aimed specifically at the freight transport sector in order to control and direct the activities of both transport suppliers and users. This level of transport legislation includes economic and technical regulation.

Economic regulation is aimed at manipulating the supply of and demand for transport by controlling the quantity and price of transport (for example, market entry; place of operation; service volume; maximum and minimum tariff levels; and profit margins). Technical regulation addresses (a) qualitative issues (for example, traffic safety; the carriage of abnormal loads and dangerous goods; vehicle dimensions; gross vehicle and axle mass; and vehicle roadworthiness); and (b) social matters (for example, external costs, such as vehicle emissions and noise, and the maximum number of driving hours per shift). Governments promulgate technical regulations and enforce them by law. The avenue through which they enforce these regulations is by granting conditional permissions and then policing and monitoring the way in which use is made of the permissions. Examples of these are:

- toll road concessioning;
- vehicle roadworthiness certification and annual vehicle licensing;
- licensing vehicle drivers and granting professional driver permits;
- a permit system to carry hazardous or dangerous goods and abnormally sized loads; and
- area licensing (e.g. a quota system to limit the number of vehicles entering congested areas during hours of business).

3.2 Direct supply

Different tiers of government and state corporations are providers of a wide range of transport services (for example, rail, pipeline and air transport operations). They are also responsible for supplying and financing transport infrastructure (for example, railway tracks, roads, seaports and airports) and support services (for example, navigation and traffic control).

3.3 Fiscal measures

Governments may use their fiscal powers either to increase or reduce the costs of different modes of transport or services in certain areas or over certain routes by imposing taxation or granting subsidies. They also may influence the factor costs of transport inputs through import duties, customs and excise levies.

3.4 Monetary measures

Governments may use their monetary powers to influence the quantity of money supply by manipulating the interest rate and applying credit control. The latter may include direct control over credit arrangements (for example, determining minimum deposit requirements and maximum payback periods when vehicles and other durable transport equipment are procured through hire-purchase and lease agreements).

3.5 Moral appeal and persuasion

This is usually a weak policy instrument, often involving educational messages, or rendering advice on issues like safety (for example, publicising the advantages of not overloading vehicles, or not speeding). It may, however, be effective when the alternative to accepting advice is the exercise by government of its powers, such as the refusal of a permit or licence, or the withdrawal of a subsidy.

3.6 Policies relating to strategic commodities

The freight transport sector is a major user of energy, especially diesel fuel and electricity, and a wide spectrum of other raw materials and intermediate goods. Government policies relating to these matters can have a significant influence on transport, even more so when these commodities or goods are imported (a) from regions where political conflict prevails, or (b) at times that the exchange rate of the currency of the importing country is weak, or when service supply interruptions occur (e.g. the supply of electric power on which certain modes of transport rely). For example, in South Africa a substantial proportion of long-distance freight carriage is conducted by rail and pipeline transport. Large infrastructure investments in these two modes of freight transport stand to be made in the near future, and a choice between electric and diesel power will need to be made before investment decisions are taken. Government intentions relating to the generation and supply of electric power, and of petroleum oil procurement from abroad will be critical in the investment decision-making process by the operators of freight rail and pipeline transport.

3.7 Procurement policy

Most government activities require the use of transport services. Therefore, through their position as large consumers/users, governments may exert a degree of countervailing power over transport operators and input suppliers. A government body might, for example, require that a successful tenderer provide in-house training to a number of junior public officials, or that a portion of the provider's income must be

[13] Button, K. J. 2010: 467.

invested in a project that promotes government policy. Governments may also wish to demonstrate social responsibility by preferring to procure inputs from groups that may be judged to come from disadvantaged backgrounds.

3.8 Provision of information

Through various agent bodies governments provide technical advice to transport operators (for example, navigation services for aviation and weather services for shipping) and provide general information to improve decision making within transport (for example, information on international trade arrangements).

3.9 Research and development

Governments may promote innovation within, and the development of, transport through their own research activities, or by supporting and commissioning outside research, such as research development projects conducted by academic institutions. These are usually conducted or financed in the public interest by governments, as transport operators/providers might not have the capacity to conduct such research.

Although these measures are technical, social, or of indirect economic nature, they significantly impact on the business performance of the freight transport industry.

4 Intended meaning of terms used in this paper

The intended meaning of certain terms used and conventions followed in this paper are as follows:

- Cost structure refers to the relationship between the fixed and variable components of total costs. Numerically, it is usually expressed as fixed cost or variable cost as a fraction of total costs. In this work, preference is given to fixed cost as a proportion of total costs.
- Cost, expenditure and price are used synonymously.
- Total costs refer to the full transaction prices borne by an operator, including all indirect taxes, plus subsidies if any inputs are subsidised.
- Fixed costs refer to expenses that cannot be avoided if a trip does not take place.
- Variable costs refer to expenses that are avoided if a trip does not take place.
- Direct costs are specific to an individual product (or cost carrier) and are fully allocated to it.
- Indirect costs refer to costs that are incurred jointly or commonly on different products (or cost carriers) so that the deemed cost of each one can only arbitrarily be apportioned.
- Cheaper means at a lower total cost per output unit at similar load factors.
- More expensive means at a higher total cost per output unit at similar load factors.

