Opportunities for Short-Sea Shipping in the Southern African Development Community (SADC) Region: Evidence based on Discrete Choice Modelling

by

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EXECUTIVE SUMMARY

This thesis investigates the development of short-sea shipping (SSS) in the Southern African Development Community (SADC) region by studying the determinants of SSS, the stated choice preference of shippers and freight forwarders and the stated intentions of maritime carriers for SSS. It is purported the introduction of SSS in SADC could reduce socio-environmental problems currently faced such as road damage, road congestion, pollution and transport related accidents.

Discrete choice modeling (DCM) is employed as the main methodology to study shipper and carrier behavior. Discrete choice modeling permits the construction of general utility functions incorporating various decision maker characteristics and choice attributes to elicit preference of respondents. The general postulate in DCM is that utility is derived from the properties of things rather than the actual thing *per se.* A particular benefit of DCM in this study is the elicitation of preference for services and interventions that have not been introduced by SSS.

The first step in the study is a theoretical investigation of the potential of SSS in the SADC region. It highlights the policy initiatives, the barriers and enablers related to the development of SSS. The proposed SSS system would have three main roles: to offer an alternative mode of freight transport service between port cities, to serve as the main leg in an intermodal transport network, and to serve feeder services between hub-and-spoke ports. The findings reveal that, SSS has the theoretical potential to work in the SADC region, given the large geographic region, projected freight volumes and customs and trade policies the SADC region is pursuing.

The second step in the study involves an a-priori study conducted to develop a general understanding of freight transport in SADC. For this purpose, a uniquely developed online survey was conducted across the SADC region to ascertain in particular: who the decision maker is in terms of freight mode choice; and what the significant attributes that influence freight mode choice are. The results reveal that both the shipper and the freight forwarder are involved in mode choice decisions, however the shipper being the dominant decision maker. Furthermore, the results of the exploded logit model reveal that the top five modal attributes that shippers consider most important are: reliability, transport cost, risk of damage, frequency of service and transit time. These results were subsequently employed to inform the shipper and carrier behavior studies.

The third step entails the assessment of shipper behavior, where trip specific mode choice decisions are studied along five intra-urban origin-destination (O-D) paired routes (which would form the study corridors). Three of these corridors considered unimodal SSS, and the two considered intermodal SSS. Unimodal SSS was studied along the following corridors: Cape Town (South Africa)~ Walvis Bay (Namibia), Walvis Bay (Namibia) ~ Luanda (Angola) and Durban (South Africa) ~Beira (Mozambique); and intermodal SSS was studied along the following corridors: Durban (South Africa) ~ Harare (Zimbabwe) and Cape Town (South Africa) ~ Windhoek (Namibia). To develop the choice scenarios, d-efficient stated choice experiments were uniquely developed for each of the corridors with the following key modal attributes systematically varied and analyzed across respondents: service frequency, reliability in terms of arriving on time, expected delay, transport cost and transport time. Subsequently, the following choice models were developed: Binary Logit, Mixed Logit and Integrated Choice and Latent Variable Structure models for the unimodal corridors; and Multinomial Logit, Nested Logit and Cross Nested Logit models for the intermodal corridors. The results highlight that in addition to the modal attributes, mode choice decisions are driven by shipper characteristics and situational characteristics. Moreover, the unimodal SSS study reveals that underlying latent perceptions also influence freight mode choice decisions; while the intermodal SSS study reveal strong correlations in the intermodal SSS alternatives, which requires improved intermodal capability if SSS is to become competitive.

The fourth step in the study entail the assessment of maritime carriers preference for SSS given varying levels of maritime conditions that include: dedicated freight volumes, income from freight, port dues discount, terminal handling fees discount and ship registration requirements. The results of an ordered logit model reveal that ship registration provisions and terminal handling charges are the most important to the development of SSS from a carrier side. Moreover, ship registration and maritime cabotage provisions require visitation to boost the participation of carriers in SSS.

The last step of the study revisits the modeling results and considers their implications through the estimation of willingness-to-pay and attribute elasticities. The results were then employed to suggest policy actions and interventions to develop SSS.

Keywords: *Short-sea Shipping, Discrete Choice Modeling, Intra-Urban freight, Maritime Transport, Africa, Southern Africa Development Community, SADC region, Coastal Shipping*

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PLAGIARISM DECLARATION

I, **Abisai Konstantinus**, hereby declare that the work on which this thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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Signed by candidate

Signature: ________________________________

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"…as an unintended consequence, our transport system is bursting at the seams and is increasingly becoming inadequate in responding to the export led growth. Our road network is increasingly becoming congested while we have not made the correct policy response to the usage of one of our underutilized endowments – our ocean for coastal shipping"

~ Jeff Radebe, (Minister of Transport, South Africa, Speech at 2017 CSIR conference)

1 INTRODUCTION

1.1 Background

The Southern Africa Development Community (SADC) region, covering 5 549 190 km^2, with a coastline spanning 14 729km, is a regional economic community that comprise 15 countries of Southern Africa (see Figure 1-1 below).[1] The SADC region was formed to achieve economic growth, development, peace and security. It strives to achieve these objectives by alleviating poverty and reaching for regional integration, whilst in line with democratic principles and sustainable development practices (SADC, 1992).

Figure 1-1: The SADC Region (SADC, 2018)

Identified as a major activator to the development objectives of SADC is the need to develop the regional freight transport system to achieve social integration, economic development, and intra-regional trade (SADC, 2013). Aptly, the SADC region (both as a unit and at respective national levels) has for a long time considered the development of Short Sea Shipping (SSS) (SADC, 1996a). SSS is a modified form of coastal shipping that

[1] SADC member states: Angola, Namibia, South Africa, Botswana, Democratic Republic of the Congo, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Tanzania, Seychelles, Swaziland, Zambia and Zimbabwe.

offers complete logistics supply services as both a supplement and alternative to road and rail (Schinas and Psaraftis, 1998). In this regard, Chapter 8, Article 8.1 of the SADC Protocol on Transport, Communication and Meteorology [2]provides that:

> "Member States shall promote the economic and social development of the Region… [amongst many things] which-
> c) Promotes a safe and clean marine, maritime and inland waterway environment; [and]
> d) Encourage the provision of accessible, viable and productive landside infrastructure."

The provisions of the SADC Protocol are enhanced at the continental level by key instruments of the African Union (AU), namely the Africa Maritime Transport Charter (AU, 2010) and the Africa Integrated Maritime Strategy (AU, 2015). Article 15 of the Charter provides that "[AU] Members shall promote [maritime] cabotage and effective participation of private sector operators at national, regional and continental levels." The proposed political actions involves developing maritime transport as part of the 'domestic' freight transport network, integrated complete with cargo consolidation centres and ports, with these maritime corridors linking to inland freight transport networks (Mokhele, 2014).

At a national level, South Africa for example has been campaigning for the development of SSS and has accordingly set targets in the South African millennial goals to achieve key objectives in the realization of an integrated maritime transport system, both nationally and beyond (NDoT, 2017). Namibia has also considered SSS as a viable way of increasing the transportation network and easing the pressure on road infrastructure development, particularly for cargoes destined to neighboring coastal countries and has accordingly cited SSS as a key development objective in the draft white document on the Blue Economy (NAMPORT, 2015). Another example is Mozambique where the Mozambique Public Maritime and River transport company (Transmaritima) recently signed an agreement with the French group, Peschaud, to develop SSS in Mozambique. Under this agreement, Peschaud will place ships in Mozambique to carry freight between Mozambican major ports (Frey, 2018).

Despite these efforts, SADC, as a collective, has yet to act to develop SSS. Particularly, it is not clear whether opportunities for SSS exist in SADC given the complex nature of maritime transport and the transportation realities in SADC (see Section 1.1.2). Thus, SSS

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[2] The protocol was passed to establish a viable sustainable transport systems in the region See Chapter 2 (SADC, 1996c, chap. 2).

in SADC remains a distant dream, fragmented in its approach and little if anything, not understood. The premise of this study is therefore to investigate opportunities for SSS in SADC, as a composite unit of transport, through planned action to shift the modal share of freight interests to SSS in order to reduce the dependency on road transport. This is done by assessing the preference of shippers, those who buy the freight transport service, and the preference of maritime carriers, those who would provide the SSS service if incepted.

1.1.1 Potential benefits of SSS to SADC

As a mode, SSS can address imbedding transport problems and meet development needs in SADC while imparting socio-economic benefits that have underlined the motivation for its political campaign worldwide (Rennie, 2002; National Department of Transport, 2011; Ombo, 2012).

For starters, where distance and volume allows, SSS has a low transport cost compared to rail, road and air (Rodrigue, 2017).[3] This strength lies in the large potential to achieve scale economies and energy efficiency in SSS (Stopford, 1997). The extraordinary big quantity of goods that an ocean-going ship can carry provides an advantage of a low unit transport cost per unit weight, and this is expounded over a longer distance travelled (Ma, 2014).

Economies of scale in shipping are additionally enhanced by attaining economies of distance (Pienaar, 2013). In shipping particularly, there are trip specific fixed costs that are not affected by the distance of the journey. For example, port charges, loading and discharging cost (i.e. terminal costs) are paid for at a fixed rate regardless of the distance travelled. As a result, the total transport cost per ton-kilometer decreases as the trip distance increases in shipping.

Furthermore, shipping has low associated infrastructure maintenance costs, which partly emanate from the doctrine of 'freedom of navigation', which allow any ship to use any part of the sea freely.[4] Linked to this, floating and moving on water comes at no cost (Ma,

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[3] For further reading, see Denisis, 2009; Lee, Hu, & Chen, 2010; McAuley, 2010; Papadimitriou, 2001. Transport costs are an important consideration in freight transport because they are an indication of what the carrier needs to incur to provide the transport service. Transport costs include both fixed costs, variable costs, time costs, and costs relating to possible inefficiencies that depend on a number of conditions related to geography, infrastructure, administrative barriers, energy and the method of packaging for the goods carried (Rodrigue, 2017).

[4] The economic market forces that operate within shipping are characterized by "perfect competition", where any new companies are free to enter the market and existing companies are free to exit, where all the companies provide a similar service with little difference, where shippers are well informed, and where a big number of shipping companies operate. Under these market conditions, there is a lot of competition among service providers and subsequently the shipper will have dominant power over the level of freight rates. This

2014).[5] There are no costs that need to be incurred in the building of sea lanes accept for additional infrastructure along the coast, which are necessary for safety of navigation such as aids to navigation and Vessel Traffic Services (VTS). Even where seaports are needed, port investments and port maintenance costs are comparatively low then road and rail infrastructure (ibid). Contrarily, road and rail development require enormous capital investments for the construction of roads, railway lines, tunnels and bridges. Moreover, shipping operates continuously for, 365 days a year without additional costs imposed on the operators, while some countries impose timetable restrictions on driving hours during the night and on weekends, and taxes for cars of different sizes (Santos et al., 2010).

Thirdly, SSS has a comparatively low negative external cost compared to road and rail. Research by the European Commission conducted in 2007, revealed that external costs generated by road transport is €0.035 per ton-km whereas the external cost for SSS is €0.009 (COM, 2008).[6] That said as well, the major negative externalities in transport are mostly related with road transportation and they include: traffic congestion, air pollution,[7] global warming (GHG),[8] transport related accidents, noise,[9] infrastructure wear-and-tear[10] and other environmental damages and pollution.[11] SSS is also more

character gives shipping a further ability to easily adapt to market changes.

[5] International Law under the doctrine of "Freedom of Navigation", gives any ship the right to use the seas including territorial waters of other countries. Article 17 of UNCLOS states: "… ships of all States, whether coastal or land-locked, enjoy the right of innocent passage through the territorial sea." Freedom of navigation is expounded to "straits used for international navigation" under article 36, to the exclusive economic zone under article 58, and to the high seas under article 78 and 87. Under the "Freedom of Navigation" doctrine, SSS is provided with a geographical advantage over other modes of transport, such as roads and rail, which don't necessarily enjoy the same rights in other countries.

[6] External costs are termed externalities because the group that is experiencing them is external to the transaction. Negative external costs emerge in transport because of scarce infrastructure and resources, and so they are an important indicator that reveals market inefficiencies in the transport sector particularly indicating those costs, which are not paid by the users, and thus lead to suboptimal prices and traffic volumes (Korzhenevych et al., 2014).

[7] Air emissions from freight transport include substances (gaseous or solid) escaping to the atmosphere, whose presence can create 'air pollution' which affects: the local climate, infrastructure, weather, health (human and wildlife), and the global environment (global warming, depletion of ozone layer). The major air pollutants are: Carbon Monoxide (CO), Nitrogen Oxide (Nox), Particulate Matter (PM), Non-methane Volatile Compounds (VOC), Sulfur Dioxide (Sox) and Ozone.

[8] The term 'global warming' refers to the gradual increase in the average temperature of the earth's atmosphere and oceans. This change is believed to be changing the earth's climate permanently. Global warming is the cause, and climate change is the effect.

[9] Noise pollution has become a concern to society due to the impact they have on the community. Negative consequences of noise pollution include: damage to hearing, disturbance of sleep, irritability, and decreased performance (Nassiri et al., 2013).

[10] Road deterioration and the formation of portholes as a result of transport activities constitute an externality, as long as road users are not charged. Heavy trucks generally cause more road damage then lighter ones. The costs associated with road deterioration include costs for wear-and-tear, reconstruction of roads, rehabilitation of bridges, and other miscellaneous costs (Newbery 1988).

[11] Different comparative studies indicate that SSS has a low marginal negative external cost, and furthermore has the greatest potential to cause a reduction in these externalities. In Taiwan, Lee et al. (2010) compared

environmentally friendly because the effects of externalities by SSS are buffered by the proximity gap that exist between the oceans, where ships operate, and population densities such as cities where people reside.[12] Externalities of road transport on the other hand usually occur in urban locations in proximity to high population densities and thus produce significantly higher damage costs (Denesis, 2009).

Lastly, linked to the quality of comparatively less air emissions in SSS, is the strength of energy-efficiency in shipping (Parajuli et al., 2001). Statistics show that in 2014, the volume of world seaborne trade accounted for an estimate 80% of total world merchandise trade (UNCTAD, 2015a), while the share of shipping in global transport energy use was only 6~9% (IEA, 2015). This advantage comes primarily from the inherent vice of floating on water, which requires minimal power to move the vessel per unit weight. A typical land vehicle has to overcome rolling resistance; grade resistance; inertial resistance; and air resistance in order to move, while ships only need to overcome wave and viscous resistance, and to a minimal level, air resistance in order to move (Kristensen, 2012).

1.1.2 SADC Transport Realities

According to the SADC Regional Infrastructure Development Master Plan (RIDMP)[13], the SADC region has an inefficient and ineffective freight transport system, that faces numerous challenges relating to the provision of adequate regional infrastructure, and related transport services, a setting which urgently requires visitation of strategies to improve, and expand the freight transport system to meet emerging demand (SADC, 2013).

The importance of freight transportation as an engine of growth, enabler of trade and a driver for socio-economic development is widely recognized the world throughout

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the environmental external costs between truck transport and SSS and found that SSS is a relatively environmental friendly mode. Similarly, in the USA, Denisis (2009) concluded that SSS is superior in terms of lower external costs compared to the all-truck transportation in the USA. Similar conclusion were also reached in studies in Australia (McAuley, 2010), and Europe (Brons and Christidis, 2013), were the external cost of SSS were found to be significantly lower than those of other modes of freight transport.

