WCTR 2013 RIO

SELECTED PROCEEDINGS

THE IMPORTANCE OF FREIGHT DEMAND FORECASTING FOR SPATIAL PLANNING - A SOUTH AFRICAN CASE STUDY

PROF. JAN H. HAVENGA, UNIVERSITY OF STELLENBOSCH, SOUTH AFRICA, JANH@SUN.AC.ZA

This is an abridged version of the paper presented at the conference. The full version is being submitted elsewhere. Details on the full paper can be obtained from the author.

ISBN: 978-85-285-0232-9

13th World Conference on Transport Research

www.wctr2013rio.com

15-18 JULY 2013
Rio de Janeiro, Brazil

THE IMPORTANCE OF FREIGHT DEMAND FORECASTING FOR SPATIAL PLANNING - A SOUTH AFRICAN CASE STUDY

Prof. Jan H. Havenga, University of Stellenbosch, South Africa, janh@sun.ac.za

ABSTRACT

This paper investigates the demand for an inland intermodal container terminal (IICT) in the City of Cape Town in South Africa. A container market segmentation approach is used to project growth for container volumes over a 30 year period for all origin and destination pairings on a geographical district level in an identified catchment area. The segmentation guides the decision on what type of facility is necessary to fulfil capacity requirements in the catchment area and is used to determine the maximum space requirements for a future IICT.

Keywords: Intermodal freight, demand planning, South Africa

INTRODUCTION

Global container traffic more than tripled in volume between 1995 and 2009, from 137 million TEUs to 432 million TEUs, growing at an average annual rate of approximately 9 percent (US Department of Transportation, 2011a). This growth is fuelled by an increasing proportion of merchandise trade being containerised to promote ease of handling and movement of goods (Garratt, 2006; Rodrigue, 2007; US Department of Transportation, 2011a and 2011b). According to Davies (2007), container volume growth is placing growing pressure on terminal capacity with ports challenged in the expansion of on-dock capacity due to constraints on land availability, environmental issues, and concerns from local communities regarding traffic congestion and impact on quality of life. He concludes that “these factors have generated growing interest in the concept of inland container terminals as a means of boosting capacity, through potential reductions in container dwell time at on-dock terminals and the transfer of non-essential terminal activity to inland locations.”

This state of affairs also holds true for the South African situation and for the City of Cape Town in the Western Cape. The Port of Cape Town has limited expansion capacity within the current Cape Town Port Container Terminal (CTCT). The port handled a total of 708 526 twenty-foot equivalent units (TEUs) in 2010 with a 50/50 split between imports and exports (Transnet National Ports Authority, 2010). The CTCT berth capacity has been upgraded to a maximum of 1.4 million TEUs per annum, but the constraint lies in the back of port and servicing facilities The port container expansion plan provides for 4.4 million TEUs in 2050 (a more than five-fold growth), but this will only be possible if infrastructure expands in a seaward direction. Similarly, the inland rail container depot is expected to reach maximum capacity in 2014 and will not be able to meet the growing needs for containerised traffic. It is envisaged that an inland intermodal container terminal (IICT) could alleviate the capacity challenges of both the port container terminal and the rail container depot.

There are several factors from the broader regulatory and spatial development arenas that support the development of an IICT. South Africa's high logistics costs and untenable externality costs due to a disproportionate long distance road freight transport market share necessitates a modal shift, with the key underlying driver the movement of rail-friendly freight from road to rail (Havenga et al., 2011; Havenga, 2012). This especially holds true for long-distance container movements between dense population centres that fit rail economics perfectly. Furthermore, pallet-friendly domestic freight on corridors should be containerised and moved to rail. From a spatial development point of view, there is an incentive to relocate industrial activity to the urban edge. The Cape Town inner city is a tourism and green node impacted by the visual noise of empty container stacks. An IICT can also contribute to job creation, a key socio-economic imperative.

The viability of an IICT should first and foremost be informed by the long term demand for such a facility. An understanding of the dynamics of future macroeconomic freight transport demand is regarded as the most fundamental data set in the analysis of the freight transportation system and for providing clarity for subsequent decision-making regarding freight transport infrastructure investments (Winston, 1982; Trujillo et al., 2000; Qi et al., 2010). The purpose of this paper is therefore to define the long term container demand for an IICT, as well as the space requirements for the IICT. This, in turn, will form the basis of a follow-on study to determine potential sites and develop a business case for the IICT.