5 Air transport

5.1 Air transport cost structure

The cost structure of air transport is characterised by fairly balanced proportions of fixed and variable costs.[14] With freight-only services, the fixed costs normally exceed the variable costs somewhat, and vice versa for passenger-only services. With combined passenger-freight services, the fixed and variable cost components are approximately even. Because of the high start-up costs, the financial barriers to entry to the airfreight market are high, more so when commencing with freight-only services, and slightly less so with combined services where the common supply of passenger and freight service leaves room for less immediate investment in freight terminals[15]. The high cost of entry to the air transport market stems from the initial cost of acquiring aircraft, the immediate long-term commitment to essential overhead cost items (e.g. terminals) and the prior recruitment of highly skilled and specialised staff. The higher need for investment in freight terminals and related facilities when an airline's business orientation towards freight services increases suggests that significant economies of scale exist in air-freight operation.[16]

5.2 Air transport efficiency

5.2.1 Cost level

The cost to transport a unit of freight by air is the highest of all modes of transport. This results from the limited carrying capacity and high capital and other operating costs of aircraft. On a full-trip basis, the cost differential becomes bigger for door-to-door services when the origins and destinations of freight shipments are well separated from airports, necessitating the use of feeder and delivery services.

5.2.2 Economies of fleet size

In air transport, there is a technical limit to the economies of scale that one can achieve by increasing the fleet size. Making use of a large fleet without increasing the number of airports visited requires frequent and large operations. This is feasible only if there is a continuously high demand for the large number of aircraft.[17] Although increasing fleet size does not necessarily result in significant economies of scale, a large fleet, but with mixed operations, may result in significant economies of scope. It may be more economical for one carrier to undertake both scheduled and charter flights than for separate carriers

[14] ICAO. 1999:1.
[15] Wensveen, J.G. 2007: 304-308.
[16] Cowie, J. 2010: 298.
[17] Wei, W. and Hansen, M. 2003: 294.

to specialise in one of the two types of service. Air and sea transport enjoy similar economies of fleet size – the second highest level after rail transport. However, air and rail transport do not generally compete with each other.

5.2.3 Economies of vehicle size

In seasonal or peak-oriented markets, operating large aircraft with flexible cargo-passenger combinations may result in increased loads and thus increased economies of scope.[18] In order not to prolong aircraft turnaround times at airports, large aircraft require effective procedures and equipment to load and unload them quickly. Air and sea transport enjoy similar economies of vehicle size – the second highest level after pipeline transport. However, air and pipeline transport are not in competition with each other.

5.2.4 Economies of infrastructure extension

An obstacle to effective logistics service delivery with air transport is its inability to provide door-to-door service. Airfreight operators are in direct competition with passenger airlines for airport access, as areas of high demand for passenger destinations are often also areas of high demand for freight. The prevalence of airport congestion (both in the air and on land) at major passenger hub airports contributes to the fact that freight-only operations tend to be at night and/or based around regional airports.[19] Adapting terminal facilities at regional and other subordinate airports that are close to concentrated areas of freight supply and demand to accommodate airfreight traffic effectively should enhance the accessibility and market coverage of this mode of transport. This could lead to total transit time savings, and reduce the cost of providing airfreight services. However, business logic requires that the value of improved airport accessibility, greater market coverage, transit time savings through less congestion and reduced cost of airport access and egress, and other benefits, must offset the cost of such airport infrastructure upgrades and extensions.

5.2.5 Economies of distance

On condition that intermediate landing is not necessary and that the crew do not need to change, longer route lengths give rise to significant economies of distance. With no intermediate landings, large time savings are achieved, as well as savings with those variable cost items that do not vary according to the length of flights. These are:

- aircraft maintenance necessitated by the number of landings (e.g. wheel fittings, tyres);
- charges for traffic control and navigation close to airports;
- landing charges;
- terminal services (such as cleaning; power connection; charges for cargo handling, loading and unloading, parking); and
- additional fuel consumption immediately after take-off.

These five points become less significant as flight lengths increase. For example, the fuel consumption rate of a Boeing 737-200(F) between Johannesburg and Cape Town carrying a payload of 20 tons over the route length of 1 271 km is 330 litres per ton payload. The comparative fuel consumption with the same aircraft and payload for the 502 km route between Johannesburg and Durban is 170 litres per ton payload carried. The fuel consumption rate per ton of freight on the latter route is 52 per cent of the former, while the route length of the latter is only 40 per cent of the former. This is because the aircraft consumes between 1 200 and 1 300 litres of fuel extra to reach its cruising altitude, whereafter it cruises at 4,24 ℓ/km, hence an economy of distance.[20]

Air and sea transport enjoy similar economies of distance – after rail transport, the second highest level.

5.3 Air transport competition

5.3.1 Predominant intramodal market type

Since the economic deregulation of airfreight transport markets, there has been a trend towards an oligopolistic market structure.[21]

5.3.2 Predominant intermodal competition

Air and road transport compete with respect to price and service. Air transport is usually faster, but as the haul becomes shorter, the speed advantage of air versus road transport diminishes, especially in the face of door-to-door road services when the origins and destinations of freight shipments are well separated from airports. Domestically, air transport competes – typically for overnight service outside core business hours – with road transport for small shipments , and internationally with transoceanic sea freight for items for which a short lead time is vital, and courier/mail consignments. Theoretically, airfreight competes for those items for which the airfreight tariff premium is less than the value added by receiving the goods sooner than by the next fastest but cheaper mode of transport.

Conveying items by air is the most desirable form of transport under the following conditions:[22]

- When the commodity is:
  - perishable;
  - subject to quick obsolescence;
  - required at short notice;
  - valuable relative to weight; or
  - expensive to handle or store.

[18] Holloway, S. 2008: 369.
[19] Cowie, J. 2010: 298.
[20] Africon. 2008: 19.
[21] Vasigh, B., Fleming, K. and Tacker, T. 2008: 180.
[22] ATA. 1988: 1.

- When the demand is:
  - unpredictable;
  - infrequent;
  - in excess of local supply; or
  - seasonal.
- When the distribution problems include:
  - the risk of pilferage, breakage or deterioration;
  - high insurance or interest costs for long in-transit periods;
  - the need for heavy or expensive packaging for surface transportation;
  - the need for special handling or care; or
  - the need for warehousing or stock in excess of what would be required if airfreight were used.