[12] Indeed, the basic pillars of SSS are to reduce pollution emissions and to reduce traffic congestion levels on the roads (Paixão and Marlow, 2002). It was therefore noted by the European Commission (EC) in 2002 that the: 'The development of short sea shipping is a central element of the strategy for achieving a clean, safe and efficient European transport system" (Pallis, 2002).

[13] The SADC Regional Infrastructure Development Master Plan (RIDMP) was adopted by the SADC members at the 32nd Ordinary Summit (August 2012). It aims to create an efficient, seamless and cost-effective trans-boundary infrastructure network in the following sectors: energy, information and communication technologies, transport, tourism, meteorology and water. The RIDMP will be implemented in three five-year intervals: 2012–17 (short term); 2017–22, (medium term); and 2022–27 (long term).

(Rietveld, Piet and Bruinsma, 2007; Rodrigue, 2017). The economic benefits of freight transport accrue only when the transport system allows users to move goods efficiently from a place of production to destinations where they are needed (Parida, 2014). It is expensive to build new roads and railway lines especially where they may go against community development and environmental goals, and there is also the fear that development of new infrastructure, particularly roads, may induce more traffic volumes (Rodrique, 2017). Consequently, striving for a balanced modal split among competing modes or developing new transport alternatives like SSS without major new capital investments being incurred is often the best initiative (COM, 2008).

Moreover, sustainability in transport has become a key development objective, at both the international and local levels (UNAGST, 2015).[14] Strategies to implement sustainable development in freight transport are numerous. However a key strategy reiterated is the employment of intermodal transport, particularly intermodal SSS (Behrends, 2011; Monios and Bergqvist, 2017).[15]

Freight transport in SADC is characterised by extreme polarization in favor of road (Mutambara, 2008). Road carries about 90 percent of intra-regional trade while rail, sea and air carries much of the remaining 10 per cent (SADC, 2015). The setup translates into a situation where there are numerous negative externalities,[16] including a high rate of transport related accidents, road congestion, high infrastructure expenditure, and environmental damage (Gatti et al., 2007; SADC, 2008).

A high mortality rate from road accidents is a major problem associated with transport by road in SADC. SADC countries are ranked highest in the world in terms of the number of road deaths per 100 000 residents per annum (Sivak and Schoettle, 2014).[17] Even

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[14] Sustainable transport is defined as "the transport development that meets the need of the present without compromising the ability of the future generations to meet their own needs" (EU transport policy). Sustainable freight transport entails balanced and synergized "economic, social and environmental dimensions of the freight transport sector in an integrated manner to ensure transportation that is safe, socially inclusive, accessible, reliable, affordable, fuel-efficient, environmentally friendly, low-carbon, and resilient to shocks and disruptions, including those caused by climate change and natural disasters" (UNCTAD, 2015b).

[15] Related strategies include improving operations, managing demand, and fostering cooperation among local governments to ensure that systems work synergistically (Monios and Bergqvist, 2017).

[16] Externalities in economics, refer to those costs which arise when the economic activities of a certain entity has an impact on another group of persons; and wherein the impact is not fully accounted by the group causing the impact.

[17] From a study on Mortality from Road crashes conducted by the University of Michigan in 2008, out of 193 countries around the world, 6 SADC members were ranked in the top 10. Namibia, Swaziland and Malawi were ranked 1,2 and 3 respectively (South Africa was not part of the study). Compared to the world average of 18 fatalities from road crashes per 100,000 population, the highest fatality rate from road crashes was in Namibia (45) and the lowest in the Maldives (2).

though causality of accidents may be linked to many factors such as roadway geometric features, traffic conditions, environmental characteristics, driver characteristics and vehicle characteristics (Dong et al., 2015), the major two cited causes are the conditions of the roads and the increasing presence of freight trucks on the roads (Korzhenevych et al., 2014; OECD, 1997). According to a South African Study on Road freight and the Environment there is a positive correlation between the growth in the number of road crashes and the growth in the number of freight trucks on urban roads (Makamo et al., 2015).

The increasing use of roads to carry freight has also been found to contribute to road congestion, which in turn causes time delays and wasted fuel (Swarts et al., 2012). Road also account for a major share of air pollution within the freight transport sector (Brons and Christidis, 2013; Denisis, 2009), and which according to the Lusaka Declaration on sustainability, takes a high toll on the health, environment and economies of African countries (SADC, 2008). Additionally, the excessive use of heavy trucks adds an additional cost burden to governments as a result of additional costs associated with road deterioration including costs for wear-and-tear, reconstruction of roads, rehabilitation of bridges, and other miscellaneous costs (Newbery, 1988). Governments in SADC are constantly building new roads and rail links, however, overloading by road users, floods, neglect and lack of maintenance have caused roads to deteriorate at alarming rates (Mutambara, 2008). Civil unrest and wars in Mozambique, Angola and the DRC have also caused significant damage to road and rail networks in these countries (Hoeffler, 2001).

Lastly, the negative impacts of the excessive use of road for freight transport in SADC are extended to other harms. For instance the impacts of road congestion are said to be longer transit times and unreliable transport services; which in turn lead to negative economic effects due to the inefficient delivery of goods and services (van Essen et al., 2011). The adverse impacts of these have both an economic dimension in terms of unattractiveness to foreign direct investors and a spatial dimension, within which businesses are marginally affected and poor people extremely affected. According to Pirie (2013) the geography of mobility deprivation “maps into household and personal vulnerability, impoverishment and socio-economic exclusion” where conditions are aggravated both by the high rate of road traffic fatalities in SADC and because these accidents mostly affect the relatively poor, especially pedestrians and children. Pirie (2003) also submits that the transmission of HIV-AIDS along key freight corridors used by long-haul truck drivers adds another dimension of geographical risk to individuals, households and transport companies because of the excessive use of road for freight.

To address these transport problems, rail has traditionally been favored as an alternative to road; however historic developments has made it doubtful that rail will ever become a serious competitor to road until reforms that address the below problems are addressed. The performance of rail in the region has been poor and continues to decline. Rail has been cited to have poor reliability, both in terms of safety and in terms of timeliness (Kritzinger-van Niekerk and Pinto Moreira, 2002). According to Mutambara (2008), this is primarily because of low availability of train wagons, poorly maintained tracks; extensive delays at border crossings, inconsistent delivery times, and poor information exchange on wagons and consignment. SADC's rail network also has serious intermodality problems that require a great effort from governments to reconcile the use of different features in the rail network. Additionally, these developments must be coupled to an extensive development of new rail networks because the current rail network is not extensive to connect the major population centers in the region. The setting therefore encourages the visitation of SSS.

To that effect, we need to consider SSS both in a unimodal sense between port cities in SADC and within intermodal transport setting between port cities and hinterland cities in SADC. Intermodal freight transport is defined as the "the movement of goods (in one and the same loading unit or vehicle) by successive modes of transport without handling of the goods themselves when changing modes" (Monios and Bergqvist, 2017).[18] Such a system might employ intermodal transport units, whereby a single loading unit is employed throughout (e.g. TEU container); or such a system might transload, whereby breakbulk shipments from the load unit of one mode is transloaded to a load unit of another mode (ibid).

The need for intermodal freight transport is enshrined in the objectives of sustainable development. The Brundtland Commission defined sustainable development as "development that meets the need of the present without compromising the needs of the future generations to meet their own needs." (Brundtland Commission, 1987). Strategies to implement sustainable development in freight transport are numerous however intermodal SSS has often been reiterated (Behrends, 2011; Monios and Bergqvist, 2017). In SADC particularly, intermodality in SSS is imperative given the unique freight transport setting, where the major population centers are located mostly in land, away from maritime ports, and where there exists a huge proximity gap between sources of supply

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[18] The Oxford 1999 dictionary gives the following definition: "a vehicle/container system involving two or more different modes".

and demand (See Chapter 2, Section 2.4). As such, intermodal freight transport is favored because it capitalizes on the inherent advantages of the different modes, by minimizing the impact of modal disadvantages, creating cost and operating efficiencies, whilst it is also environmentally friendly, and it offers capacity and provides more options to shippers (Monios and Bergqvist, 2017).

1.2 Problem Setting and Research Questions

On the backdrop of the background provided, SSS for SADC is studied. Within the context of this study, SSS is modeled as a hypothetical mode of transport for freight along transport corridors running parallel to the sea. Thus, SSS would be perceived as a mode of transport for freight whereby a conscious intention exists to concentrate freight flows on sea-based routes where those routes run more or less parallel to major transport corridors on land within the SADC region.

In such a system, consider a typical shipment of a container within the envisioned SSS setting as follow: a container will be picked up from the shipper's premises by a land-based mode and then transported over a considerable short distance to a seaport (port) and then loaded onto a ship; from where the container is transported by sea for the major part of the transport leg. At the destination port, the container is unloaded, cleared and then transferred to a land-based mode for delivery at the consignee's premises.[19] A pictorial illustration of SSS operation is shown in figure 1-2. In essence SSS occurs in a multimodal transport setting, however for ease of communication only the term SSS is employed throughout the thesis.

The actors in the freight procurement chain typical involve the shipper (consignor), the carrier (transport service provider) and the receiver (consignee). The shipper buys a service from the carrier, which is typically to transport a shipment between a certain origin-destination pairing. Intermediaries such as freight forwarders and 3PL are sometimes employed in this process. Freight forwarders (i.e. Clearing and Forwarding agents) act as agents for the shipper, in: carrier selection, customs and clearing duties, documentation, packaging and consolidation for containerized cargo (Rigtering, 2010). For very specialized shippers (such as mines and car manufactures) the entire freight

[19] The study setting is defined only to the extent of furthering the dialogue of SSS in SADC. The SSS market is wide and varied, and may include other shipping sectors such as ro-ro, dry-bulk, break-bulk, wet-bulk and general cargo.

procurement process can be outsourced to third parties such as 3PL and 4PL, who are specialist firms in logistics and supply chain management.

On this backdrop, it is typical that when introducing a new mode to the existing transport system, authorities generally want to know the level of improvements and infrastructure required for the different modes involved to operate effectively in order to achieve a certain level of modal split among competing modes (Rodrigue and Notteboom, 2010). SSS and the requirements for its development are complex and current literature (used in developed countries) is not necessarily compatible with the requirements for SSS development in SADC. Suitable solutions can only be obtained by investigating the factors from the local setting and accordingly draw conclusions.

The study therefore aims to fill that gap of empirical void in SADC, and fittingly employs a behavioral modeling framework approach in the form of discrete choice modeling (DCM), to guide empirical analysis to determine the conditions under which SSS could work in SADC. It has been proven that by studying the preference of transport users for freight transport, opportunities for SSS can be revealed (Brooks and Trifts, 2008). This approach is also in line with the provisions of the SADC Protocol on Transport, Communication and Meteorology to establish a customer-sensitive and needs driven approach (SADC 1996, sec. 8.1, (e)).

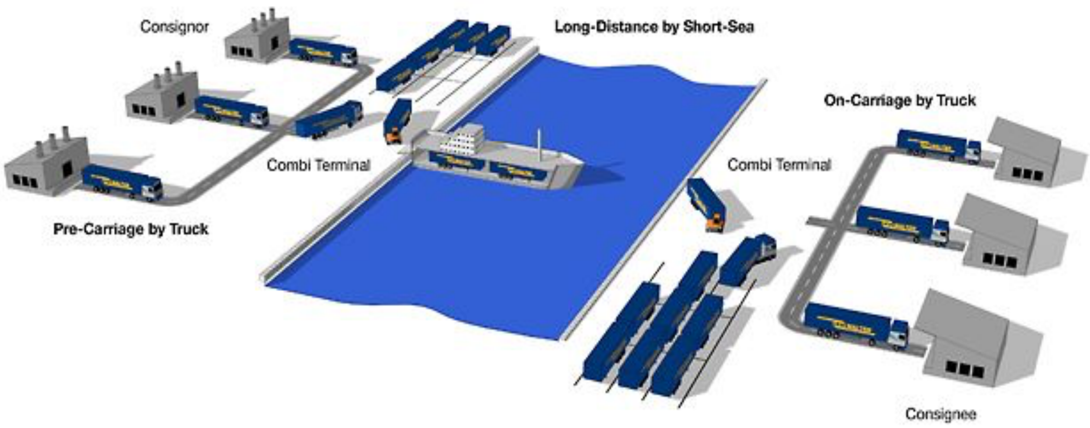

Figure 1-2 SSS operation (source: LKW, 2016)

1.2.2 General Research Question:

In order to achieve the SSS setting described, the general research question addressed in this thesis is: What are the perceptual requirements for the development of SSS in SADC?

1.2.3 Study Aims:

To address the research question, the aim of this study is to form an understanding of the factors that influence the development of short-sea shipping (SSS), and using that understanding, to develop discrete choice models that will enable the assessment of SSS development in SADC.

1.2.4 Specific Research Questions

i. What are the general determinants of SSS, and how does SADC fare in terms of these?
ii. Which choice factors influence freight mode choice decisions in SADC and what importance do shippers associate with their definitive attribute levels, both in a unimodal SSS setting and an intermodal SSS setting?
iii. What importance do maritime carriers associate with definitive attributes and attribute levels of the regional maritime transport industries?
iv. What is the impact of these findings on policy interventions, and SSS infrastructure development with regard to the attractiveness of SSS?

1.2.5 Research Objectives

i. Assess the determinants of SSS and the transport conditions in SADC.
ii. Determine who the decision maker is in terms of freight mode choice in SADC.
iii. Determine the choice factors that are most important to the shipper in terms of: freight mode choice, and that encourage and discourage the use of maritime transport in SADC.
iv. Determine specific freight transport corridors and optimal sample sizes that is representative of the SADC region and subsequently develop Stated Choice Experiments (SCEs), associate survey instruments, and Discrete Choice Models (DCM) to assess shipper behavior in SADC both in a unimodal setting and an intermodal SSS setting.
v. Develop SCEs, associate survey instruments, and DCM to assess conditions under which maritime carriers in SADC will participate in SSS.
vi. Evaluate the impact of policy interventions, and SSS infrastructure development on the attractiveness of SSS.

1.3 Contribution to New Knowledge

As a first contribution, the study contributes to research on freight transport in SADC and shipper behavior by describing the freight transport landscape through rigorous statistical treatment of real-world practice and decision-making. It is a well-known fact that the freight transport sector has received less research attention than passenger transport (Bendall and Brooks, 2011; Brooks et al., 2012b; Feo-Valero et al., 2016). This is even more so in SADC where there is a lack of freight demand data and where most sources of freight demand data are unreliable and generally unsynchronized (Vilakazi et al., 2014; Zamparini et al., 2011).

Secondly, previous choice studies that have studied the development of SSS, have considered it mostly from a shipper perspective (Bendall and Brooks, 2011; Brooks et al., 2012b; Feo-Valero et al., 2016; Feo et al., 2011b). This study considers SSS both from a shipper and a carrier perspective, and thus provides a holistic solution to the development of SSS in the SADC region.

Thirdly, the study contributes to the global body of maritime literature when it studies intra-regional maritime transport demand and supply in the SADC region, which constitute developing economies in Africa. In so doing, the study brings forth ideas on strategies and determinants for SSS in developing economies, and furthermore the implications of these strategies to the end users, the shipper and/or the carrier.

Fourthly, by considering the development of SSS in an African context, the study makes another contribution to the global literature of maritime transport. Not that the conception of SSS is not already well established in other parts of the world, but this idea brings with itself certain cultural anomalies, under a different composition of geography, law and level of maturity of industry. Added to this, the study further contributes to the regional and global bodies of maritime literature by formalizing SSS in SADC. In SADC, maritime transport is well represented in strategies and ministerial speeches, however not in formal publications.