INTERMODAL FREIGHT

Intermodal freight transport is defined as "a transport system that allows at least two different modes to be used in an integrated manner in a `door-to-door' transport chain. In addition, it is a quality indicator of the level of integration between different transport modes" (European Commission, 1997). Integration requires the promotion of efficient interconnection and interoperability between networks and modes. 'Interoperability' refers to harmonised interfaces between transport systems and a high level of service. 'Interconnection' refers to the physical interconnection of networks through new design and expansion of the transport infrastructure and interchanges (Keller, Tsavachidis and Hecht, 2000). In the case of domestic intermodal freight transport in South Africa, the transport modes specifically refer to road and rail freight transport. The process of intermodal transport consists of short-distance road feeder services to an intermodal terminal in a logistics hub where freight is consolidated into main-line block trains running the length of the corridor to a destination terminal. From the destination terminal, it is transported to distribution centres or end destinations via road transport (Havenga et al., 2011).

An inland intermodal container terminal supports the creation of high throughput ports which aim at linking, through a dedicated rail corridor, on-dock rail facilities to a nearby inland terminal where containers can be sorted by destination. Inland terminals typically have more land available and road terminal access is less problematic (Notteboom and Rodrigue, 2009). Inland ports consequently facilitate increased throughput capacity to sustain growth at major container seaports (Jones Lang LaSalle, 2011), thereby addressing port-related congestion and pollution problems (Rahimi et al., 2011). Shifting domestic freight to intermodal solutions is also becoming increasingly important due to the potential for a reduction in overall transport costs, an increase in economic productivity, a reduced burden on highway infrastructure, higher returns from public and private infrastructure investments, reduced energy consumption, and increased safety (Berwick, 2001).

A successful inland intermodal terminal must contain three key elements: scale, rail and proximity to a large customer base (Jones Lang LaSalle, 2011). According to Paul and Woodbury (2006), the location determinants of intermodal terminals include those sites which (1) offer the lowest possible transportation costs with easy road access; (2) have direct rail service or access to branch lines, (3) have proximity to existing and new customers, and (4) facilitates access to suppliers and vendors. Optimal terminal location is typically informed by econometric modelling, supplemented with environmental, social and political considerations specifically relevant to the local environment (Van der Houwen, 2009; Rahimi et al., 2011).

The long life span of transportation infrastructure however requires that decision-makers, first and foremost, both accurately assess current capacities and successfully predict long term desired capacities (RTI, 2000: 36). Substantial cargo volumes in nearby catchment areas are therefore the critical driver for financial and operational sustainability of an intermodal terminal (Sea Freight Council of New South Wales, 2004). This paper sets out to define these cargo volumes, and subsequent site size requirements, for the City of Cape Town.

RESEARCH STRATEGY

For the purpose of determining long term container demand for an IICT, the facility is seen as delivering three distinct container services i.e. (i) port container services focusing on *inter alia* back of port services, customs and staging (back of quay) with the objective of delivering a dry port service, (ii) an intermodal container terminal focusing on *inter alia* container transhipments, container handling and container maintenance with the objective of engineering modal shift and (iii) container storage services focusing on *inter alia* warehousing and empty stacking with the objective of supporting the City of Cape Town's aesthetics.

The maximum size requirements for the IICT are identified through the development of appropriate container market segmentation, based on the long term movement characteristics of containers through and in a designated catchment area. This also indicates what type of facility should satisfy future demand for container movements on a spatial and functional level.

Catchment area

A true understanding of demand is based on the postulated catchment area for the IICT. This catchment area is defined based on the extent of the railway lines that service the Port of Cape Town and the surrounding geographical districts. The catchment area spans the Cape Peninsula (200km radius around the port of Cape Town) and includes the Cape Town Port Terminal and Cape Town-Gauteng/Northern Cape-Durban corridor. The assumption was also made that any future terminal will operate on a hub-and-spoke system with all rail freight originating within or destined for the area passing through the terminal (refer Figure 1). A hub-and-spoke system consists of low-density traffic consolidated at central locations, then shipped in greater volumes along central corridors (RTI, 2000:39).