6 Road transport

6.1 Road transport cost structure

Of all forms of transport, road transport has the smallest proportion of fixed costs to total costs, making this market sector highly competitive, and thus less prone to monopolistic or oligopolistic behaviour. Among the factors leading to the high proportion of variable costs are the following:

- The fuel consumption of road transport vehicles is relatively high, making fuel cost a proportionally large variable cost component.
- Road infrastructure is publicly owned. Governments to a great extent recover road-user cost responsibility through levies included in the price of fuel (of which the consumption is already high) and toll tariffs, thereby converting a fixed cost responsibility into a variable transport expenditure.
- Freight terminal facilities (whenever a road haulier actually owns such facilities) are less capital-intensive than the terminal facilities of other forms of transport.

For combination vehicles that are permanently engaged in long-distance carriage, fixed costs vary between approximately 35 per cent and 40 per cent of total costs, and for rigid goods vehicles permanently employed in local delivery and collection work the fixed and variable costs are fairly evenly balanced. Whenever long-distance operations involve frequent travelling on tolled roads and high payments of overtime remuneration and over-night allowances, variable costs may rise to 70 per cent of total costs.[23]

6.2 Road transport efficiency

6.2.1 Cost level

The cost to transport a unit of freight by road is (after air transport) the second highest, and third highest of all modes of transport on short trips, where road is cheaper than rail transport.[24] In view of the fact that rail transport achieves considerably more economies of distance than road transport, road transport becomes progressively more expensive than rail transport for all classes of freight as trip distances increase above approximately 500 kilometres. For trips shorter than roughly 150 kilometres, road transport is virtually always cheaper than rail transport. For all types of goods that can possibly be carried either by road or rail transport between the same trip origins and destinations, the equal cost distance of the two modes lies between approximately 150 and 500 kilometres. (For example, the equal-cost distance for the shipment of standard intermodal containers and units of palletised freight by road and rail is approximately 500 km.) Comparing road freight costs with other modes over all route distances, pipeline is cheaper than road transport. Over equal distances, the unit cost in ton-km to carry freight by sea is substantially lower than road transport. However, road transport is cheaper than inter-port sea carriage when, firstly, the sailing distance between the ports is too short for vessels to gain sufficient economies of distance; and/or, secondly, the trip origins and destinations of freight shipments are significantly remote from the ports, and vice versa when the inter-port distance is substantially long and/or the origins and destinations are close to the ports.

6.2.2 Economies of fleet size

Increased road vehicle fleet sizes, coupled with productive utilisation of this greater capacity, can result in some economies of scale. Although the achievement of economies of scale emanating from fleet size is moderate, it is in relative terms, after rail transport, the second highest of the various modes. Own facilities, such as terminals – particularly for specialised carriers – provide opportunities for economies of scale.[25] Potential sources of economies of scale are a workshop owned by the business for vehicle maintenance and repairs; standardisation of vehicles, which reduces the quantity of spare-part inventories; discount on bulk purchases, and so on.

6.2.3 Economies of vehicle size

As the carrying capacity of road vehicles increases, vehicle-specific costs increase less than proportionally. Vehicle-specific costs are running costs, such as fuel and oil consumption, maintenance and tyre wear. Also, engine size and number of crew members required increase less than proportionally to an increase in vehicle size.[26] The costs of dispatching and load documentation tend to remain the same regardless of load or shipment size that vehicles of

[23] Road Freight Association. 2012: 7-19.

[24] Pienaar, W. J. 2007: 269.
[25] Cowie, J. 2010: 286.
[26] Road Freight Association. 2012: 7-19.

different sizes can carry. These relationships account for the trend towards long-haul road vehicles whose length, width, height and gross vehicle mass are often the maximum that road-traffic legislation allows. Although the achievement of economies of vehicle size in road transport is significant, it is in relative terms along with rail transport the lowest, resulting mainly from the limits of vehicle dimensions prescribed through legislation.

6.2.4 Economies of infrastructure extension

In view of the fact that governments typically recover road-user cost responsibility, except licence fees, through levies included in the price of fuel and through toll tariffs, thereby converting a fixed-cost responsibility into variable transport expenditure, road transport businesses do not gain significantly from enlarged road capacity. However, with standing costs being fixed, at least on a monthly basis, extensive travelling (many kilometres per month) and the avoidance of travelling during periods of traffic congestion so as to increase trip speeds, some economies of density, albeit small, in terms of infrastructure use can be attained.

6.2.5 Economies of distance

Generally, owing to the high ratio of vehicle running costs (which accumulate as distances increase) to total costs of individual vehicles, and the relatively small terminal facilities or absence of own facilities, road transport does not enjoy significant economies of distance – in fact it is the second lowest of all modes of transport, with pipeline transport having the least.

A few trip-specific operating cost items are incurred on certain journeys. These are:

- toll fees payable where applicable;
- permit fees, in the case of trips into neighbouring countries;
- escort fees, when certain abnormal loads are carried;
- overtime remuneration and accommodation allowances for vehicle crews; and
- documentation costs and handling costs at trip ends when consignors and consignees are unable to provide handling equipment.

The first four of the five points above are, whenever they occur, usually less than proportionally related to distance. Therefore they can contribute somewhat to economies of distance. It is only the fifth item that is not affected by trip distance at all. Being a relatively small cost item, it is too small to contribute significantly towards economies of distance. All five of these cost items are avoided if a trip is not undertaken, and therefore they are variable costs. Their occurrence will increase the variable cost as a proportion of total cost.