Lastly, the study provides a strategy as to how to sustainably develop and expand the freight transport networks in SADC to meet emerging demand of freight, and thereby achieve social integration, economic development, and inter regional trade (SADC, 2013). There is a particular need for regional cooperation and integration if ample transport infrastructure development is to be achieved. SADC, via the Protocol on Transport, Communications and Meteorology puts onus on the member states to promote economically viable integrated transport services within the region characterized by high performance standards and compatible with responsible environmental management (Chapter 3, Article 3.1). [20]

[20] The Protocol further provide that under such a system, the modes must compliment and co-operate with each other, having due regard to modal choice optimization and the provision of multimodal transportation.

1.4 Limitations of Research

The research in this thesis is limited to the study of SSS development in SADC. SSS is known to be a complex and multidisciplinary issue (Brooks et al., 2006). It entails components in freight transport, sustainable transport planning, logistics and maritime law and policy. Putting these subjects together can be complicating, and hence, the wrong understanding of concepts can lead to failure in the development of SSS. Because of this, an entire chapter is dedicated to introducing SSS and its determinants.

The core focus in the research is the behavioral decision-making framework of shippers (including freight forwarders) and carriers. Shipper behavior is rooted in freight demand, whereas carrier behavior is rooted in maritime policy and economics theory. Individual shipper and carrier behavior are modelled to elicit preference for SSS. The observable service attributes are limited to observable service characteristics developed in the study. Measurement errors and ambiguity in definition of the alternatives, the modal attributes and the choice sets are potential sources of limitations in the description of the shipper and carrier behavior in the study.

Lastly, the factors that influence freight mode choice are examined with focus on intra-urban freight. Therefore, whenever the expression 'mode choice' is used, it should be construed as intra-urban freight mode choice happening between distant urban centers where the distances justifies use of SSS. The origin-destination pairings where potential for SSS is studied is provided in the different study components.

1.5 Challenges to Research

The biggest challenge in the study is the collection of data. There were foremost challenges in terms of sourcing funding to facilitate extensive data collection. Extensive applications to the South African Maritime Safety Authority, the Directorate of Maritime Affairs in Namibia and the SADC committee were written, however these applications were turned down. A budget was made available by the Centre for Transport Studies (Prof. Mark Zuidgeest) to pay for the data collection phase and for training, and additionally, the Namibia Ports Authority assisted with ad hoc interviews, travel expenses and meetings with shippers and carriers.

To achieve these objectives, SADC member states agree under Article 3.2 to have "a harmonized transport policy covering the establishment of infrastructure, logistics systems, and institutional frameworks, legal and financial frameworks, execution of research and technology transfer, and the development of effective communication networks".

Data collection was furthermore constrained by generic challenges inherent to freight studies including: the challenge of identifying the decision maker in freight mode choice, unwillingness of shippers to participate in freight studies in fear of disclosing confidential information that could hinder their competitiveness, and uniquely to this study, a language barrier considering the study was conducted only in English where in some countries like Angola, DRC, Mozambique and Tanzania, English is not a first language.

Lastly, the requirements towards freight transport models are complex as they need to include various modes and they also need to cover different industries with their different dynamics and structures, covering different commodities trading in different market structures such as short-lived fashion as well as slow moving bulk goods like fertilizer. De Jong, (2014) submits that inter-regional freight transport models additionally need to consider demographic parameters, geographical boundaries and trade agreements, economic developments, technological developments and their impact on production processes and structures and ultimately on freight mode choice. To cope with this complexity, a case-based modelling approach around a single policy issue of regional importance , the development of SSS for containerised freight was employed in all survey instruments that were developed in the auspices of the study (De Jong, 2014).

1.6 Motivation for research

The need to develop SSS for SADC is imperative. Considering that the sea in theory is limitless, and the projected freight volumes, the introduction of SSS will indefinitely lead to the expansion of the transport network thereby improving cargo flow. The development of SSS will also lead to a number of things: a balanced share of freight transport, flexibility within the transport network, decreased unit cost of transport, maintenance of vital links within the transport chain and increased competitiveness for the port hinterland.

The introduction of SSS will also improve the region's international competitiveness for logistics services and investment attractiveness leading to higher rating on many international indicators.[21] The introduction of SSS could also lead to improved port productivity. By swiftly transshipping containers out of a hub-port, using feeder vessels

[21] For example, the World Bank Logistics Performance Indicators (LPI) assess countries on six components of logistics: efficiency of customs and border clearance, transport infrastructure quality, flexibility and ease of arranging competitive shipments, quality and competence of logistics services, and the rate at which consignees receive shipments (The World Bank, 2014).

and container barges, SSS can cause an increase in the capacity of many port terminals in the Region.

The growth of the maritime industry has been on the agenda of African Union (AU) and the SADC community for some time, but the advancement of these thoughts have been slow and short of a strategy (Hare, 2013; The Brenthhurts Foundation, 2010). Maritime transport is considered the lynchpin of the world economy and its development has been highly considered on the agenda for the African continent (AU, 2010). The SADC protocol on integration also provides that a *"…region striving for stronger integration needs an efficient transport system to facilitate trade and socioeconomic ties*" (SADC, 2016).

In this regard, Stopford (2009) provides that shipping offers the transport system that is needed for economic development; to which Adam Smith (1776) added centuries ago, that it's a cheap source of transport that can open up wider markets for speculations. The growth of the maritime industry will create jobs and business opportunities giving an opportunity for growth of other markets (Ma, 2014). SSS can also contribute to the development of ancillary activities and industries such as ship design and construction, ship surveying, ship registration, maritime law and administration, and maritime auxiliary services (for example, insurance, banking, brokering, classification and consultancy.

1.7 Research Approach

The study employs a mixed-method approach to meet its objectives. The initials stages are mostly theoretical and qualitative, and they relate to developing the understanding of SSS and mode choice preference in freight transport. Later stages, which consist of choice modeling and inference, are mixtures of quantitative and qualitative methods.

Discrete choice modeling (DCM) was specifically identified as the best approach to capture the key behavioral measures that will induce mode shift of freight to SSS under various interventions and policies. DCM is particularly employed in the study due to its flexibility to capture behavioral realism; as it permits the construction of general utility functions incorporating various decision maker characteristics and choice attributes; which can furthermore be used to elicit preference for services and interventions that have not yet been introduced (Train, 2002).

Such knowledge can provide guidance on potential measures and interventions that need to be introduced to develop SSS in SADC and it can also play a key role in devising cost benefit analysis for infrastructure development and business investments; and when transport planners and policy makers find it necessary to devise policies to force a modal shift towards other sustainable transport alternatives such as rail.

1.8 Structure

Chapter 1 introduced the overall study, and it laid down the aims, and objectives of the study. The problem setting was described and the envisioned SSS system was described in brief. Subsequently, Chapter 2 provides an overview of SSS including a description of SSS, its determinants, and provides a description of the freight transport landscape in SADC. The aim of Chapter 2 is to provide an overview of SSS to the reader and to highlight the potential for SSS in SADC. It addresses the first research objective of the thesis.

Chapter 3 is dedicated to the methods and to that end discusses formulation of the discrete choice models and the stated choice experiment employed in the study. The discrete choice models employed in the study are formulated and the associated stated choice experiment techniques (i.e. the d-efficient experiment design) is derived.

Chapter 4 is dedicated to the review of literature as it pertains to behavioral modeling in freight transport. Special emphasis is put on the development of SSS throughout this chapter.

Chapter 5 discusses the steps taken for stated choice experiment design, survey design and data collection. Particularly in this chapter, the attribute levels are set, the utility functions are specified, the experiment is designed, and the survey instruments are developed and described.

Chapter 6 describes the freight procurement landscape in SADC by ascertaining who the decision-maker is in terms of mode choice in SADC and by determining the significant modal attributes that shippers consider when they make freight mode choice decisions.

Chapter 7 feeds from chapter 6 and is respectively dedicated to modeling the preference of shippers for unimodal SSS and intermodal SSS. Various discrete choice models are developed to explain shipper behavior in SADC.

Chapter 8 is dedicated to carrier preference. It describes the maritime landscape in SADC and reports on the preference of maritime carriers and operators in SADC.

Chapter 9 brings it all together. It considers case base scenarios of various interventions in terms of policies and interventions required to develop SSS, and it discusses the implication of the modeling results.

Finally, Chapter 10 is the conclusion chapter. It highlights the critical findings of the study, summarizes the results, the limitations of current research, and future areas of research. The venture flow for the study is depicted in Figure 1-3 below.

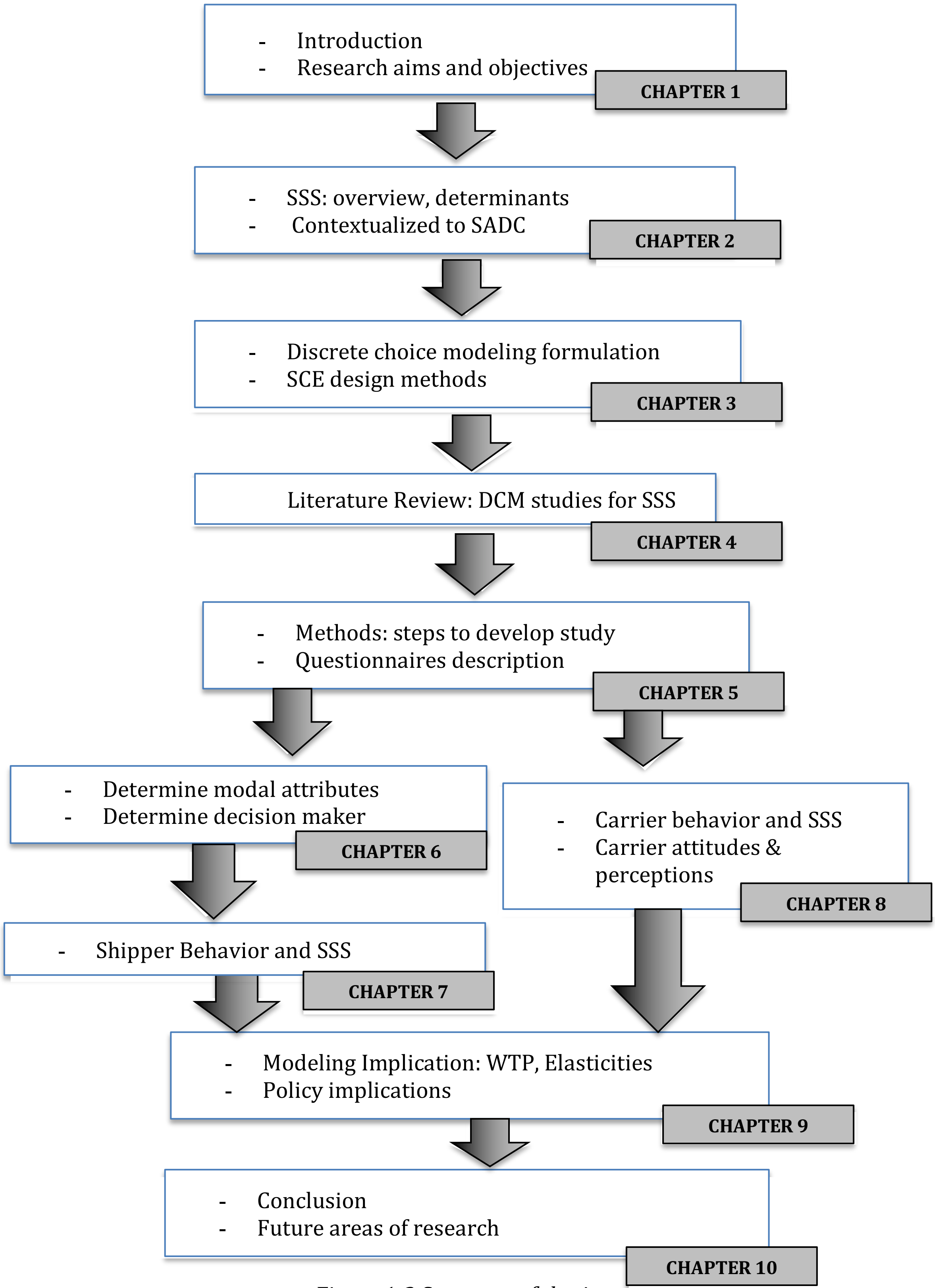

Figure 1-3 Structure of thesis

"Shipping is one of the major catalysts of economic development. Shipping is a cheap source of transport which can open up wider markets of speculation, offering shipping of even the most everyday products at prices far below those that can be achieved by any other means."

~Adam Smith, (*Wealth of Nations,* 1776)

2 SSS IN SADC: OVERVIEW AND DETERMINANTS*

The aim of this chapter is to provide an overview of SSS including its description, its historical development, its determinants both from the demand and supply side of SSS and the contextualization of these factors to the freight transport setting in SADC.

2.1 Description and Definition

Seaborne transport (also known as maritime transport or shipping) is generally classified deep-sea (DSS) or short-sea depending on trade distance and trade characteristics (Stopford, 2009). As figure 2-1 below shows, short-sea shipping (SSS) provides transport services by sea within a region, while deep-sea shipping [as the name implies] caters for inter-continental trade.

Figure 2-1 DSS and SSS operation (source: author)

Within a hub[22] and spoke setting, shipping lines employ very large vessels on trans-ocean routes and limit their calls to a few hub ports. This is done in order to save time and exploit economies of scale (Gelareh and Pisinger, 2011).[23] SSS would subsequently service the intra-regional routes connecting the hub ports to feeder ports located within the continents (or regions as illustrated in Figure 2-1).[24]

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* *Parts of this Chapter were published by the author in Konstantinus et al. (2019).*

[22] Hub ports are big regional ports that can process large volumes of cargo. They allow logistic companies to take advantage of economies of scale and density in shipping, and thereby lowering their shipping costs.

[23] In the past ships engaged in liner operations would stop over in every port on a specific route at least once. Today, ships are bigger and so not all ports can accommodate them. Subsequently large intercontinental ships will only stop at large hub ports where anchoring is feasible and a quick turnaround time can be achieved.

[24] This is practice is known as 'feedering'. Mostly international containerized cargo that is transported this way.

Another setting might be as follow: a big international freight carrying ship would call at a hub-port within a region and discharge freight. The freight may be destined for the sub region hinterland or for transshipment at another hub port within the region. From the hub port, the cargo is transported further to their destination ports using smaller ships, which operate on a frequent schedule, on specified routes. When employed in this way the objective of SSS is to offer the main leg of intermodal transport (Musso et al., 2010).

Despite the drive for SSS starting in the early 90's, still to date, there is no single accepted definition of SSS (Marlow et al., 1997; Medda & Trujillo, 2010; Paixão & Marlow, 2002; Lombardo, 2004). The most widely used definition comes from the US maritime administration (MARAD), which defines SSS as a *" commercial water born transportation system that does not transit an ocean. It is an alternative form of commercial transportation that utilizes inland and coastal waterways to move commercial freight from major domestic ports to its destination"* (MARAD, 1999, p.1). Due to the many speculations regarding the exact definition of SSS, its definition often varies from region to region, from policy to policy, and from author to author. For instance, Marlow et al. (1997) associates SSS with the type and size of ships commonly employed in SSS, Stopford (2009) defines it as a maritime feeder transport service within a region in competition with unimodal road transportation, while Douet & Cappuccilli (2011) uses cargo type and vessel type to define SSS. This lack of consensus in the definition for SSS was ignored by the European Union (EU) during the inception stages of SSS and to their disadvantage, it was later identified as causative to the methodological problems and obstacles for scientific research and market analysis of SSS (Lombardo, 2004). The adoption of an improper definition by the European Council (EC) was also blamed for the implementation of unfit, contradictory public policies, and the overestimation of the modal shift by the EU and consequently improper strategic planning and slow modal shift in favor of SSS (Douet and Cappuccilli, 2011).