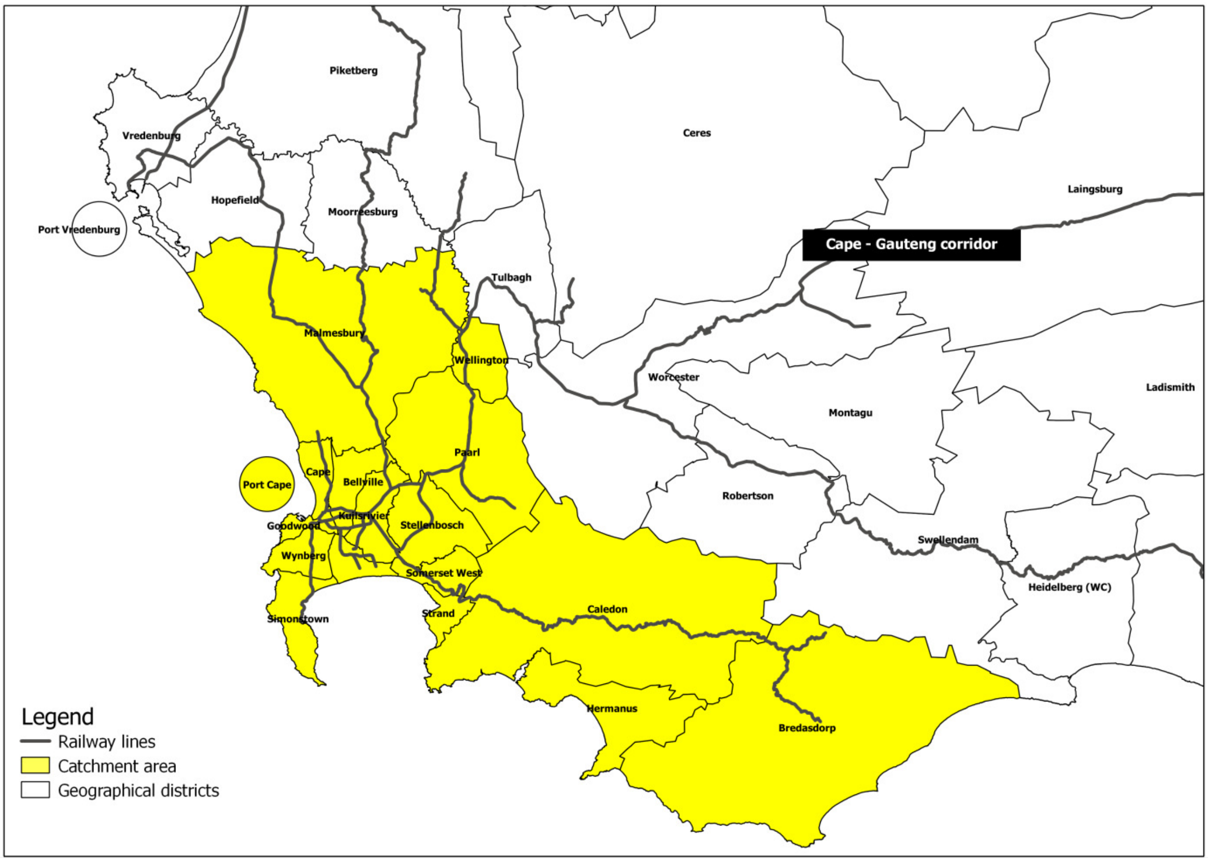

Figure 1: Catchment area for proposed IICT

Currently, almost all containers are transported by road to and from the CTCT. A future intermodal or bi-modal solution that incorporates rail is envisaged for the IICT.

Determining long term container demand

Container volumes for this study are obtained from the South African Freight Demand Model (FDM). It provides a comprehensive measure of freight flows for all modes between 372 geographical districts of South Africa for 71 commodities. The FDM also develops a 30- year forecast in five year intervals. It utilises a disaggregated social accounting matrix framework based on magisterial district supply and demand. The results are compared with detailed industry research and correlated with known freight flows (GAIN, 2012). The container demand forecast is based on commodity-level export and import-volume forecasts from the FDM, as well as the propensities of these commodities to be containerised. The methodology for container demand forecasting is therefore driven by information on current container content, forecasts of long-term growth in demand for current and potential container content, and 'fitting' these to maximum propensities to containerise. This provides more accurate forecasts than purely extrapolating historical trends. Havenga and Van Eeden (2011) highlight that extrapolated forecasts potentially overestimate South Africa's required port capacity for container handling by 300% over a 20-year period, compared to the commodity-based forecast. This shows the potential danger of planning and investing in infrastructure based on extrapolating historic trends for containers. In addition, a sense of realism in forecasting is supported by the increasing likelihood of a reduction in consumption due to economic pressures and higher energy prices (Notteboom and Rodrigue, 2009).