6.3 Road transport competition

6.3.1 Predominant intramodal market type

Road freight transport competition ranges from open to oligopolistic. The fixed costs of operators with non-specialised fleets who carry truck loads and do not own any terminal facilities are very low. The financial barriers to market entry for these operators, especially in cases where their vehicles are hired or leased, even more so for single-vehicle operations, are very low, and this market segment is highly competitive.[27] Of all freight transport industry segments, the aforementioned non-specialised truck-load (TL) road haulage is the closest to perfect competition. Against this, specialised carriers and carriers of part-loads, also called less-than-truck-load (LTL), and parcels generally require terminals. This increases their fixed costs, and they face some financial barriers to entry. Their unit costs decrease with increased traffic volume (economies of density) and distance of haulage (long-haul economies). Although specialised and LTL carriers operate in an oligopolistic market, it is one in which competition is reasonably intensive and mostly based on the price charged. Fleet sizes in the road freight market vary between one vehicle (often owner-driver operators) and more than a thousand.

Larger road transport carriers who own suitable terminals can achieve considerable economies of scope by sorting and then consolidating heterogeneous part loads effectively into homogeneous containerised shipments, thereby creating an economy of density, which, in turn, enhances economies of scale. However, none of these potential advantages preclude competition from smaller operators, which indicates that the achievement economies of scale in road transport is not strong.[28]

6.3.2 Predominant intermodal competition

Road transport competes with rail transport for break-bulk and containerised freight, with air transport for small shipments , and with sea transport on inter-seaport services.

7 Rail transport

7.1 Rail transport cost structure

Owing to the high capital investment in rail infrastructure (railway lines and terminal facilities, such as large administrative buildings, stations, marshalling and classification yards, sheds, goods depots and workshops) and the longevity of rolling stock, such as locomotives and freight wagons, the ratio of fixed to total costs is very high – the second highest of all modes of transport (after pipeline transport). Approximately 75 per cent of rail transport

[27] Cowie, J. 2010: 286.
[28] Button, K. J. 2010: 125.

costs are fixed over the short term.[29]

7.2 Rail transport efficiency

7.2.1 Cost level

Overland pipeline transport is the cheapest mode for those types of commodities that can be transported by pipeline. Either rail or road transport is the cheapest mode of transport for all those commodities that cannot be carried by pipeline. In view of the fact that rail transport achieves considerable economies of distance, it becomes cheaper than road transport for all classes of freight transport as trip distances increase above approximately 500 kilometres. However, for trips shorter than roughly 150 kilometres, road transport is virtually always cheaper than rail transport. For all types of goods that can possibly be carried either by road or rail transport between the same trip origins and destinations, the equal cost distance lies between approximately 150 and 500 kilometres.[30]

7.2.2 Economies of fleet size

Economies of fleet size in rail transport are attained through operating long trains, the carrying capacity of which is well utilised, and not simply by operating a large vehicle fleet of wagons and locomotives. In this context, rail transport enjoys the highest level of economies of fleet size of all modes of transport.

There are considerable economies in hauling more wagons per train and employing a stronger locomotive whenever train lengthening requires this. However, there comes a point where an additional locomotive will be needed with further train lengthening. Demand permitting, logic dictates that several wagons should be added when an extra locomotive is employed to keep the required train and locomotive traction power efficiently in balance. The economies stemming from operating the longest trains technically possible and employing multiply-linked locomotives are that, firstly, only one locomotive crew remains necessary for multiply-linked locomotives; secondly, traffic scheduling and control of a few long trains are simpler and potentially safer than operating several short trains, which in total carry the same payload volume or mass as a single long train; and, thirdly, the utilisation of railway lines increases because the required minimum time headways and following distances between short and long trains differ proportionally less than the difference in train length.

7.2.3 Economies of vehicle size

The width of rail wagons is limited by the gauge of the railway line. Efficiency requires that the same gauge be used throughout the system. The height of wagons is limited by overhead clearances along the way. The length of wagons is limited by their structural robustness to withstand the pressure exerted by payload mass on wagon sections not directly supported by sets of axles and wheels, and by the maximum axle mass loads that railway infrastructure can accommodate. Although the achievement of economies of vehicle size in rail transport is significant, it is in relative terms along with road transport the lowest, resulting mainly from the limits of vehicle dimensions dictated by technical considerations described above.[31]

7.2.4 Economies of infrastructure extension

With rail transport, the move from a single- to a double-track system may quadruple the capacity of the line by eliminating directional conflict, and a quadruple track should increase capacity even more as it permits segregation by speed. However, there is no sense in building railway lines of larger capacity than will be required.[32]

7.2.5 Economies of distance

In view of the fact that rail transport has relatively high terminal costs, it enjoys substantial economies of distance as trip length increases – the highest of all modes of transport.

When analysing rail transport, one should distinguish between unit costs (for example, the cost per ton-kilometre) decreasing due to economies of density and of distance. Through economies of density and distance, a rail transport operation may enjoy a natural monopoly on a particular route. On condition that the utilisation of train-carrying capacity is high, the former economy stems from its cost structure, which is characterised by a relatively high ratio of fixed to total cost so that with increasing the annual distances of all trains collectively, the fixed cost per unit of performance (train-kilometres and eventually ton-kilometres) declines faster than the variable cost increases per additional unit of performance within the output capacity, and the latter economy from the high amount of terminal operating costs (at trip ends) that do not change as trip distances increase.