2.2 Historical development of SSS

The practice of SSS has its genesis in traditional coastal shipping practices were small merchant ships tended to sail within sight of the coastline while moving goods and people from one seaport to another (Lombardo, 2004). Ships of old were relatively small in size and had a proportionally small cargo carrying capacity. They also had very unreliable schedules and events of cargo lost at sea was not uncommon (Hare, 2009). With the advent of time, technological advancements led to the invention of trucks and trains and to the development of national highways and railway systems which offered faster and more reliable transport services. The emergence of globalization in industry further pushed for complex supply chains, which demanded shorter lead times and thus made road transport a preferred mode for freight transport. Of course, this meant that ships could not compete with the faster land-based modes and so, ultimately, the use of coastal shipping for freight transport declined as a result.

Figure 2-2: Typical Coastal Freighter in 1850 (Casson, 1964)[25]

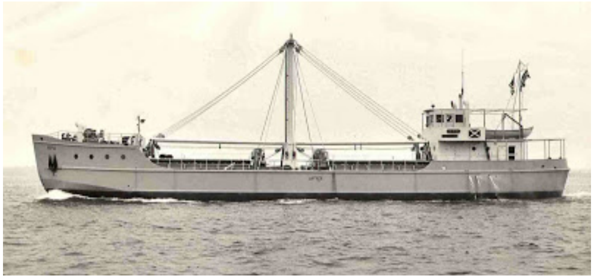

Figure 2-3: Typical Coastal freighter in 1950 (Sparkman & Stephens, 2010)[26]

Figure 2-4: Typical coastal freighter in 2016 (Svendsen and Tiedemann, 2014)[27]

In recent years however, the world has witnessed an increasing demand for freight transport in virtually every part of it (UNCTAD, 2015b). It has at the same time also become apparent that freight transportation is accompanied by numerous negative externalities, which are not always accounted for in the total transport cost (Newbery, 1988). Road, particularly, has the highest negative externalities compared to rail and SSS. However, notwithstanding these shortcomings, road appeals best to shippers because it

[25] Typical characteristics: Length 30m, 6m Beam, Draft 1m, top speed depends on wind, typical cargo: general, capacity 100 tons.
[26] Typical characteristics: Length 43m, 9m Beam, Draft 3m, top speed 9 knots, typical cargo: packaged items, capacity 275 tons (Insert MV KPO).
[27] Typical dimension, 130m Length, Beam 20 m, Draft 7m, typical cargo: containerized, capacity 700 teu (8000 tons), top speed 18.5. However today, SSS employ ships ranging in size typically between 400dwt and 6000dwt (Stopford, 2009a). Small bulk carriers, tankers, containerships, and ro-ro ships are employed to fit the shipment requirement. Many of these are traditionally slow moving (averaging speed of 13 knots) however, the need to improve service times have seen the introduction of faster ships such as wave pierce catamarans and other high-speed water crafts. The designs of these ships place much emphasis on cargo flexibility, and maneuverability to be able to enter and depart ports quickly, and with little pilot assistance as possible (EC, 2006).

is faster, flexible, and is still the only mode that conveniently offers door-to-door intra urban freight transport in many parts of the world.

At the same time, Banister, (2008) provide that concerns for climate change, energy use, environmental impacts, and a lack of financial capital are driving the need to adopt new approaches to planning, designing, building, operating, and maintaining transportation systems. Subsequently, climate change adaptation techniques are now being applied to "engineering specifications, alignments, and master planning, incorporating associated environmental measures, promoting green freight and logistics, and adjusting maintenance and contract scheduling" (COMCEC, 2017, p. 28).

On this backdrop, the push towards SSS has emerged. Authorities could not continue to rely on road transport because the associate negative externalities could be exacerbated if road was excessively employed (Akinbami and Fadareb, 1997; Calthrop and Proost, 1998). This compounded to a growing worry of stagnation in transport infrastructure investments has been a core driver in the explicit political agenda to shift freight from road and to look at coastal shipping under its incarnated version of SSS as an attractive complement to road and rail (Douet and François, 2011; Styhre, 2014).

2.3 Determinants of SSS

The terrain to grow SSS is typically a large geographical area that is industrial, where there are sufficient waterways that are navigable by ships, that has sufficient ports connecting these waterways (Ma, 2014). Big regions such as Europe, and North America where there are long coastlines, or Asia where there exist many habitable islands have been ideal for SSS activities (ibid). In addition to this, the development of SSS is said to be influenced by weather, economic factors and regulations that govern freight transport.

For SSS to be viable from a carrier perceptive, there has to be justifiable volumes of freight that require transport by sea. The volume of freight is derived from trade, however government initiatives such as logistical initiatives like transshipment and political action to use SSS can also induce freight volumes for SSS (EC, 2011b). It is for this reason that countries like China that produce primary commodities (such as mining extracts) in one part of the country and in another region process these to feed economic activities tend to be ideal for SSS development (Ma, 2014). From a shipper perspective, freight volumes may also play a part in inducing SSS. A great example of this is that is the SSS route between Gothenburg and Ghent linking Sweden and Belgium which was started pretty much by Volvo. On this route, manufacturing of car parts happens in Gothenburg and assembly of cars happens in Ghent. In a similar fashion, areas who function as regional transshipment hubs for major shipping lines such as Hong-Kong, Malta and Singapore have a large volume of SSS activity (Baird, 2006).

2.3.1 Ports and SSS

Furthermore, the conditions of ports in a region are particularly crucial for the development of SSS. The port is a vital organ of the maritime transport system, such that its competitiveness has often been linked to relevant economic variables such as export competitiveness and final import prices (Blonigen & Wilson, 2006). Recent statistics show that over 80 percent of global trade by volume, and over 70 percent of trade value pass through ports (UNCTAD, 2015a). However, it is also in the port, where about 66 percent of maritime transport costs are incurred, during wharfage, handling and storage of goods (Ma, 2014). It is furthermore where most delays of goods occur and most expenses by ships in terms of ship operations expenses are incurred (ibid).

Fittingly, Clark et al., (2004) provides that poorly performing ports are also said to hamper trade, especially for developing countries. In line with this finding, Blonigen & Wilson, 2006 found a positive correlation between growth in national trade and port performance; a finding supported by the 2014 World Bank report on port competitiveness that provides that ports play an important role in enhancing economic growth, poverty eradication and diversification (The World Bank, 2014). According to Sánchez et al., (2003), port competitiveness may be enhanced by decreasing port costs, increasing port efficiency, maintaining port infrastructure and improving inter-port connectivity.

2.3.2 Economic Factors for the development of intermodal SSS

In addition to the competitiveness of ports, Musso et al (2010) proposes a framework based on the *la Hoover* theory in Economics,[28] that jointly considers distance and transport cost when considering intermodal SSS. The framework identifies the critical threshold in terms of distance and costs that determines SSS competitiveness, particularly in an intermodal chain setting when competing with land-based modes. They submit that if SSS replaces a part of a journey that is usually done by road, the additional modal change will imply a higher general cost. Total transport time increases, while reliability, punctuality and safety are hindered by bottlenecks, congestion, mistakes and safety. These costs are compensated by the savings achieved by SSS because of changing

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[28] See (Hoover, 1949) as cited in (Musso et al., 2010b)

cargo volumes, economies of scale and economies of density. SSS is consequently chosen when the optimization of modes on the different legs generates benefits higher than the additional transshipment costs (Musso et al., 2010, p. 406).

A borrowed example in Figure 2-5 from Musso et al (2010) below illustrates this. The journey 'between origin O to destination D has both SSS and road available for the main leg 'A-B', and only road is available for the initial stages 'O-A' and the final stages 'B-D'. Function 'a' depicts the total cost for using the road only option, while function 'b' depicts the total cost for using SSS for the main leg (A-B) and road for the initial and final stages of the journey. Modal transfer costs are added at 'A' and 'B'. As can be seen the SSS leg (A-B) has a lower cost and thus more advantageous when the sea leg is long enough to compensate for terminal costs.

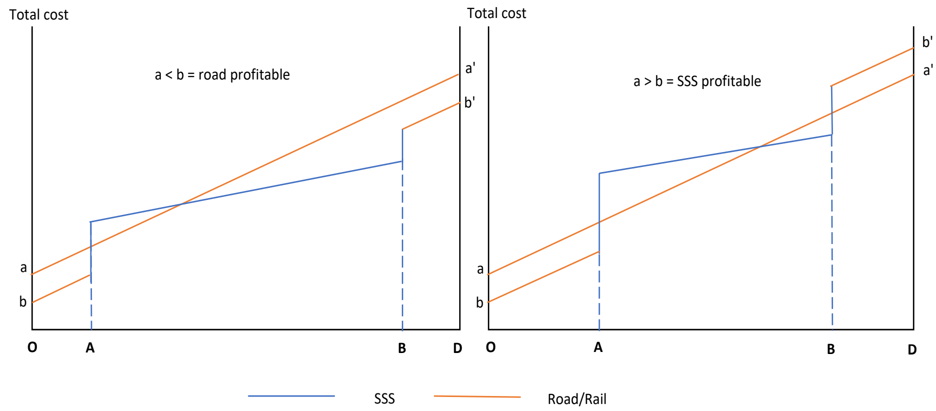

Figure 2-5: Distance and Cost threshold for intermodal SSS (source: Musso et al (2010))

Where O, A, B and D are not aligned, a formula may be used to find the combination of transport costs, terminal costs, land distances and intermodal distances that will account for SSS competitiveness. The respective total costs for road transport between O and D (T_{OD}) and for SSS (T_{OABD}) between O and D via ports A and B may be given by (Musso et al., (2010):

$$T_{OD} = C + t_{m_1} \times d_{OD} + S \quad (1)$$

$$T_{OABD} = C + t_{m_1} \times d_{OA} + T + t_{m_2} \times d_{AB} + T + t_{m_3} \times d_{BD} + S \quad (2)$$

where C and S terminal handling costs in O and D respectively, t_{m1}, t_{m2} and t_{m3} are the transport rates per kilometer for mode m_1 (road), m_2 (SSS) and m_3 (road), over respective distances with d_{OD} denoting land transport distance by road, d_{OA} and d_{BD} denoting road-based distances for intermodal SSS option and d_{AB} is the sea based distances; and finally where T is the transshipment-generalized cost in ports (mode transfer costs) and.

Each journey will thus identify the respective land and sea-based distances, which satisfy the conditions according to the transshipment costs, and the rates per (nautical) mile of mode m_1 or m_3 (road) or m_2 (SSS) where the competitiveness of SSS can be optimized. Accordingly, the competitiveness of SSS (m_2) will increase with:

i. Low terminal costs: T (i.e. port charges)
ii. Low freight rates by SSS: t_{m2}
iii. Increase transport costs by road: t_{m1} and t_{m3} (i.e. carbon pricing on roads).

In a nutshell therefore, SSS will be competitive when there is a higher ratio of *AB to OD* and where this is a higher ratio of t_{m2} to ($t_{m1} + t_{m3}$). As to the exact levels, this depends on geography and other factors peculiar to the respective region such as weather and the efficiency levels of competing modes. A study by Brooks and Trifts (2008) found that in Australia, SSS was truck-competitive in maritime corridors under 1,000 nautical miles under specific conditions. A similar study by Brooks & Trifts in Canada found SSS to be truck competitive in a specific route at a distance of 743 nautical miles but became preferred at a distance exceeding 1000 nautical miles (Brooks and Trifts, 2008). In Greece, Sambracos & Maniati (2012) found that SSS as an alternative to the road freight transport is possible in the area spanning from Patra to West Attica covering a distance of about 250km, which is equivalent to 135 nautical miles (Sambracos and Maniati, 2012).

Related to the above, mode choice studies which investigated the viability of SSS in Europe done by the EC in 1996 revealed that the door-to-door price by SSS would had to be 35 percent less than that of road if European shippers were to switch to SSS (Zachial, 2001). Similarly, a mode choice study by García-Menéndez et al. (2004) which investigate the modal shift of freight from road to SSS in Europe revealed that shippers are more sensitive to changes in the transport costs of road than that of SSS; and therefore, it was concluded that modal shift to SSS can only be induced by imposing 'ecotax' on road.

However, notwithstanding the importance of economic factors, measures solely based on cost and distance will not induce demand for SSS; shippers must also perceive SSS to be suitable for their transport needs. Numerous studies in freight consider a class of qualitative factors. Thus, besides cost and distance, shippers generally consider reliability, transit time, rate of damage, flexibility and frequency of service (Winston, 1981; Fowkes et al., 2004; Massiani et al.,2008). These factors however, tend to vary from time to time and from region to region. It was thus made an objective in this study, to determine the mode choice factors, a priori the stated choice experiments (see further section Chapter 6 for discussion on mode choice attributes).

2.4 Policies to develop SSS

Globally, different national and regional authorities such as the United States Maritime Administration (MARAD) and the European Commission (EC) have funded several projects and enacted policies aimed to strengthen the competitiveness of SSS and achieve modal shift from road to SSS (Douet and Cappuccilli, 2011; MARAD, 1999). In Europe, were the development of SSS has been extensively pursued, SSS accounts for 37% of intra EU trade, and it has furthermore been the only mode to keep up with road based transport (ECSA, 2016). Road now accounts for 45%, while rail accounts 10% and air and pipelines account for 5% for intra EU trade.

The success of European SSS is said to be attributable to political actions that were taken to improve the competitiveness of SSS (Brooks, Hodgson, & Frost, 2006). The main policies for SSS today in Europe include policies dedicated to fund SSS transport infrastructure (TEN-T projects) and those dedicated to support SSS operations and activities (PACT and Marco Polo I and II) (Paixão Casaca and Marlow, 2005). The big step in in the development of European SSS is said to have come about with the conception of the Trans-European Transport Network (TEN-T). The main goal of TEN-T was "to remove bottlenecks in transport infrastructure, as well as to ensure the future sustainability of transport networks by taking into account energy efficiency needs and the challenges of climate change" (Suárez-Alemán, 2015). The inherent implication of this aim was that that both the concerns for the environment and concerns against unfair competition from other modes (particularly by road) were addressed. The working objective of TENT-T was further "to stimulate investment in an integrated transport network covering all of the EU community through the different modes of transport" (ibid). The grants provided for SSS under TEN-T cover feasibility, technical and environmental studies as well as equipment and services to develop maritime transport (Casaca and Marlow, 2007), and regarding the efficiency aspect of SSS it aims "to increase and modernise port capacity, and improve their ability to handle intermodal transport activity" (Morales-fusco et al., 2012).

Linked to the TEN-T initiative, is the 'Motorways of the Seas' (MoS) program, which was incepted under the TEN-T networks in 2004. The aim of MoS is "to concentrate flows of freight on sea-based logistical routes in such a way as to improve existing maritime links or to establish new viable, regular and frequent maritime links for the transport of goods between member states so as to reduce road congestion and/or improve access to peripheral and island regions and States" (EC, 2011). The MoS program provides for a regular door-to-door links carried via ports with quality standards in transit time, costs, flexibility and with little paperwork. MoS integrates SSS with other modes of transport such as rail and road, and it furthermore strives to make the seaborne leg of such transport chains seamless and efficient by investing in various aspects of SSS in order to grow its modal share (Morales-fusco et al., 2012).