Defining the segmented container freight flows

A key point of departure is that any future IICT would most probably not handle all container volumes in a designated area and therefore it is necessary to do a proper market segmentation of container flows. Based on the type of movements that are best suited to intermodal transport, six container freight flow segments were identified for a future IICT in the Western Cape Province. Intermodal-friendly freight is defined as freight flows between dense origin-destination pairs of 100 000 tons per annum (a minimum of a train per week) over distances greater than 500 km (Bärthel and Woxenius, 2004; Havenga et al., 2011). In addition, for import/export container flows, the port terminal congestion is offset by an inland intermodal hub. These segments are described in Table 1.

Table 1: Description of container freight flow segments

Segment		Description
1	Imported long-distance	Imported container friendly commodities transferred by rail from the CTCT travelling north on the Cape-Gauteng corridor
2	Exported long-distance	Container friendly commodities travelling south on the Cape-Gauteng corridor and exported through the CTCT
3	Exported local customers	High volume local exporters that export deciduous fruit, processed foods, beverages, citrus or motor vehicle parts and accessories (the top five export commodities) through the port
4	Domestic intermodal north	Container friendly commodities from districts in the catchment area travelling northbound on the Cape-Gauteng corridor
5	Domestic intermodal south	Container friendly commodities travelling southbound on the Cape-Gauteng corridor destined for catchment area districts
6	Empty containers	Empty container movements are not explicitly modelled by the FDM. Empties are estimated as a percentage of loaded container movements, but in the opposite direction: • Imported empties are 49% of loaded export TEUs • Exported empties are 43% of loaded import TEUs • Domestic intermodal empties are 36% of loaded TEUs

The segmented flows are underpinned by a future road-rail intermodal solution for South Africa where a modal shift to rail is aggressively pursued and more rail-friendly commodities are containerised. Furthermore, the segmentation guides the decision on what type of facility is necessary to fulfil capacity requirements in the catchment area and will be used to determine the maximum space requirements for a future IICT.

Space requirement for the IICT

The maximum spatial requirements for the IICT are estimated by using a land utilisation measure of containers per hectare (ha) per year. This metric evaluates the efficiency of both operations (throughput) and land use. Analysis of a number of studies shows that an acceptable lower and upper limit for this metric would be 2 000 to 13 000 TEUs and an average would be 6 000 TEUs per ha per year (Tioga group, 2010 and Le-Griffin and Murphy, 2006).

DISCUSSION

Analysis and results

A total of 651 240 loaded containers were moved in, out and through the catchment area in 2010 (the base year). The Cape town Container Terminal (CTCT) handled 414 222 loaded containers in 2010; therefore 64% of all loaded containers in the catchment area were destined for or came from the port. Table 2 shows the projected loaded container demand growth for the entire catchment area at the forecast intervals. It is forecasted that almost 2.2 million loaded TEUs will be handled in the catchment area in 2041.

Table 2: Total loaded container volumes and CAGR for the catchment area

Year	TEUs	CAGR
2010	651 240	-
2016	831 132	4.15%
2021	1 007 794	4.05%
2026	1 198 529	3.89%
2041	2 173 114	3.96%

Figure 2 depicts the growth in container flows at these forecast intervals. (The map is a stylised outline of South Africa, with the lines depicting bidirectional freight flows, and line thickness representing the density of the flows). It is evident that long distance corridor freight flows are projected to grow at a much higher rate than the arterial freight flows.