7.3 Rail transport competition

7.3.1 Predominant intramodal market type

Owing to the large initial cost as an absolute quantum and the high ratio of fixed costs in freight rail transport, the breakeven point between revenue and total cost occurs at a very high level of production. This means that a large volume of freight services must be sold before a profit can be realised. This may

[29] Havenga, J. H. and Pienaar, W. J. 2012: 2.
[30] Pienaar, W. J. 2007: 269.
[31] Bonsor, N.C. 1984: 96.
[32] Button, K. J. 2010: 123.

imply that a profit can only be realised if there is one incumbent rail operator in the market, i.e. a natural monopoly.[33]

Economic features such as high barriers to entry, economies of scale and high breakeven points have historically meant that rail freight transport has been a highly concentrated intramodal market. In terms of the number of market participants, the supply of rail freight transport is (after pipeline transport) the second most highly concentrated of all transport modes. Since the 1990s in Europe and Australia, ownership of rail infrastructure and of train operations has been organisationally divorced. With this arrangement, any prospective rail transport operator may gain open access to existing rail infrastructure and tracks under certain prescribed conditions. The advocates of this new rail transport agreement argue that it reduces the barriers to entry and limits monopolies, making the rail transport market more competitive. The potential (or possible threat) of easy market entry is said to incite the incumbent operator to function more efficiently and effectively. Despite these reforms, few new operators have entered the rail freight market.[34] In countries where the infrastructure ownership and train operations have been divorced, operators have mainly entered the market to satisfy a very specific shipper need or small niche market. Experience has thus far shown that intra-rail competition under the new dispensation gives room for the formation of duopolies, and not larger oligopolies with three or more incumbent competitors.[35]

7.3.2 Predominant intermodal competition

Rail transport competes with road transport for break-bulk and containerised freight. Because the unit cost decreases when output capacity increases, rail transport gains substantial economies of scale (mainly through advantages of density and of distance) with high utilisation – and even more so in the case of a double-track operation with long trains.[36]

Although rail transport is more expensive than pipeline transport, it can effectively compete with a parallel pipeline service when it has adequate available capacity and the pipeline operates at levels close to capacity.[37]

Rail transport competes with inter-port sea transport for all types of freight.

8 Pipeline transport

8.1 Pipeline transport cost structure

As with rail transport, pipelines provide their own right of way. Since the pipe component, the pumps and the tank and plant facilities are highly specialised and durable, fixed cost constitutes a high portion of the total cost – the highest of all modes. Pipeline transport is highly efficient when the utilisation of capacity remains consistently high. Transport cost per unit carried rises rapidly if actual usage falls below capacity, because of the high ratio of fixed to total operating cost. Because the fixed costs of pipeline transport are proportionately much higher than variable costs, and continuous pumping may take place with no need for any return flow and no materials handling takes place, economies of scale prevail in pipeline transport. Because of the high capital costs of a pipeline, the financial barrier to entering the market is high. Approximately 85 to 90 per cent of pipeline transport costs are fixed over the short term.[38]

8.2 Pipeline transport efficiency

8.2.1 Cost level

Overland pipeline transport is the cheapest mode of transport – it is substantially cheaper than road and rail transport.[39] For example, between Durban and Gauteng in South Africa, over a route of 704 kilometres, pipeline tariffs per litre of fuel are approximately half those of rail and one-fifth of those of road transport.[40] It is therefore clear that a Durban-based petroleum wholesaler that does not have access to pipeline or rail transport between Durban and Gauteng is subject to the likelihood of competitive foreclosure of marketing its product(s) in Gauteng.[41]

8.2.2 Economies of vehicle size and infrastructure extension

Pipeline transport has unique characteristics: the carrying unit (i.e. the 'vehicle') is also the infrastructure. On the principle of economies of density, an increase in pipe diameter can result in a lower unit cost. The fundamental relationships involved depend upon the principles of geometry concerning the relation between the surface area of a pipe's wall and its volume. Consider a circular cross-section of a pipe. Because the area of a circle is πr^2, its area increases with the square of the radius. The circumference increases only in proportion to the radius, since the circumference is $2\pi r$. The friction that must be overcome to move a liquid commodity through a pipeline is the friction between the liquid and the wall of the pipe. Therefore, increasing the diameter of a pipe will increase the quantity of liquid in the pipe faster than it will increase the area of the wall of the pipe in contact with the liquid.

[33] Cowie, J. 2010: 289.
[34] Amos, P. 2007: 6; Pittman, R. 2005:181.
[35] Di Pietrantonio, L. and Pelkmans, J. 2004:27.
[36] Pienaar, W.J., De Bod, A. and Havenga, J.H. 2012: 20.
[37] Rabinow, A. R. 2004: 27.
[38] Department of Logistics, Stellenbosch University. 1998: 34; Pienaar, W.J. 2009: 130.
[39] Pienaar, W.J., De Bod, A. and Havenga, J.H. 2012: 16.
[40] Africon. 2008: 35.
[41] Nersa. 2007: 20.

Consequently, there are gains in economies in the propulsion power required to pump the same quantity of commodity by increasing the diameter of the pipe. There are also economies in the cost of the pipe itself. For larger pipes, the quantity of body steel per unit of pipe carrying capacity is less than for smaller pipes.

Pipeline transport does not necessarily require a return journey or return pumping process. This eliminates joint costs. Because cost is incurred without adding value each time goods are handled at a terminal or storage facility, a primary logistics objective is to eliminate handling wherever possible. With the carriage of crude oil and petroleum products by pipeline, this objective is fully met. Commodity intake, haulage and discharge are combined in one process, usually a remote-controlled one.

An uninterrupted and prolonged throughput of a large volume of homogeneous product increases economies of density. Should such continuous pumping with a specific product not be sustainable, common production can make petroleum pipelines more cost effective, since a variety of petroleum products can be pumped consecutively, thereby enhancing the achievement of economies of scale through economies of scope.