It is further purported that a key step in the development of SSS in Europe, was the liberalisation of European shipping services in 1985 (Pallis, 2002). Liberalisation meant the rights for cabotage services were extended to all regional shipowners and to the larger geographic Europe (and later entirely removed). This ensured a larger market in which SSS could operate and it also gave vessel operators access to longer routes, ensuring that there were now new corridors of sufficient length to allow coastal shipping to compete with land-based alternatives (Bendall & Brooks, 2011). This note is particularly useful to the development of SSS in SADC, as the South Africa has recently approved the Comprehensive Maritime Transport Policy (CMTP), which amongst many things, advocates for a cabotage regulatory framework that limits the carriage of goods between South African ports to South African registered ships (NDoT, 2017).This point is revisited later during the carrier component when we gauge the views of carriers on cabotage in SADC, and the impacts of their participation in SSS in SADC.

2.5 Freight Transport in SADC and potential inhibitions to SSS Development

On the backdrop of a discussion on the determinants of SSS, we must consider the freight transport setting in SADC. We must consider the transport infrastructure, international trade, intra-regional trade and we must lastly consider both the enhancers and inhibitors of SSS.

2.5.1 Transport Infrastructure

The SADC region comprises a landmass of 5.55 million km^2, a collective GDP of US$706 billion and a combined population of 337 million (SADC, 2015). It has freight transport sector that entails road, rail, air and maritime transport that is characterized by a coastline spanning 14 729 km, a total road network spanning approximately 900 000 km, of which 100 000 km represent primary roads that connect major cities and freight transport corridors and 14 interconnected national railway networks, which span 10,000 km, connecting the major ports of the region (SADC, 2013). [29]

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[29] 11 of these rail networks form the Interconnected Regional Rail Network (IRRN). South Africa's railway network forms the major part of this network accounting for nearly 62 per cent of network (RFDM, 2015). The modal share of rail has suffered a decline over the years primarily because of reasons cited in Chapter 1, which include: poor reliability, high accident and failure rates, and high costs and low freight volumes. The majority national railway companies are also operating at a loss and most are not really financially

The extensive port system in SADC is majorly dominated by South African ports; both in terms of sheer numbers as well as the capacity and volumes handled. South African ports also serve the majority of landlocked countries in SADC. The majority ports in SADC were primarily designed to serve the needs of the individual countries and their natural hinterlands, and thus there is an apparent fragmentation in the general transport networks that connect the ports (RFDM, 2015). Many of SADC ports are also general ports, focused on a variety of imports and mineral exports and hence unadapt to SSS (ibid). The high average growth rate in Africa over the last few years has additionally had a marked effect on the utilisation and efficiency of these ports and so many are operating around their design capacity (SADC, 2015). New opportunities for new operations are however emerging slowly, such as the specialisation of ports for container handling or for dry bulk handling, especially so in high potential markets in SADC such as Namibia and Tanzania.[30]

As illustrated in Figure 2-6, the SADC region furthermore has an extensive network of freight transport corridors. These freight transport corridors were first set up in the 1980's due to the many Land Locked Countries (LLCs) in the region, but a particularly motivation was to by-pass South Africa in rejection of the apartheid government in South Africa at the time (COMCEC, 2017). Development of these corridors were mostly starting from a port and developed protruding inwards towards LLCs.

Today, the SADC transport corridors (shown in Figure 2-6) are regarded as some of the successful corridors in the world (ibid). Some of the features that made them successful include: common political objectives, adopting a common language (English), similar road and rail design and operational standards, co-operation amongst member states and the establishment of corridor specific secretariats (ibid). The SADC Corridor approach to regional development is furthermore based both on well-maintained and operated infrastructure and the provision of seamless transport services (ibid).

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sustainable (Havenga et al., 2014). The main reason for this is because of initial loss of freight volumes to road, which primarily came about because of road transport deregulation in the region. Ironically now, rail requires a substantial increase in freight volumes in order to become viable (RFDM, 2015).

[30] The growth of container throughput for the entire African continent is estimated to grow at 2% higher than worldwide average (RFDM, 2015; UNCTAD, 2013). It is further estimated that as Africa's demand increases at about 6% on average per annum, the capacity in ports increases by about 8%. In terms of bulk ports, there are very few specialized ports in SADC. Again this is not expected to continue especially given that SADC is a mass exporter of mineral products, so we could soon see the growth of dry bulk ports in the near future (RFDM, 2015).

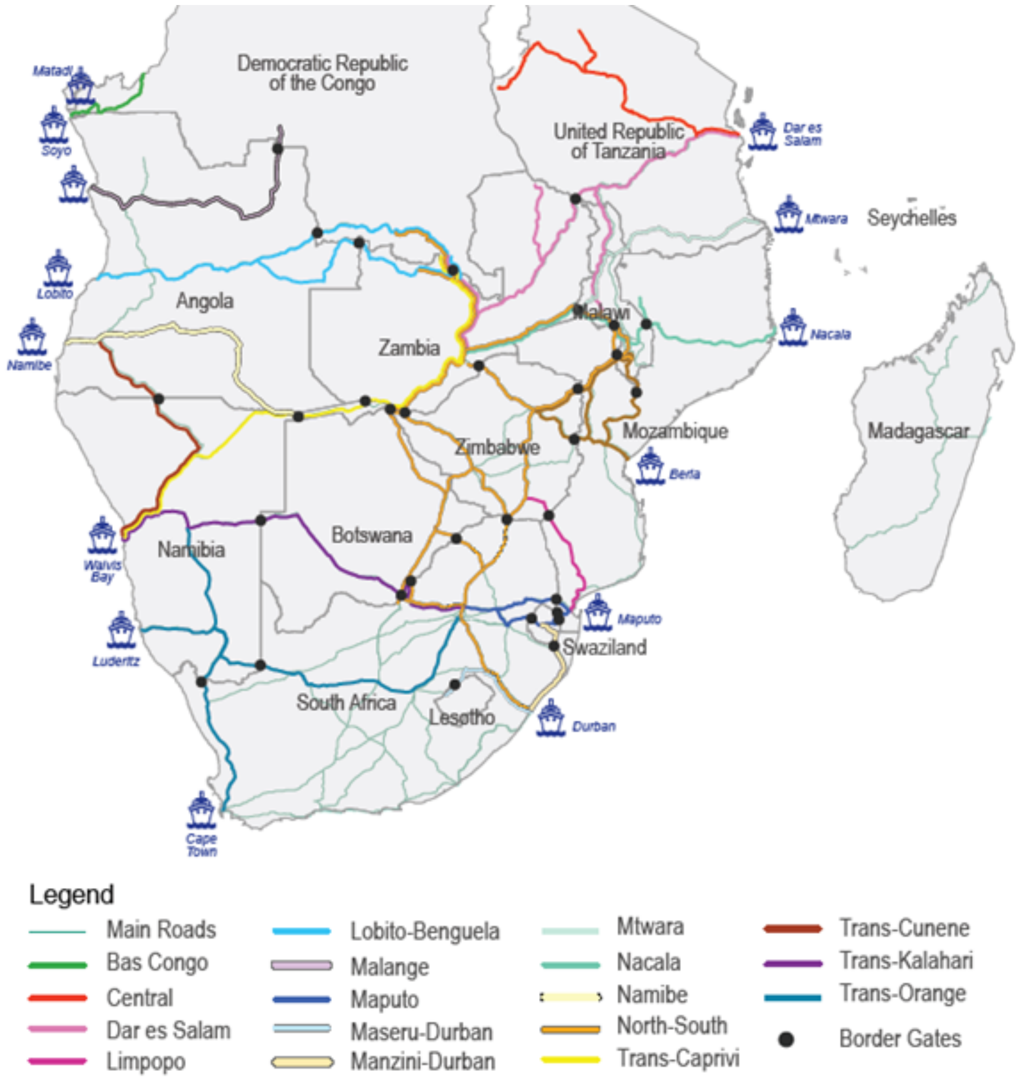

Figure 2-6: SADC Transport Corridors (Source: SADC website).

2.5.2 International trade

As a region, SADC relies heavily on international trade. As figure 2-7 shows, containerized goods make up the biggest share of total goods imported while exports are primarily bulk cargoes as figure 2-7 (RFDM, 2015). Furthermore, international trade projections forecast an exponential growth of freight movement in SADC in the next 20 years, and it is perpetuated that this growth will put immense pressure on the regional transport network as figure 2-8 shows. The region projects a growth of goods passing through the region's maritime ports, from 92 million tonnes in 2009 to 500 million tonnes by 2027 (SADC, 2013).

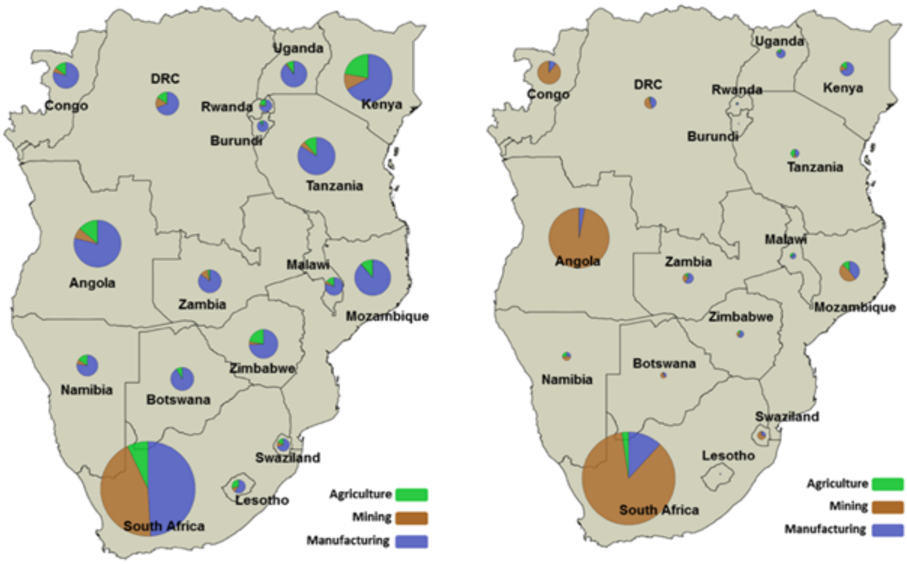

Figure 2-7: *2014 Seaborne imports left and exports right (GAIN Group, 2015)*

Figure 2-8 shows that these projections compared to the infrastructure levels in SADC shows a negative correlation, implying that freight transport infrastructure in SADC are either stagnant or dilapidating. The graph in Figure 2-8, shows a graph of the 'SADC transport infrastructure level' score according to the World Economic Forum (WEF, 2016) pegged against the projected levels of freight volumes passing SADC's maritime ports (SADC, 2012).

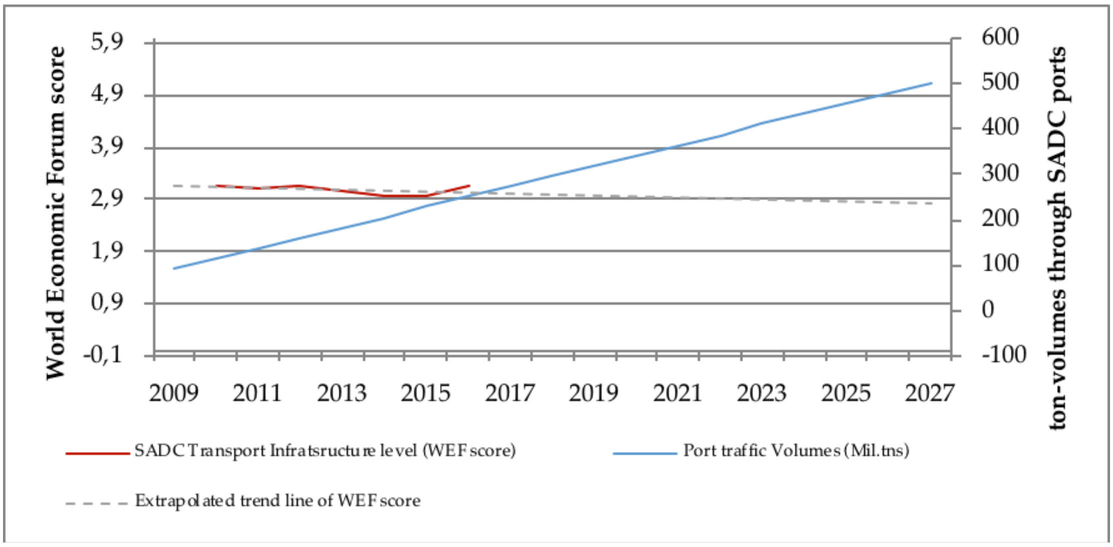

Figure 2-8: Transport infrastructure versus freight growth projections in SADC (SADC, 2013; WEF, 2016)

The World Economic Forum's (WEF) transport infrastructure score, which is assigned out of 7, with 1 lowest and 7 best, is compiled from the perceived quality of overall infrastructure, quality of roads, quality of railroad infrastructure, quality of air infrastructure and availability of airline km per week. It provides a score for the business operating environment and competitiveness in over 140 countries (WEF, 2016). The WEF score for transport infrastructure for 12 SADC member states (excluding Comoros, Seychelles and Mauritius) was aggregated as a WEF score for SADC and compared to the freight projection in SADC.

From figure 2-8, there appears to be an inversely proportional relationship between freight growth and level of infrastructure. Even though Figure 2-8 is based only the correlation between transport infrastructure and WEF score, one thing that is clear is that the transport infrastructure in SADC will soon not be able to cater for the projected freight volumes. Indeed, there also a strong possibility of stagnation in transport infrastructure investments, as new roads and rail way infrastructure might not be enough to improve freight transport conditions in SADC.

2.5.3 Intra-regional trade and freight flows

In contrast to international trade with SADC, intra-SADC trade grew very slowly in the last 2 decades (Skordis et al, 2001). This has been in spite of the important focus placed on free trade agreements and policies to boost intra-regional integration. Traffic across SADC Corridor Borders is typically around 300 trucks and 500 vehicles per day, which is not very high (ibid).

Nonetheless, SADC has made significant progress to eliminate tariffs for intra-regional trade, particularly with the inception of the SADC Free Trade Area (FTA) and the establishment of the SADC Customs Union (Lewis, 2003; Parida, 2014). It was anticipated that lifting of tariffs for intra-regional tariffs will lower transport costs and lead to more intra-regional trade, however, an audit conducted in 2011 on the implementation of the SADC Trade Protocol revealed that members states found the SADC rules complex and difficult to apply. Kamau (2014 submits that internal customs border controls still exist and new rules are not being applied uniformly, as a result of which according to Chidede (2017), intra-SADC trade stands at a mere 10 percent (Chidede, 2017). Chidede, (2017) further argues that compared to other regions in the world such as South-East Asia (24%), EU (40%), 10% for SADC is very low.

The FTA in SADC has great potential for intra-regional trade but only assuming member states apply the FTA rules (Fall and Gasealahwe, 2017). Based on estimates from gravity equations of bilateral trade in SADC has increased by 62% by the free trade agreement (ibid). The estimations suggest that tariffs and non-tariff measures have inhibited trade between SADC members. The results are encouraging for deepening SADC regional integration as they suggest that there is scope to further boost trade in the region.

Table 2-1 and Table 2-2 depicts the projected intra-regional trade volumes for the SADC mainland.