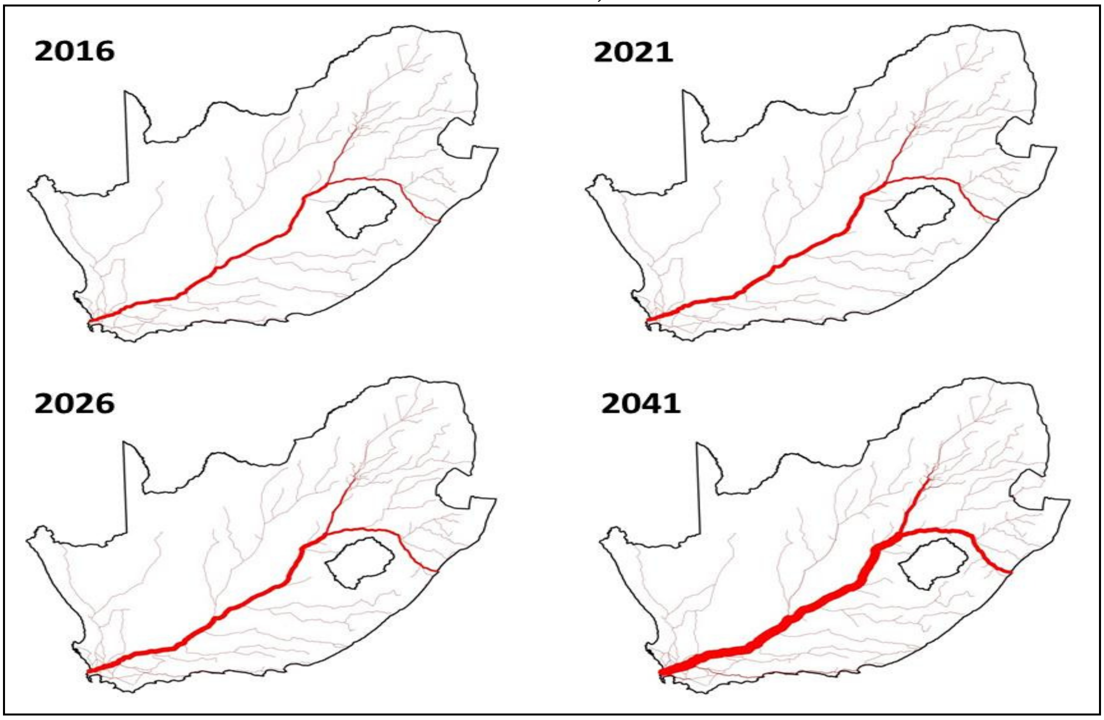

Figure 2: Forecasted inland loaded container flows to and from the catchment area

The potential market for the IICT of this total loaded container volume is determined by the six container segments defined earlier. The segmented container volumes are shown in Table 3 for the base year (2010) and the forecasted intervals up to 2041. The total container volume that could be handled by a future IICT in 2041 is calculated as 723 121 TEUs of which 69% will be loaded containers and 31% empties.

Table 3: Summary of base year and forecasted segmented container volumes (TEUs)

Segment		2010	2016	2021	2026	2041
1	Imported long-distance	38,244	52,170	66,118	81,235	153,974
2	Exported long-distance	33,593	42,972	50,791	59,038	97,364
3	Exported local customers	92,558	107,906	116,901	124,741	152,862
4	Domestic intermodal northbound	8,396	11,200	14,442	18,513	45,399
5	Domestic intermodal southbound	9,137	12,266	15,867	20,377	50,264
6	Imported empties	61,814	73,930	82,169	90,051	122,611
	Exported empties	16,445	22,433	28,431	34,931	66,209
	Domestic empties	6,312	8,448	10,911	14,000	34,439
Total TEUs		266,499	331,325	385,631	442,886	723,121

The fastest growth rate (albeit from a low-base) is expected in the domestic intermodal market, as depicted in Figure 3.