8.2.3 Economies of distance

Longer pipelines do not give rise to significant economies of distance, in fact this is almost non-existent – the lowest of all modes of transport. The reason for this is that additional pump stations and more pipes in direct proportion are required for longer distances.[42]

8.3 Pipeline transport competition

8.3.1 Predominant intramodal market type

In terms of the number of market participants, the supply of pipeline transport is the most highly concentrated of all transport modes. The absolute number of firms is low, but the significant measure of concentration is the number of participants in a specific transport market segment or corridor. With a few exceptions, there is but one crude oil, one products and one natural gas pipeline connecting producing areas or refineries and areas of consumption. This high degree of monopoly power results from declining unit costs with increases in capacity, so that the lowest costs are achieved by a concentration of output in a single pipeline. A high degree of concentration is efficient, and changes towards a more competitive market structure through economic regulation would entail high losses in efficiency. Therefore, pipeline operations that can fulfil entire market demand are natural monopolies.[43]

Where the distance between supply points (such as geographically separated oilfields or ports of entry) is high in relation to the delivery distance to the market area, such an area's fuel demand can often be most efficiently fulfilled by two or more different pipeline operations. For example, from 2014 onwards, the province of Mpumalanga in South Africa will receive petroleum products via the Transnet products pipeline from refineries close to the port of Durban and the Petroline products pipeline from the port of Maputo in Mozambique.[44] In the latter case, a pipeline transport oligopoly (in this case, more specifically, a duopoly) will exist.

In view of the abovementioned considerations, financial stakeholders in pipeline operations tend to consolidate and start with a large initial investment, which tends to yield higher returns, partly because of economies of scale and partly because of inherent performance characteristics (for example, a 30 cm pipe operating at capacity transports three times the quantity carried by a 20 cm pipe).[45] The gains from scale are substantial. For example, the lowest cost for a throughput of 100 000 barrels of crude oil per day in a 45 cm pipeline would be approximately double the cost per barrel when compared to carrying 400 000 barrels per day in an 80 cm pipeline over the same distance.

The implications for the industry are important. It would be extremely wasteful, for example, for four competing refineries in a consuming area in which each used crude oil from the same area of origin to build four pipelines. If, for example, each required 100 000 barrels per day, then building four parallel 45 cm pipelines instead of a single 80 cm pipeline would double the cost per barrel for transport. Efficiency dictates a common system for use of the same pipeline in such circumstances. It also follows that costs for carrying petroleum on a route that has a large pipeline will be much lower than on other routes not thus provided. There will be external economies in locating large refining capacity in the same area.

8.3.2 Predominant intermodal competition

Although pipeline transport is overland the least expensive mode of transport, rail transport can effectively compete with a parallel pipeline service when rail transport has adequate spare capacity and the pipeline operates at levels close to capacity.

Despite the fact that tank ships run empty during return trips, pipeline transport can only compete cost-wise with sea transport between the same origin and destination if the pipeline route is considerably shorter than the sea route, or where sea transport is subject to exceptional charges, such as heavy canal dues.[46] An example is the 254-km long Trans-Israel crude oil pipeline route between Eilat on the Red Sea and Ashkelon on the Mediterranean coast. This route is

[42] Gwilliam, K. M. 1970: 202.
[43] Meyer, J. R. *et al.* 1964: 225.
[44] Petroline. 2008: 5.
[45] Papacostas, C.S. and Prevedouros, P. D. 2001: 240.
[46] Faulks, R. W. 1982: 36.

substantially shorter than the one around Africa, and cheaper than utilising the Suez Canal.[47]

9 Sea transport

9.1 Sea transport cost structure

The cost structure of sea transport is similar to that of air transport. It is characterised by balanced proportions of fixed and variable costs. Sea transport does not need a supplied right of way. The travel 'way' involved, namely the sea, does not require investment, and seaports are not owned or supplied by shipping firms. Expenses in ports can be as high as a third of direct voyage costs.[48] However, these obligations only arise when a port is visited.

9.2 Sea transport efficiency

9.2.1 Cost level

The total unit cost to carry freight by sea is the lowest of all modes of transport. Over equal distances the unit cost in ton-km to carry freight by sea is substantially lower than any of the three modes of land transport. However, these three modes can be cheaper than inter-port sea carriage when, firstly, the sailing distance between the ports is too short for vessels to gain sufficient economies of distance; secondly, the trip origins and destinations of freight shipments are accessible by road, rail or pipeline, but are significantly remote from the ports, and vice versa when the inter-port distance is substantially long and/or the origins and destinations are close to the ports; and, thirdly, where sea transport is subject to exceptional charges, such as heavy canal dues.

9.2.2 Economies of fleet size

As is the case with air transport, economies of scale are possible with large individual vessels and not necessarily with large fleet operations. Single-ship operators or operators operating a few ships – for example operators of charter ships – are often able to compete with larger scheduled conference liners, which indicates that sea transport enjoys little in terms of economies of fleet size.

9.2.3 Economies of vehicle size

Like most forms of transport, shipping benefits through economies of scale are associated with operating larger ships.[49] Larger ships result in lower costs per ton (in the case of bulk shipping) and lower costs per standard container (in the case of container shipping).[50] However, larger ships may cause problems for other areas of the maritime industry, mostly at the ports. Bigger ships require wider entrance channels, deeper draughts, larger cranes and other loading and unloading equipment, as well as sufficient storage space to hold the volumes of freight before or after loading and unloading them. Air and sea transport enjoy similar economies of vehicle size – after pipeline transport, the second highest.

9.2.4 Economies of infrastructure extension

Evidence exists that in port operations a fourfold increase in container port size can reduce the cost of handling container traffic by approximately one-quarter.[51] However, seaports are not owned or supplied by shipping firms, so ship owners may not automatically reap the benefits of improved port efficiencies. Port charges are levied by the owning port authority. Whether a portion of the value of efficiency improvements and other cost advantages are passed on to visiting ships will depend on the policy of the governing port authority. Often, the various commercial ports in a country reside under the control of a single port authority, which may set uniform port charges for similar port services throughout, regardless of the different cost structures and changing degrees of competitiveness among ports.