Table 2-1: Intra-regional imports on the SADC mainland, thousand tons (RFDM, 2015)

	Agriculture			Manufacturing			Mining		
Country	**2013**	**2019**	**2044**	**2013**	**2019**	**2044**	**2013**	**2019**	2044
Angola	111	126	236	974	1159	2339	32	37	147
Botswana	374	397	514	1897	2158	4069	165	189	335
DRC	74	104	385	1537	1984	6080	72	101	426
Lesotho	218	225	259	757	866	1382	53	63	96
Malawi	136	1507	511	535	636	1546	44	48	144
Mozambique	155	164	280	1450	1768	4335	45	57	94
Namibia	154	168	260	1741	2047	4091	78	94	202
South Africa	597	666	1243	4063	5077	13054	3032	3469	6994
Swaziland	191	197	234	730	830	1499	118	139	200
Tanzania	96	122	392	542	684	1786	12	18	25
Zambia	41	48	88	1596	1930	4451	909	1212	2067
Zimbabwe	439	497	1028	1110	1282	2610	117	151	448
Grand total	**2591**	**2869**	**5431**	**16933**	**20420**	**47242**	**4677**	**5577**	**11179**

*Note: data for some SADC members was not available.

Table 2-2: Intra-regional exports on the SADC mainland, thousand tons (RFDM, 2015)

	Agriculture			Manufacturing			Mining		
Country	**2013**	**2019**	**2044**	**2013**	**2019**	**2044**	**2013**	**2019**	**2044**
Angola	0	0	0	5	5	7	2316	2707	6007
Botswana	8	8	17	214	265	477	334	388	787
DRC	1	1	3	93	120	359	486	725	935
Lesotho	2	2	2	85	109	299	25	27	34
Malawi	61	73	205	158	204	651	10	16	22
Mozambique	154	171	443	2830	3574	9734	129	140	284
Namibia	248	291	602	403	485	1132	379	432	955
South Africa	1415	1488	1861	11168	13053	26082	746	882	1462
Swaziland	47	49	58	514	654	1759	45	48	61
Tanzania	111	141	372	670	802	2402	78	99	224
Zambia	346	419	1171	840	1047	3093	46	52	115
Zimbabwe	199	212	454	486	600	1508	226	233	552
Grand total	**2591**	**2855**	**5188**	**17465**	**20919**	**47504**	**4821**	**5751**	**11438**

*Note: data for some SADC members was not available.

A concerning factor, with regard to trade patterns between SADC member states, is the domination intra-regional trade by South Africa which accounts for approximately 68% of exports and 15% of imports (Sandrey, 2013). The remainder of SADC countries are net importers from South Africa with roughly 58.7% of all imports into SADC member states and 46.2% of all exports out of SADC member states originate or are destined for South Africa (ibid). Fittingly, South Africa is also the biggest economy in the region, forming about 56% of the entire SADC economy. The domination by South Africa has in part resulted in unbalanced trade flows, whereby trucks leaving South Africa are fully laden and return empty on the return leg (Vilakazi et al., 2014). This setup has contributed to the high cost of freight transport in SADC as truckers have to account for the empty return leg when they invoice a shipper on the head leg (ibid).

Figure 2-9 shows a 30 year freight flows projection for the SADC region. Note that most of these freight flows are concentrated along major corridors in SADC. Further note the projected growth of intra-regional trade across SADC and particularly the emergence of new transport corridors. A major share of these are away from South Africa to other SADC member states (RFDM, 2015). New trade corridors such as the Lobito ~ Lubumbashi and Namibe ~ Lubango corridors in Angola are expected to grow. Strong growth is also expected the in Nacala and Beira corridors of Mozambique as Figure 2-9 shows.

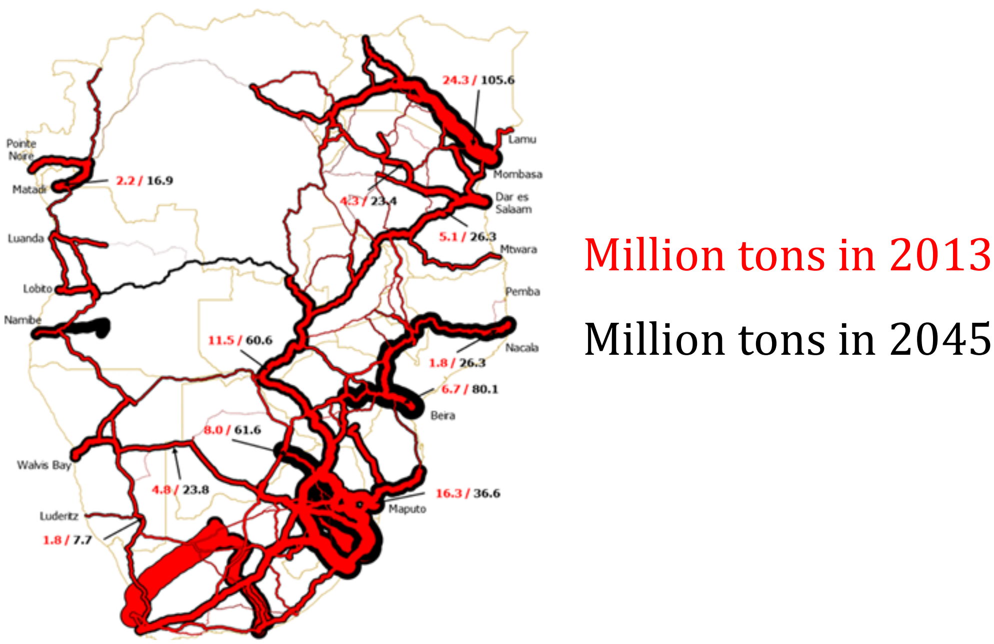

Figure 2-9: Freight flows projections in mainland SADC (RFDM, 2015)

2.5.4 Potential Impediments to the development of SSS in SADC

Major impediments to the development of SSS in SADC centre around poor logistics performance, and high cost of freight transport in SADC. A 2017 survey of the logistics conditions conducted under the auspices of the Trade and Industrial Policy Strategies (TIPS) revealed that the majority of SADC members score very low under the World Banks's Logistics Performance Indicators (Lowitt, 2017). The underperforming areas were majorly customs and infrastructure levels (Lowitt, 2017). A consoling fact however is a generally improvement trend in the overall performance of SADC as a region (ibid).

Furthermore, ports in SADC, as critical nodes along the maritime transport chain are said to be unprepared to address the needs of fast cargo movements (NDoT, 2011). The average turnaround time for a deep-sea container ship is 3 days in SADC (OECD, 2010), and the average transit time of a container through the port is 5 days (Namport, 2016; Portnet, 2016; Ports, 2016). The causes for these long transit times has been cited to include: outdated procedures, old and insufficient infrastructure, insufficient and miss use of cargo handling equipment, downtime associated with maintenance and strikes, and a low level of information technology employed (Rennie, 2002; NDoT, 2011; OECD, 2010; UNCTAD, 2014). There is also a lack of capacity to accommodate a large number of ships at the same time; a scenario that could further lead to port congestions and increased turnaround time if shipping traffic increases (RFDM, 2015).

The ports in SADC have additionally some of the highest port charges in the world, and if SSS were to operate, port costs would constitute a high share of the transport costs (Ensor, 2013). The reason for the high port charges in SADC can in-part be blamed on the port-pricing strategies employed in many of the regional ports. Many ports within the region employ the ad-valorem based wharfage charge method, which assigns a charge depended on the value of the cargo, having little consideration for the actual cost incurred or the value of the service provided by the port authority (Mchizwa, 2014). UNCTAD encourage the adoption of the Cost, Performance, Value (CPV) method which relates the port charge to the cost incurred in offering the service, the performance efficiency and the value of the service rendered (UNCTAD, 1985). It is argued to be an approach where the ports can utilize in order to achieve multiple objectives within the constraints imposed by its financing requirements and the external competitive environment.

Tied to this, is the high cost of inland transport due to inadequate physical infrastructure and delays at border barriers which create further challenges for freight transport in SADC (GIZ, 2013). The estimated effective speed of road transport within SADC is between 6 km/hour and 12 km/hour, with rail transport scoring even worse with an average speed of 4 km/h (UKAID, 2016). Three quarters of the time spent in a cross-border journey, is due to customs delays and not the actual speed once in motion (ibid).

Collaboration between SADC member states is also found wanting. To that effect, it is purported that cross-border freight delays are a key contributor that adds cost and unpredictability to the supply chain, making SADC countries unattractive participant in international trade (Hoffman et al., 2016). Such delays in SADC are mainly due to pre-clearance and border processing delays that add considerably to the transit time of freight flows and by implication affecting transport reliability (Kamau, 2014).

Furthermore, unlike many regions of the world, SADC's population densities are concentrated inland, far away from coastal areas (Tkalich and Sundarambat, 2008). Typically, countries whose major population lives within 100 km from the sea generally achieve better growth rates than those countries whose major population lives beyond this 100 km zone (Hausmann, 2001). Coupled to this, the main cities in SADC are very distant from each other creating a spatially challenged economy. These two factors (distance from ports, and the spatial gap) create a proximity gap in terms of reduced interaction among the economic agents of different member states, and therefor make the transport systems less efficient and more difficult to achieve scale and density economies (CSIR, 2014; Naudé, 2009). Seen in light of developing SSS, the proximity gap creates opportunity for SSS along key transport corridors in SADC due to the large distances between cities in the region.

A key weakness however is that 9 of the 15 states that make up SADC are landlocked member states that also have poor performing economies. Most SADC countries further face difficulty in achieving gains from specialisation; which is compounded by low population densities, low urbanisation, and weak internal transport links are exacerbated by a strong prevalence of corruption (Naude, 2009). The WEF Global Competitiveness Report for the year 2014–2015, accordingly submits that the top inhibiting factors to doing business in SADC are: access to finance, the prevalence of corruption, bureaucracy, insufficient human capital and a lack of physical infrastructure (WEF, 2015).

Lastly, submissions against SSS particularly in SADC has often cited weather, particularly on the southern coast of Africa as unsuitable for SSS operations (NDoT, 2011). Adverse weather conditions can create problems to manouvre the vessel during navigation in restricted waterways, and during berthing or unberthing operations (House, 2007). Wind and waves particularly have an effect on the fuel consumption through added resistance and reduced ship propulsion efficiency (Dallinga et al., 2013). Other weather conditions prevalent in SADC particularly that result in reduced visibility, such as fog and rain, wherein ships are generally required to proceed at slower speeds (COLREGS, 1972, Rule 19). Slow speed can reduce the transit time, reliability and subsequently the competitiveness of SSS. SSS is also affected by the state of tide and the air temperature but the conditions must be extreme to be effective (Leviäkangas et al., 2011).[31]

2.6 Chapter Conclusion

In this chapter, the factors for SSS development were discussed and these were contextualised to SADC. For SSS to be viable, it needs to appeal both to the shipper who procures the transport service and maritime carrier who conducts the SSS transport service. Thus, the demand factors include economic considerations of freight transport; and the supply factors include geographic, economic and political considerations. Now given the large geographic region, the projected freight volumes and the customs and trade policies that the SADC region is pursuing; opportunities for SSS are theoretically visible. However, there are a number of shortfalls that needs to be addressed. Of note, port competitiveness, customs provisions and policies for intra-regional trade require impetus. Additional work is also required in terms of policy to support SSS. The situation is lastly found wanting of empirical support. There is a particular need to study the determinant factors and the quantification of their contribution to SSS development in SADC.

[31] Ice is not generally a serious phenomenon in SADC, however the occurrence of thick ice in ports and waterways with low flow velocities like in Europe can have navigation to be suspended, and (or) the ship to incur additional costs in hiring an icebreaker. Thus, on some routes in Europe, SSS are required to have ice classification (interview volvo). The occurrence of ice can also damage aids to navigation, leading to reduced safety of navigation and inoperable waterway infrastructure (e.g. inoperable locks due to ice).

"…[We] are engineers who build and operate machines that explain how people make choices, and how they select themselves into groups. Our machines are crafted with mathematics and live in computers, so they do not fire the public imagination like a new bridge or a new particle accelerator. However, in each case an innovative design can advance the science. Whether it is a well-written novel, a well-made wine, a fine dish, a clever computer chip, or a well-crafted micro econometric analysis, good design instructs, brings pleasure, and lifts the human spirit."

~Daniel L. McFadden, (Speech at the Nobel Banquet; December 10, 2000)

3 DCM: METHODS AND DATA

This chapter discusses and reviews DCM theories, models, and associate data types. It proceeds as follow; first a formulation of the discrete choice models employed in the study is had, followed by a review decision-making rules and then the data requirements for SP data.

3.1 Background

Discrete choice modeling (DCM) fall under the class of behavioral models that models individual behavior (Winston, 1983). A behavioral model is defined as one, which represents the decisions that consumers or users make when confronted with alternatives (Domencich and McFadden, 1975). Under the behavioral framework, DCM is embedded in the assumptions of economic rationality and utility maximization (Hall et al., 2004).

The framework for DCM is represented by a set of four general elements: the decision maker, the alternatives, the attributes and the decision rule (Ben-Akiva & Bierlaire, 2003).

- The decision maker is the entity that makes decisions regarding the choice.
- The alternatives refer to a discrete choice set containing a finite number of alternatives that can be explicitly listed, and that are mutually exclusive (i.e. picking one alternative necessarily implies not picking any of the other alternatives).
- A decision maker only makes a choice from this finite set of alternatives.
- A specific decision rule is then employed by the decision maker to processes the information and to evaluate the alternatives from which a mode choice is made.

Furthermore, discrete choice models may be assigned into different families depending upon key assumptions of the researcher on the functional form of the error component (Domencich and McFadden, 1975). If the assumption is: the error component is normally distributed, it will lead to the formulation of the Multinomial Probit Choice model (Probit), otherwise if the assumption is the error component is Gumbel (extreme value) distributed, it will lead to the formulation of the General Extreme Value (GEV) models. [32]

[32] The probit model is very flexible: it is able handle random taste variation, it allows any pattern of substitution; and it is applicable to panel data that has temporarily correlated errors (Hensher, 2015, p98). That said however; Probit models require normal distribution for the error term, and in some situations, this can be inappropriate and can subsequently lead to perverse forecasts.

Because DCMs model behavior at the level of the individual, they typically use data from surveys, data from direct observations and data from record databases (Louviere et al., 2000). The data type may be revealed preference (RP) or stated preference (SP) data. RP data capture actual choices made to actual existing situations where the attributes are defined and the alternatives exist in reality, whereas SP data is developed by a systematic and planned experiment design process (Train, 2009).

3.2 Decision-making rules in DCM

Decision-making rules in DCM are classified into two broad categories: non-compensatory decision-making and compensatory decision-making rules (Araña and León, 2009; Hauser et al., 2009).

3.2.1 Compensatory versus Non-compensatory Rules

Non-compensatory rules are employed in such a way that good performance of a certain alternative in one evaluative criterion does not necessarily offset or compensate for poor performance on another evaluative criterion (Hauser et al., 2009). Examples of non-compensatory rules include: Elimination by Aspects (EBA), [33] Disjunctive, [34] and Conjunctive[35] Rules. Compensatory rules on the other hand, hinges the performances of an alternative on the collective utility that the decision maker derives from choosing the alternative, such that, good performance of an attribute would compensate for poor performance of another in the same alternative. This study, similar to the majority of freight mode choice literature employs the compensatory decision-making framework, in particular Random Utility Maximization (RUM).