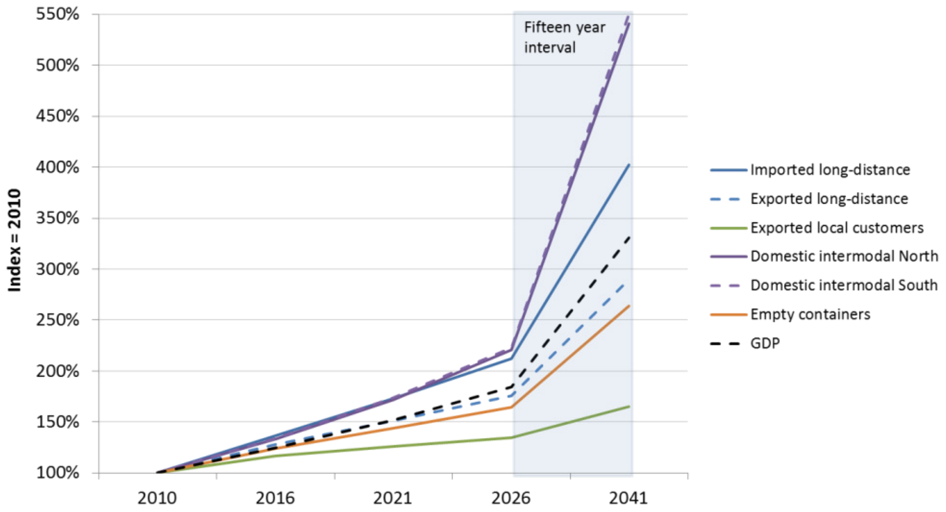

Figure 3: Forecasted growth rates for the container segments

The forecasted volumes indicate that a strong focus is required on long-distance import and export container movements whilst accommodating large volumes from local exporters and expanding the domestic intermodal market. This change in focus is in line with the South African Government's policy to shift more freight from road to rail and also with the goals of the national rail operator to target rail friendly commodities and of moving more palletised commodities into containers. In addition, the volume of empty containers supports the inclusion of container storage services at the IICT.

These results are used to quantify the maximum space requirements for the future IICT.

Space requirement for the IICT

Table 4 shows the maximum future spatial requirements (in ha) for each forecasted year based on the limits defined in the research approach.

Table 4: Maximum future spatial requirements for the IICT

Land utilisation	TEUs/ha/year	Year	TEUs	ha
Lower limit	2,000	2010	266,499	133
Middle	6,000			44
Upper limit	13,000			20
Lower limit	2,000	2016	331,325	166
Middle	6,000			55
Upper limit	13,000			25
Lower limit	2,000	2021	385,631	193
Middle	6,000			64
Upper limit	13,000			30
Lower limit	2,000	2026	442,886	221
Middle	6,000			74

<table>
<tr><th>Land utilisation</th><th>TEUs/ha/year</th><th>Year</th><th>TEUs</th><th>ha</th></tr>
<tr><td>Upper limit</td><td>13,000</td><td></td><td></td><td>34</td></tr>
<tr><td>Lower limit</td><td>2,000</td><td rowspan="3">2041</td><td rowspan="3">723,121</td><td>362</td></tr>
<tr><td>Middle</td><td>6,000</td><td>121</td></tr>
<tr><td>Upper limit</td><td>13,000</td><td>56</td></tr>
</table>

Depending on the level of capacity utilisation (low, medium or high) the maximum space requirement by 2041 for the IICT would be 362, 121 and 56 hectares, respectively.

CONCLUSION

The expected container flow demand from and to the City of Cape Town indicates the need for a facility that can render port container services, domestic intermodal transport services and container storage services. Space requirements for the IICT were calculated based on container flow segmentations for the catchment area. The availability of forecasts up to 2041 from South Africa's FDM enable the selection of future-proof sites (that are able to handle future container volumes) – therefore facilitating confidence in the required long term investment decision. This understanding of future demand and size requirements of a potential IICT serves as the starting point for a feasibility study and identification of suitable locations.

REFERENCES

Bärthel, F. and Woxenius, J. 2004. Developing intermodal transport for small flows over short distances, Transportation planning and technology, 27(5):403-424.

Berwick, M. 2001. North Dakota strategic freight analysis: Item I. Intermodal highway/rail/ container transportation and North Dakota. Fargo: North Dakota State University.

Davies, P. 2007. Challenges in Developing Viable Inland Container Terminals, Conference proceedings of the 2nd Annual National Urban Freight Conference held in Long Beach, CA.

European Commission. 1997. Communication from the Commission to the European Parliament and the Council: Intermodality and intermodal freight transport in the European Union. Brussels.

Qi, F., Yu, D. and Holtkamp, B. 2010. A logistics demand forecasting model based on Grey neural network. Sixth International Conference on Natural Computation (ICNC), 10-12 Aug, Volume: 3: 1488 – 1492.

Garratt, M. 2006. Forecasting for long-term investment in the container shipping industry – a holistic approach. MDS Transmodal. Available from: http://www.mdst.co.uk/attachments/downloads/Hamburg_Dec06.pdf (Accessed 18 July 2011).