9.2.5 Economies of distance

Generally, for container vessels and the various types of bulk carriers, expenses in ports are in the order of a third of direct voyage costs (this can constitute up to roughly 40 per cent if the ship itself or its cargo requires prolonged and/or special berthing and handling arrangements).[52] In view of the high terminal expenditure and the fact that the 'way' of travel involved – the sea – does not require investment or any significant expenses apart from navigational support that may sometimes be necessary, ships enjoy substantial economies of distance as voyage lengths increase. Air and sea transport enjoy similar economies of distance – the second highest after rail transport.

9.3 Sea transport competition

9.3.1 Predominant intramodal market type

Seaborne trade can be classified into two main categories – bulk cargo and general cargo. Both the bulk and general cargo trades make use of ships that are supplied partly from fleets owned by the bulk and liner industries, supplemented by vessels obtained from the charter market. Ocean shipping competition ranges from open competition, as in the case of bulk (tramp) shipping and the charter market (individual ships seeking cargo), to oligopolistic cartels, as in the

[47] EAPC. 2009.
[48] Stopford, M. 2009: 225–236.
[49] Talley, W.K. *et al*. 1986: 91
[50] Stopford, M. 2009: 75.
[51] Heaver, T. D. 1975
[52] Stopford, M. 2009: 225–236.

case of liner shipping conferences. A liner shipping conference is an association between a number of ship owners that offer their services on a given sea route according to conditions agreed by the members.

In exchange for the right to operate as legal cartels, the participating operators usually assume common-carrier obligations within the market they serve. These include operating according to published route plans (i.e. predetermined ports of call), time schedules (although this is difficult to adhere to in sea transport) and tariffs (freight rates); and acting in a non-discriminatory way towards users.

As opposed to the services offered by liner shipping conferences, charter ships do not operate according to a fixed route or published schedule. Instead, a shipper charters, or leases, a ship for a particular voyage (or voyages) or a given time, called a voyage charter or a time charter. A charter agreement can either be a gross or a bareboat charter. A gross charter is a charter agreement by which the ship owner furnishes crew and equipment and incurs other expenses, such as port costs. A bareboat charter is a charter agreement under which a shipper charters a vessel without a crew, assumes full possession and control of the vessel, and is generally invested with temporary ownership powers.[53]

Should shippers making use of liner operations judge that the rates charged by conferences are too high, they may turn to a charter operator in an effort to obtain more competitive rates. The presence of charter operators can inhibit conference liners from charging excessively high tariffs, which works in favour of shippers. However, the main operational benefit of charter operators is that they are often able to supply service in peak periods, thereby helping to bring the demand for and supply of ship capacity into balance. The market for ship chartering is a fluid supply-and-demand situation: varying from peak- to low-season demand. The charter phenomenon is said to be one of feast or famine for shipowners.[54]

Under the banner of anti-cabotage legislation, many nations prohibit ships faring under a foreign flag the right to provide service between domestic ports.

9.3.2 Predominant intermodal competition

Sea transport, especially coastal shipping, competes with road and rail transport through inter-seaport services. On trans-oceanic trips, air transport offers competition for small high-value shipments when a short transit time is required.

10 Concluding summary

The cost to transport a unit of freight by air is the highest of all modes of transport, and by road the second highest on long trips and third highest on short trips, where road is cheaper than rail transport. In view of the fact that rail transport achieves considerably more economies of distance than road transport, road transport becomes progressively more expensive than rail transport for all classes of freight as trip distances increase above approximately 500 kilometres. For trips shorter than roughly 150 kilometres, road transport is virtually always cheaper than rail transport. For all types of goods that can possibly be carried either by road or rail transport between the same trip origins and destinations, the equal cost distance of the two modes lies between approximately 150 and 500 kilometres. Overland pipeline transport is the cheapest mode for those types of commodities that can be transported by pipeline. Either rail or road transport is the cheapest mode of transport for all those commodities that cannot be carried by pipeline. The total unit cost to carry freight by sea is the lowest of all modes of transport. Over equal distances the unit cost in ton-km to carry freight by sea is substantially lower than any of the three modes of land transport. However, these three modes can be cheaper than inter-port sea carriage when, firstly, the sailing distance between the ports is too short for vessels to gain sufficient economies of distance; secondly, the trip origins and destinations of freight shipments are accessible by road, rail or pipeline, but are significantly remote from the ports, and vice versa when the inter-port distance is substantially long and/or the origins and destinations are close to the ports; and, thirdly, where sea transport is subject to exceptional charges, such as heavy canal dues.

Table 1 provides a comparative summary of the most salient economic features of the five modes of freight transport.

[53] Brodie, P. 2006: 5, 92, 250, 286.
[54] Bardi, E.J. *et al*. 2006: 249.

Table 1. Comparison of salient economic features of transport modes

Economic charateristics	Air	Road	Rail	Pipeline	Sea
Cost	Highest	Second highest	Moderate	Second lowest	Lowest
Cost structure (fixed- to total-cost ratio)	Balanced (Second lowest, similar to sea)	Lowest	Second highest	Highest	Balanced (Second lowest, similar to air)
Predominant intramodal market type	Oligopoly	Ranging from open to oligopoly	Natural monopoly. Duopoly when access is open	Natural monopoly	Open (charters) and oligopoly (liner operators)
Predominant intermodal competition	*Road*: small shipments; *sea*: trans-oceanic, small, high-value shipments	*Rail*: break-bulk and containers; *air*: small shipments	*Road*: break-bulk and containers; coastal shipping: any shipments	*Rail*: when pipeline operates close to capacity	*Road and rail*: inter-port services; *air*: trans-oceanic, small, high-value shipments
Economies of fleet size	Second lowest (similar to sea)	Second highest	Highest (achievable through long trains)	Lowest, non-existent (referring to number of pipes)	Second lowest (similar to air)
Economies of vehicle size	Second highest (similar to sea)	Lowest, although achievement is still significant (similar to rail)	Lowest, although achievement is still significant (similar to road)	Highest (referring to pipe diameter)	Second highest (similar to air)
Economies of distance	Second highest (similar to sea)	Second lowest	Highest	Lowest (almost non-existent)	Second highest (similar to air)