Young et al, (1981) challenged the employment of compensatory decision-making in freight. The authors argued that shippers can simplify the decision-making process by gradually eliminating alternatives and attributes that don't meet the standard of their respective criteria. Henceforth, they argue, non-compensatory decision-making framework such as EBA might be preferable in the freight context as it show that freight mode choice is influenced by different factors for manufactured and non-manufactured goods. Such an approach however can be tedious and academically challenging. For instance, a key feature of the EBA model is the assumption that individual search modal

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[33] EBA: the decision maker selects certain aspects (attribute levels) and eliminates all alternatives that have that aspect. The choice is then made from the remaining alternatives.
[34] Disjunctive Rule: Alternative required to satisfy target level of attribute and when choice stops when all but one attribute have been eliminated.
[35] Conjunctive Rule: minimum levels of acceptability on each alternative attribute is first set, and then an evaluation criterion of importance to the respondent is set that a cut-off point will be set below which brands would not be considered further.

attributes in a sequential fashion, starting with attributes considered most important and gradually proceed to those that are least important. As each attribute is considered, each alternative is compared to that attribute. If the alternative falls below the minimum accepted level, it is eliminated and not considered further. The process continuous iteratively until one alternative remains. Each model therefore requires calibration and must be tailored for different classes of shippers with each iteration.

The compensatory decision-making framework is further branched into two: Random Utility Maximization (RUM) and Random Regret Minimization (RRM) (Hensher et al., 2015). The difference between RUM and RRM may be described as inverse. Under the RUM framework, it is assumed that the decision-maker will choose a mode that yields the highest utility for the user (Ben-Akiva and Larman 1985),[36] while under the RRM framework, it is assumed that when choosing, the decision-maker anticipate and aims to minimize regret (Chorus, 2012). In this regard, regret arises when one or more non-chosen alternatives perform better than the chosen alternative.

Although the idea of regret minimization is not new in freight, its incorporation in freight mode choice is very recent (Boeri and Masiero, 2014; Keya et al., 2018). Reviews of the application of both RUM and RRM decision rules provide conflicting findings (Chorus, 2012; Chrzan and Forkner, 2014). However because RRM is fairly new, particularly in the freight context, much work is still required to identify the optimum efficient designs under this framework. It is imperative for the researcher to remember that decision rules act only as guidelines. It does not mean that respondents make choices according to the decision rules we use, but rather, the decision rule is to be regarded as a convenient way of representing the process.

Because the study employs the RUM framework, the derivation of RUM is discussed next.

3.2.2 Random Utility Maximization

Under RUM, each attribute is assigned defining dimensions that are called attribute-levels; which allow for the alternative to be reduced to a scalar utility value. The postulate is that decision makers make trade-offs among attributes based on the sum utility value that is derived. The utility function may be expressed as follow: the decision maker *n* will

[36] The *utility* of a transport mode is the total benefit associated with the user for a specific trip.

choose the alternative *j* that provides the greatest utility to him/her. This relationship can be expressed as follow:

Alternative *j* is chosen if and only if: $U_{nj} > U_{ni} \; \forall \; j \neq i$ (3)

where: U_{nj} is the net utility function for mode *j* for individual *n,* and;

U_{ni} is the net utility function for competing mode *i* for individual *n.*

For the sake of convenience, the net *utility* is presented as a linear function of the modal attributes, weighted by the coefficients to the parameter estimates, which attempts to represent their relative importance as perceived by the decision maker *n* (here the transport user). A typical representation of this utility function of a mode *j* may be shown as follow:

$$U_{nj} = \theta_1 x_{nj1} + \theta_2 x_{nj2} + \cdots \theta_k x_{njk} \quad (4)$$

wherein: $x_{nj1} \ldots x_{njk}$ are *k* number of attributes of mode *j* for individual *n,* and

$\theta_{1 \ldots} \theta_k$ are *k* number of coefficients attached to every attribute.

The attributes that collectively determine the mode choice are composed of a measurable-observable component (systematic component)[37] and an unobservable component (random error component). The presence of an unobservable component means that mode choice cannot be predicted with certainty, but rather only a probable outcome can be derived. This however does not mean that the decision maker maximizes utility in a random manner, but rather, it means that randomness arises because the analyst cannot fully observe the set of influencing factors and the complete decision calculus.[38] Hence, the utility is modeled as a random variable in order to reflect this uncertainty. A typical *random utility model* is thus depicted as:

$$U_{nj} = V_{nj} + \varepsilon_{nj} \quad (5)$$

where V_{nj} is the deterministic part of the utility for individual *n,* for mode *j; and;* ε_{nj} is the error term capturing the uncertainty of the utility for mode *j,* for individual *n;*

[37] The systematic component is that part of utility contributed by attributes observable by the analyst. It can further be broken up into different components: relating to the attributes of the alternative, related to the characteristics of the decision maker, and it also represents the interactions between the attributes of the alternatives and the characteristics of the decision maker.

[38] According to Manski (1977), there are four different sources of errors: unobserved attributes of alternatives, unobserved characteristics of decision-makers, measurement errors and proxy variables.

Given the description of the error term ε_{nj} above, its distribution depends critically on the specification of the deterministic part V_{nj}. The error term is not defined for a choice but it is rather defined relative to the representation of the choice situation; and because the error term varies across decision maker, it is treated as random.[39]

In order to model choices, further assumptions about the error term are made. The common assumption is that for each alternative from a choice set, the error term will be randomly distributed a certain density over the respondents and choices. Specifically, the probability P that individual n in a choice task s will select alternative j is given as the probability that outcome j will have the maximum utility:

$$P_{nsj} = P\ (\varepsilon_{nsj} - \varepsilon_{nsi} > V_{nsj} - V_{nsi}, \forall j \neq i) \quad (6)$$

This equation reflects that the probability differences in the error terms, $\varepsilon_{nsj} - \varepsilon_{nsi}$ will be less then the difference in the deterministic terms, $V_{nsj} - V_{nsi}$.

Subsequently, to estimate the choice model, the maximum likelihood estimation (MEL) approach is typically employed. MEL involves the specification of some objective function, namely the likelihood function. In the likelihood function, the unknown parameters, (which are those parameters related to the data) are defined in a utility specifications and are subsequently estimated by maximizing the function (Hensher et al., 2015). Discussion of the MEL methodology is however beyond the scope of this discuss; the reader is referred to Chapter 5 of Hensher et al., (2015) for a detailed discussion on MEL.

3.3 Family of Discrete Choice Models

In this study, only the GEV family of models are employed; in particular, the following models are employed to perform different analysis in the course of the study: the Multinomial Logit (MNL), Binary Logit (BL), Exploded Logit (EL), Integrated Latent and Variable Structure (ICLV), Ordered Logit (OL), Mixed Logit (ML), Nested Logit (NL) and Cross-nested logit (CNL) models. The derivation of these models is discussed over the next few sections.

3.3.1 Multinomial (MNL) and Binary Logit (BL)

The Multinomial Logit model (MNL) model is the workhorse of DCM and it has been extensively employed in freight mode choice and SSS related studies (Brooks et al., 2012,

[39] This point becomes relevant when evaluating the appropriateness of various discrete choice models.

2011; Feo et al., 2011a; García-Menéndez et al., 2004; Kim et al., 2014; Puckett et al., 2011). It is also employed as the base on which more sophisticated models are build.

MNL is derived under three primary implications of assumptions: first, that the error component in equation 5 is Gumbel distributed; secondly, that it is independently and identically distributed across alternatives (IID), and thirdly, that it is independently and identically distributed across individual observations (IID) (Koppelman and Bhat, 2006). A Gumbel distribution means that the utilities associated with the choice should be considered as a linear sum of attributes and they should further have the same scale parameter (Ben-Akiva and Bierlaire, 2003). The second and third assumptions are grouped together, and termed "Independence of Irrelevant Attributes" (IIA), and this basically means: the relative choice probability for any pair of alternatives is independent of the absence or presence of other alternatives, and the variance is equal across alternatives (Hensher et al., 2015). [40] The three assumptions taken together lead to the mathematical formulation of the MNL Model, such that the probability of alternative *j* being selected is given by (Train, 2009):

$$P(j) = \frac{\exp\,(V_{nsj})}{\sum_{j=1}^{J} \exp\,(V_{nsi})}, j, \ldots, J, \tag{7}$$

where *P(j)* is the probability of alternative *j* being selected by decision maker *n*,

The above model form (as shown in equation 7) is referred to as closed-form because applications does not require further estimation (Hensher 2005, p. 86). From this derivation, the Binary Logit (BL) Model is also adopted, however the BL model consider only two alternatives. Thus in the BL model formulation, the probability that alternative 1 is chosen, given the choice set contains alternatives 1 and 2, is given by the following formula:

$$P(j) = \frac{\exp\,(V_{nsj})}{\exp(V_{nsj}) + \exp\,(V_{nsi})} \tag{8}$$

where *P(j)* is the probability of alternative *j* being selected; and, V_{nsj} *and* V_{nsi} are the systematic components of utility for alternatives *j* and *i*.

[40] The IIA property is a big weakness of the MNL model. It basically means that the choice between any two alternatives does not depend on the characteristics of other additional alternatives. These assumptions may be addressed either by use of GEV models which relaxes the second of these assumption (IID), but does not address the other two; or by use of Probit models which relaxes all three assumptions.

Since there are only two alternatives in the BL model, the probability of choosing one alternative equals to 1 minus the probability of the other alternative. The implication of this formulation is that the probability of choosing an alternative increase monotonically with an increase in the systematic utility of that alternative and similarly it decreases with increases in the systematic utility of each of the other alternatives. The likelihood of the sequence of choices for decision maker *n* is then given by:

$$L_n = \prod_{s=1}^{S} P_{j_{ns}^{*}ns}(\beta, \delta) \tag{9}$$

where j_{ns}^{*} represents the choice alternatives available to the decision maker *n* in choice situation s (out of S choice situations), β is the weight associated with the coefficients and; δ is the baseline preference or dislike for alternative *j.*

The choice probabilities in a MNL/BL model take a closed form and are readily interpretable, thus making the results easy to perceive such as the effects of policies and investments in freight transport (Train, 2009). Due to the ease of application of the MNL model, it is the most used to model freight mode choice (de Jong et al., 2013).

3.3.2 Nested Logit (NL)

Notwithstanding the benefits of the MNL model, it can be restrictive. In particular, the IIA property assumption results in the failure of the MNL model when correlated alternatives are presented, and the 'red bus/blue-bus' paradox is a good example for illustrating this shortcoming (McFadden, 1974). The development of other models has arisen largely to avoid this. The Nested Logit (NL) model is an extension of the MNL model designed to capture correlations among alternatives. It proceeds from the partial relaxation of the IID assumption in the MNL by allowing the nesting of alternatives, which are thought to share similarities in the unobserved utility (Koppelman and Bhat, 2006).

In the NL specification, the choice set is partitioned into two or more subsets to allow alternatives to share common unobserved components among one another (Louviere et al., 2000, p. 138). The partitioning of choice sets is done in such a way that the IIA principle holds within each nest; and for alternatives in different nests, the IIA principle does not hold (Train, 2009). In other words, it is assumed that the error components within each choice subset are correlated with each other and the correlation between alternatives within the different nests is zero (ibid). Figure 3-1 depicts the tree diagram for a NL model configuration employed in the study (following Hensher et al., 2015 p.103).

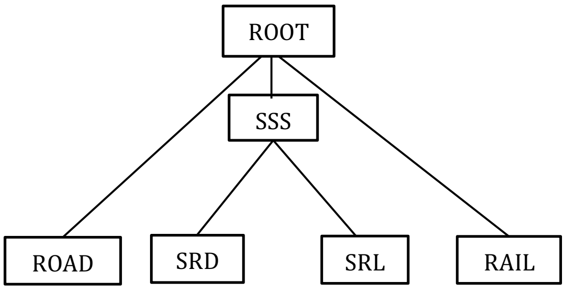

Figure 3-1: Tree diagram for mode choice in a NL model configuration

If we take the example as depicted in Figure 3-1 above where the four sets of alternatives are partitioned in three subsets (nests) denoted by *b*, the utility for alternative *j* nested within the nest *b* is given by (ibid):

$$U_i = \mu_{(j \mid b)} \sum_{s=1}^{S} \beta_k x_{nsjk} + \varepsilon_{nsj} \tag{10}$$

where $\mu_{(j \mid b)} = \frac{\pi^2}{6var(\varepsilon_{nsi|b})}$ is the nested parameter indicating the degree of nesting between alternative *j* and another alternative within the nest *b* as opposed to outside the nest; $\sum_{s=1}^{S} \beta_k x_{nsjk} + \varepsilon_{nsj}$ is the random utility component of the utility of alternative *j* as specified by equation (7) and; ε_{nsj} is assumed to have a cumulative distribution, such that: $\varepsilon_{nsj} = \exp(-\sum_{s=1}^{S}(\sum_{j\in b} e^{-\varepsilon nj/\lambda s})^{\lambda s}$

To properly see the link between mode choice probabilities, Hensher et al., (2015) proposes we examine the choice probabilities produced from the NL model, and accordingly expresses the probability that alternative *j* being chosen is given by (ibid, p.104):

$$P_{nsj} = P_{nsj|b} \times P_{nbs}$$

$$= \frac{\exp(\mu_{(j|b)} V_{nsj|b})}{\sum_{i\epsilon b}(\mu_{(i|b)} V_{nsi|b})} \times \frac{\exp(\frac{\lambda_b}{\mu_{(j|b)}} \log(\sum_{j\epsilon b} \exp(\mu_{(j|b)} V_{nsj|b})))}{\sum_{b=1}^{B} \exp\left(\frac{\lambda_b}{\mu_{(i|b)}} \log(\sum_{j\epsilon b} \exp(\mu_{(i|b)} V_{nsi|b}))\right)} \tag{11}$$

where P_{nsj} is the conditional probability that respondent *n* will select alternative *j* in choice task *s* given the alternative belongs to nest *b*; P_{nbs} is the probability of respondent *n* choosing nest *m*; and λ_b is the scale parameter for the nest *m*, which can further be expanded as $\lambda_b = \frac{\mu}{\mu_b}$. The impact of attribute *x* within P_{nsj} is given by β_k however within the nest b, the impact is given by $\frac{\beta_k}{\lambda_b}$. Subsequently to estimate the NL, we restrict the value of λ between 0 and 1; with, when λ goes to 1, the NL escalates to become the MNL.

The implication of this formulation is that alternatives in one nest will exhibit a higher degree of similarity and competitiveness than alternatives from different nests. This is because the derivation of the NL model is based on the assumption that alternatives in a common nest share common components in their random error terms, which can be decomposed into one portion that is associated with each alternative and another that is associated with groups of alternatives.

3.3.3 Cross Nested Logit (CNL)

The cross nested logit (CNL) model is able to capture more complex correlation structures then the NL model (Ben-akiva and Bierlaire, 1999; Small, 1987). It is basically the NL model extended such that each alternative may belong to more than one nest as illustrated in Figure 3-2. For instance, if we consider the example provided in the previous section, where the choice set *n* is partitioned into *b* nests. In the CNL formulation, for every individual nest, the utility for alternative *j* nested within the nest *b* is given by (Hess, 2016):

$$U_j = \mu_{(j \mid b)} \sum_{k=1}^{K} \beta_k \, x_{nsjk} + \varepsilon_{nsj} \quad (12)$$

where $\mu_{(j \mid b)} = \frac{\pi^2}{6var(\varepsilon_{nsi|b})}$. Is the nested parameter indicating the degree of nesting between alternatives within a nest as opposed to outside the nest; and;

$\sum_{k=1}^{K} \beta_k x_{nsjk} + \varepsilon_{nsj}$ is the random utility component of the utility of alternative *j*.