GAIN (Growth and Intelligence Network). 2012. Freight Demand Model 2010, Stellenbosch, South Africa.

Havenga, J.H. 2012. Rail renaissance based on strategic market segmentation principles. Southern African Business Review 16(1):1-21.

Havenga, J.H., Simpson, Z., Fourie, P.F. and De Bod, A. 2011. Sustainable freight transport in South Africa: Domestic intermodal solutions. Journal of Transport and Supply Chain Management 5(1): 146-169.

Havenga, J.H. and Van Eeden, J. 2011. Forecasting South African containers for international trade: A commodity-based approach. Journal of Transport and Supply Chain Management 5(1): 170-185.

Havenga, J.H., Simpson, Z., Fourie, P.F. and De Bod, A. 2011. Sustainable freight transport in South Africa: Domestic intermodal solutions. Journal of Transport and Supply Chain Management. November 2011: 149-169.

Jones Lang LaSalle, 2011. The emergence of the inland port. Perspectives on the global supply chain, Spring 2011, available at: http://www.joc.com/sites/default/files/u48783/JLL-WhitePaper-The%20emergence_of_the_Inland_Port.pdf (14 May 2013).

Keller, H., Tsavachidis, M. & Hecht, C. 2000. Interconnection of trans-European networks (long-distance) and regional / local networks of cities and regions. Final report for CARISMA, available at: http://www.transman.hu/Projektek/carisma.pdf (May 2013).

Le-Griffin, HD and Murphy, M. 2006. Container terminal productivity. USA: University of Southern California.

Rahimi, M. Asef-Vaziri, A. and Harrison, R. 2011. Integrating Inland Ports into the Intermodal Goods Movement System for Ports of Los Angeles and Long Beach, available at: http://www.metrans.org/research/final/07-01_Rahimi_Final_Report.pdf (14 March 2013).

Rodrigue, J-P. 2007. Gateways, corridors and global freight distribution: The Pacific and North American maritime/land interface, Conference proceedings of the International Conference on Gateways and Corridors held in Pan Pacific Vancouver: Vancouver, 2-4 May 2007.

Notteboom, T. and Rodrigue, J-P. 2009, The future of containerization: Perspectives from maritime and inland freight distribution, Geojournal 74(1):7-22.

Paul, S. and Woodbury, N. 2006. Opportunity Assessment for an Inland Intermodal Container Facility in Kamloops. Thompson Rivers University, Canada, available at: http://www.venturekamloops.com/docs/3ea46d986297c5a3.pdf (15 May 2013).

RTI, 2000. Transportation and the Potential for Intermodal Efficiency-Enhancements in Western West Virginia: Final phase I report. May 2000, available at: http://muwww-new.marshall.edu/cber//Research/TRP99-00_FR1.pdf (11 May 2013).

Sea Freight Council of New South Wales, 2004. Developing freight hubs - A Guide to Sustainable Intermodal Terminals for Regional Communities, available at: http://www.pacificintermodal.com.au/PacificIntermodal/userfiles/file/Developing_Freight_Hubs.pdf (13 May 2013).

Tioga Group. 2010. Improving marine container terminal productivity, Prepared for the Cargo Handling Cooperative Program, USA.

Transnet National Ports Authority. 2010. Port Statistics 2010, Unpublished figures, South Africa.

Trujillo, L., Quinet, E. and Estache, A. 2000. Forecasting the demand for privatized transport. World Bank. Available from:

https://www.ppiaf.org/sites/ppiaf.org/files/documents/toolkits/highwaystoolkit/6/pdf-version/3-11-3.pdf (Accessed 8 November 2012)

US Department of Transportation. 2011a. Long-Term Trends in Container Throughput. Washington DC: Bureau of Transportation Statistics, US Department of Transportation.

US Department of Transportation. 2011b. America's Container Ports: Linking Markets at Home and Abroad. Washington DC: Bureau of Transportation Statistics, US Department of Transportation.

Van der Houwen, A. 2009. The port of Rotterdam and the use of intermodal transportation - What is the optimal distance to the port of Rotterdam for an inland container terminal? Bachelor thesis. Erasmus University Rotterdam. Erasmus School of Economics.

Winston, C. 1983. The demand for freight transportation: models and applications, Transportation Research Part A: General, 17(6): 419–427.