References

1. Africon. 2008. *Study on the macro-economic impact of fuel costs in transport*. Contract report produced for the National Department of Transport. Pretoria.
2. Air Transport Association of America (ATA). 1988. *Air Cargo from A to Z*. Washington, DC: Air Transport Association of America.
3. Amos, P. 2007. *Vertical Separation of Railways*. Washington DC: World Bank.
4. Bardi, E. J., Coyle, J. J. and Novack, R. A. 2006. *Management of Transportation*. Mason: Thomson.
5. Bonsor, N.C. 1984. *Transportation Economics: Theory and Canadian Policy.* Toronto: Butterworths.
6. Brodie, P. 2006. *Commercial Shipping Handbook*, 2nd edition. London: Informa.
7. Button, K. J. 2010. *Transport Economies*, 3rd edition. Cheltenham, UK: Edward Elgar.
8. Cowie, J. 2010. *The Economics of Transport: A Theoretical and Applied Perspective*. London: Routledge.
9. Department of Logistics, Stellenbosch University. 1998. Report to Petronet on the development of a defensible pricing mechanism. *Contract report produced for Petronet.* Stellenbosch.
10. Di Pietrantonio, L. and Pelkmans, J. 2004. *The Economics of EU Railway Reform*, BEEP briefing 8. Bruges European Economic Policy Briefings. Bruges: College of Europe.
11. Eilat Askelon Pipeline Co. Ltd. (EAPC). 2009. Pipelines. Available: http://www.eapc.co.il/print/english/pipelines.html (Accessed 2009, 4 May).
12. Faulks, R.W. 1982. *Principles of transport*, 3rd edition. London: Ian Allen.
13. Gwilliam, K.M. 1970. *Transport and public policy*, 2nd edition. London: George Allen & Unwin.
14. Havenga, J. H. and Pienaar, W. J. 2012. 'The creation and application of a national freight flow model for South Africa', *Journal of the South African Institution of Civil Engineering* 54(1): 2–13.
15. Heaver, T. D. 1975. *The Routing of Canadian Container Traffic through Vancouver and Seattle*. Vancouver: WESTMAK.
16. Holloway, S. 2008. *Straight and Level: Practical Airline Economics*, 3rd edition. Aldershot, UK: Ashgate.
17. International Civil Aviation Organization (ICAO). 1999. Digest of Statistics. Montreal: ICAO.
18. Meyer, J.R., Peck, M.J., Stenason, J., Zwick, C. 1964. *The economics of competition in the transportation industries*. Cambridge, Massachusetts: Harvard University Press.
19. National Energy Regulator of South Africa (Nersa). 2007. "Licence condition relating to tariffs of a petroleum pipeline system including storage facilities." 29 March. Available: http://www.dme.gov.za (Accessed 2008, 2 June).

20. Papacostas, C. S. and Prevedouros, P. D. 2001. *Transportation Engineering and Planning*, 3rd edition. Englewood Cliffs: Prentice Hall.
21. Pegrum, D. F. 1973. *Transportation: Economics and Public Policy*, 3rd edition. Homewood: Richard D. Irwin.
22. Petroline. 2008. Environmental impact assessment for Petroline RSA (Pty) Ltd for a proposed liquid fuels pipeline from Komatipoort to Kendal and a liquid fuel storage facility near Nelspruit. Available: http://www.petroline.co.za [Accessed 2008, 14 October].
23. Pienaar, W. J. 2007. 'A proposed regulatory framework for road and rail freight transport in South Africa', *South African Journal of Science and Technology* 26(4): 265–278.
24. Pienaar, W.J. 2008. 'Economic evaluation of the proposed road between Gobabis and Grootfontein, Namibia', South African Journal of Economics 76(4): 667–684.
25. Pienaar, W. J. 2009. 'Economic aspects of pipeline transport: A South African perspective', *South African Journal of Science and Technology* 28(2): 119–140.
26. Pienaar, W. J., De Bod, A. and Havenga, J.H. 2012. 'Economies of density in rail freight transport: potential for utilisation in Southern Africa', *Risk governance and control: financial markets and institutions* 2(1): 16–21.
27. Pittman, R. 2005. Structural separation to create competition? The case of freight railways. *Review of network economics* 4(3): 181—196.
28. Pretorius, J. 1997. *The effect of conditions in the transport sector on the competitiveness of South* African *industries in foreign markets*. MComm thesis in Transport Economics. Stellenbosch: Stellenbosch University.
29. Rabinow, R.A. 2004. *The Liquid Pipeline Industry in the United States: Where it's been, where it's going.* Report prepared for the Association of Oil Pipe Lines. Available: http://www.aopl.org/about/pipelines.html (accessed on 2007, 4 July).
30. Road Freight Association. 2012. *Vehicle Cost Schedule*, 45th edition. Pretoria, South Africa.
31. Stopford, M. 2009. *Maritime Economics*, 3rd edition. London: Routledge.
32. Talley, W.K., Agarwal, V.B. and Breakfield, J.W. 1986. 'Economies of density of ocean tanker ships', Journal of Transport Economics and Policy 20: 91-99.
33. Vasigh, B., Fleming, K. and Tacker,T. 2008. *Introduction to Air Transport Economics: From Theory to Applications*. Aldershot, UK: Ashgate.
34. Wei, W. and Hansen, M. 2003. 'Cost Economics of Aircraft Size', Journal of Transport Economics and Policy 37(2): 279–296.
35. Wensveen, J.G. 2007. Air Transportation: A Management Perspective, 6th edition. Aldershot, UK: Ashgate.