An example of a CNL nesting structure employed in the study is depicted as follow:

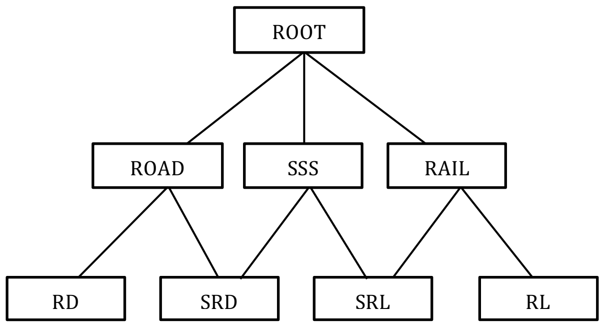

Figure 3-2: CNL SSS nesting structure

The probability that alternative *j* is chosen given a CNL structure with *B* nests b_1 to b_B, the is now expressed as follows (adopted from Hess, 2016):

$$P_{nsj} = \sum_{b=1}^{B} P_{nsj|b} \times P_{nbs} \tag{13}$$

$$= \frac{\left(\sum_{i \epsilon b} \quad (\alpha_i, b^{\exp^{V_{nsi}}})^{\frac{1}{\lambda_b}}\right)^{\lambda_b}}{\sum_{c=1}^{B}\left(\sum_{j \epsilon c} \; (\alpha_i, c^{\exp^{V_{nsi}}})^{\frac{1}{\lambda_c}}\right)^{\lambda_c}} \times \frac{\sum \quad (\alpha_j, b^{\exp^{V_{nsj}}})^{\frac{1}{\lambda_b}}}{\sum_{j \epsilon c} \; (\alpha_i, c^{\exp^{V_{nsi}}})^{\frac{1}{\lambda_c}}}$$

where: b and c denote individual nests; α_j, b is the degree of membership of alternative j to nest b, respective of the conditions:

$$0 \leq \; \alpha_{j,b} \; \leq 1 \qquad \forall \, j, b \quad and \sum_{c=1}^{N} \alpha_{j,b} = 1 \qquad \forall \, j \tag{14}$$

3.3.4 Mixed Logit (ML)

The ML model is termed mixed logit because the choice probability is a mixture of logits (MNL). The ML model, also called the mixed multinomial logit model or random parameter logit differs from the MNL model in the sense that the ML assumes that some of the parameters are random, i.e. they follow a particular probability distribution that allows the estimation of parameter weights for the population to vary randomly around a mean (Hensher et al., 2015).

$$\beta_{nj} = \overline{\beta}_k + \eta_j Z_{nj} \tag{15}$$

where $\overline{\beta}_{nj}$ represent the mean of the distribution of marginal utilities held by a sample, η_j represent a deviation of preference among sampled respondents around the mean and; where Z_{nj} represents random draws from a specified distribution.

If we consider the example of Dada et al., (2019) random heterogeneity was incorporated in the baseline sensitivity for the respective alternatives (δ_j) which allowed them to capture additional differences across respondents not captured by the socio-demographic interactions (Δ). This random heterogeneity was incorporated in δ_j as follow (ibid):

$$\delta_j = \mu_j + \sigma_j + \xi_j \tag{16}$$

This formulation basically allows the ML model to generalize the MNL model by allowing the coefficients of observed variables to vary randomly between individuals instead of being fixed. How it works is as follow: the ML model partitions the observed component of the random utility equation into two; one correlated and the other uncorrelated. It then allows one part of the error term to be heteroscedastic across individuals and correlated over alternatives, and the other part independently and identically distributed across alternatives and across individuals. The randomized parameters allow heterogeneity across respondents in their sensitivity to observed exogenous variables, such that equation (5) now becomes (ibid):

$$U_{nj} = (\beta + \vartheta_{nj})X_{nj} + \varepsilon_{nj} \quad (17)$$

where β is a vector of coefficients, ϑ_{nj} is an error component that is heteroscedastic and correlated across alternatives; X_{nj} is the observed variables and is related to respondent n and alternative *j*, and ε_{nj} is the random component (with a IID Gumbel distribution).

The probability of choosing alternative *j* given ϑ_{nj} is now given by (Hess, 2016):

$$P_j = P(j|X_{nsj}, Z_n, V_n) = \frac{\exp(V_{nsj})}{\sum_{j=1}^{K} \exp(V_{nsi})} \quad (18)$$

where $V_{nsj} = \beta'_n X_{nsj}$ and $\beta_n = \beta + \Delta_{z_n} + \Gamma v_n$;

X_{nsj} = K attributes of alternative *j* in choice scenario s faced by respondent *n*.

Z_n = vector of respondent characteristics that influence the mean of taste parameters.

V_n = vector for *K* random variables with zero means and known variances and zero covariances.

Following the above formulation, observed heterogeneity is captured in the term Δ_{z_n} while unobserved heterogeneity is captured in Γv_n. The parameters to be estimated are betas (*β),* the *K x M* matrix of parameters (Δ) and the non-zero elements of the lower triangular Cholesky matrix[41] (Γ). With the presence of such random heterogeneity, the likelihood in Equation (9) is modified as follow (Dada et al., 2019):

$$L_n = \int_{\xi} \prod_{s=1}^{12} P_{jns}(\beta, \Omega_{\delta})\phi(\xi)\mathrm{d}\xi \quad (19)$$

where $\phi(\xi)$ is the standard Normal density function, where $\Omega_{\delta} = <\mu_j, \sigma_j>$ and where the likelihood function is replaced by an integral over the distribution of ξ. This model no longer has a closed form solution for the likelihood function; therefore, it requires a simulation-based solution (cf. Train, 2009).

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[41] This is a decomposition of a hermitian positive definitive matrix into the product of its lower triangular matrix and its hermitian transpose (Stewart, 2000).

3.3.5 Ordered Logit

The rank-ordered logit (OL) model is generally employed to model the preference of individuals where these preferences are partially observed through ranking. It may be likened to a series of MNL models, where for the most preferred item an MNL is estimated, followed by a subsequent MNL for the second ranked item excluding the rank 1, and the process continues iteratively until a complete ranking containing a product of separate MNL probabilities is obtained (Fok et al., 2012).

$$V_{ns} = \beta_k X_{ns} + \alpha Z_n + \theta\omega_{ns} \quad (20)$$

where β_k; α ; θ are parameters to be estimated from the data; Z_n are variables measuring attributes of respondents that are not varied between selections, X_{ns} are variables about the choices, and ω_{ns} represent variables for a relationship between choice *s* and individual *n*.

The observed outcome (Y_{ns}) for individual *n* per choice scenario *s*, can take different values *K*, going from *k=1,....,K*, and accordingly the mathematical formulation for the probability for *k* value to be observed given no other selection is made may be depicted as follow (Hess and Palma, 2019):

$$P_{Y_{n,s=k}} = \frac{\exp^{\tau_k - V_{ns}}}{1+\exp^{\tau_k - V_{ns}}} - \frac{\exp^{\tau_{K-1} - V_{ns}}}{1+\exp^{\tau_{K-1} - V_{ns}}} \quad (21)$$

where $P_{Y_{n,s=k}}$ is the probability of alternative *k* being selected given no other selection was made;

τ_k represents the vector defined by the thresholds parameters employed in the model; and,

V_{ns} is the systematic component of the utility function in equation,

The above formulation thus shows that when the first selection is made, the second ranked position can be chosen from the remnant items in the set (i.e. *K-1*). We can also see that there is an assumed independence between the choice scenarios (Likelihood and Cox, 1975). The likelihood of obtaining a ranking of items in choice set K is therefore a product of *s* logit probabilities estimated in a partial likelihood procedure as depicted below:

$$L_{Y_{n,s}} = \sum_{k=1}^{K} \delta_{(Y_{n,s=k})} \left[\frac{\exp^{\tau_k - V_{ns}}}{1+\exp^{\tau_k - V_{ns}}} - \frac{\exp^{\tau_{k-1} - V_{ns}}}{1+\exp^{\tau_{k-1} - V_{ns}}}\right] \quad (22)$$

where for normalization $\tau_k = +\infty$ and $\tau_0 = -\infty$, such that $P_{Y_{n,s}} = 1$ is given by $\frac{\exp^{\tau_k - V_{ns}}}{1+\exp^{\tau_k - V_{ns}}}$

3.3.6 The Integrated Choice and Latent Variable Structure (ICLV) model

The integrated Choice and Latent Variable Structure (ICLV) model may be viewed as an expanded discrete choice modeling framework that combines different discrete choice models into a single structure that is estimated simultaneously (Kim & Rasouli, 2014). The ICLV model, also known as the hybrid choice model, was developed to capture the effect of psychometric factors, such as attitudes and perceptions on the variation of choice preference (Ben-akiva & Bierlaire, 1999).[42] As Dada et al., (2019) provides, the ICLV model recognizes that attitudes or perceptions are not directly observed, but rather, they manifest in the form of latent indicators such as answers to attitudinal questions. These latent variables are then used to explain both the value of the observed indicators and a part of the heterogeneity in the choice model component.

The ICLV model consists of a set of structural relationships, which indicates causal relationships between observable attributes and latent variables. If we consider the latent variable α_{jns} with alternative *j* for respondent *n* in choice task *s*; the structural equation of the ICLV model is expressed as follow:

$$\alpha_{nsj} = \lambda_j X_{nsj} + \gamma_j z_n + \eta_{jn} \quad (23)$$

where λ_j is a vector of estimated parameters measuring the impact of the attributes of alternative *j* in choice situation *s* for respondent *n* on the latent variable towards that alternative, for a specific respondent and choice situation. The latent perception is also influenced by respondent characteristics z_n, again with an alternative-specific vector of estimated parameters γ_j; and where η_{jn} is a standard Normal disturbance, which varies across perceptions and across respondents, but is constant across choice situations for the same respondent (ibid).

Given the use of the mixed logit and the ordered logit model in the ICLV model structure of this study (as later shown in chapter 7), equation 16 is now amended to read as follow:

$$\delta_{jns} = \mu_a + \sigma_b \xi \quad + \tau \quad \alpha_{nsj} \quad (24)$$

Wherein the additional parameters τ capture the impact of the latent perception of using mode *j* with the baseline preference for using mode *j*. With I_{jn} now capturing the measurement of the latent variable by respondent *n* to the perception for alternative *j,* the likelihood of the actual observed value of I_{jn} as LI_{jn} is now obtained by:

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[42] Latent factors are factors that potential exist but are not presently evident or realized such as attitudes and perceptions.

$$LI_{jn}(\alpha_{jn}, \zeta_j) = \sum_{p=1}^{5} x_{I_{jn},p} \left(\frac{e^{s_{I_j,p} - \zeta_j \alpha_{jn}}}{1 + e^{s_{I_j,p} - \zeta_j \alpha_{jn}}} - \frac{e^{s_{I_j,p-1} - \zeta_j \alpha_{jn}}}{1 + e^{s_{j,p-1} - \zeta_j \alpha_{jn}}} \right) \quad (25)$$

where: $x_{I_{jns},p}$=1 if and only if respondent n chooses answer p on the lickert scale for alternative *j*; the impact of the latent variable α_{jn} on I_j captured by ζ_j; and the parameter $s_{I_j,p}$ denoting the limits that will be estimated, as per normalisation that $s_{I_j,0} = -\infty$ and $s_{I_j,5} = +\infty$.

Accordingly, the estimation of the probability of the observed choices and the latent variables is now jointly maximized, as follow (ibid):

$$L_n = \int_{\eta} \int_{\xi} \prod_{s=1}^{12} P_{j_{ns}^{*}ns}(\beta, \Omega_\delta, \Omega_\alpha, \tau \quad) \times \prod_{j=1}^{3} LI_{jns}(\alpha_{nsj}, \zeta_j)\, \phi(\xi)\phi(\eta \quad) \mathrm{d}\xi \mathrm{d}\eta \quad (26)$$

where Ω_α= <λ_j, γ_j>.

3.3.7 Exploded Logit (EL)

The exploded logit (EL) model is employed to model the preference of individuals for ranked data items, where a set of choices is ranked by the same respondent (Skondral and Rabe-Hesketh, 2003). The EL model is slightly different from the other models discussed up to now, in the sense that it is rooted in decision field theory (DFT) which is very different from to both RUM and RRM (Hess and Palma, 2019, p. 35). The key assumption in the DFT decision framework is that the preferences for alternatives update over time. In such a setting, the decision-maker is said to consider all the alternatives until an internal threshold is reached (similar to the concept of satisficing, where one of the options is deemed 'good enough'), where the decision-maker will stop deliberating on the alternatives as a result of running out of time to make the decisions.

The formulation of the EL model for the observed ranks postulates an underlying utility model. If we consider $A_n = \{a_n^1, \ldots, a_n^{A_n}\}$ as the set of A_n alternatives available for respondent n , the probability of observed rankings is given by (Skondral and Rabe-Hesketh, 2003):

$$P(R_n | A_n) = \prod_{k=1}^{A_n - 1} \frac{\exp\,(V_n^{r_j^k})}{\exp(V_n^{r_n^s})} \quad (27)$$

where: $R_n \equiv \{r_n^1, r_n^2, \ldots, r_n^{A_n}\}$ the ranking for respondent n given a set of alternatives; V_j^b is the deterministic component for unit b and alternative j, and r_j^k is the alternative given rank k;

3.4 Data for DCM

To develop discrete choice models, data about the alternatives and the choice attributes that are believed to influence the choice process must be obtained. To that end, it was established that both RP data and SP data are employed. RP data is typically captured by three methods: direct observation, from existing records of choices made; or from surveys wherein respondents are queried about their choices (Ben-Akiva et al., 1994). SP data in contrast, employ a systematic and planned experiment design process from whence the data is obtained (Hensher et al., 2015).

Traditionally the transport studies domain had favoured RP over SP data (Wardman, 1988). However, nowadays SP data forms the more popular of the two methods (Lindahl, 2015). There are different SP methods available, including: stated choice analysis, best-worst method, conjoint analysis, trade-off analysis, functional measurement, t transfer price method (Kroes and Sheldon, 1988). These can be used to derive estimated measures for willingness to pay (WTP), willingness to accept (WTA)[43] and other wide applications and specific valuations. Of all SP methods, discrete choice modeling (DCM) or stated choice and conjoint analysis (CA) are the most widely used (Louviere et al, 2010).

Louviere et al, (2010) conducted an extensive derivation and differentiated between conjoint analysis (CA) from stated choice analysis (or DCM). They provide that, CA is generally inappropriate for economic evaluation and should be used with caution in economic applications. CA is rooted in conjoint measurement theory, which is purely mathematical and more concerned with the behavior of systems as opposed to individual human preference in DCM which is based on random utility theory (see Section 3.2.2). Conoint Analysis, as we alluded earlier, uses the profiles of choice alternatives to estimate underlying part worth utilities, while DCM presents experimental replications of the market with focus on market accurate predictions (Louviere et al, 2010). For this reason, it is argued that DCM is better suited to provide insights into how people make choices.

This study employs DCM and stated choice experiments, and accordingly discussion is limited to such. Further reference to SP data must also be construed as stated choice.

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[43] WTP is the maximum price an individual is willing to pay in return for a good or service. WTA is the minimum amount of monetary compensation an individual is willing to receive to give up a good or service.

3.4.1 RP versus SP data

The wide application of SP data in transport research is due to a number of advantages that SP data has over RP data. For starters, the fact that RP surveys capture actual behavior; it gives validity to actual behavior that is consistent with the behavior in the real market (Louviere et al., 2000). That said however, RP data is often blamed to constraint the resultant data analysis, and particularly limits the ability to make predictions as data is derived from observed options only (Ben-Akiva et al., 1994). RP methods are also expensive to employ and are furthermore known to be complex to analyze and difficult to measure, particularly when a high number of alternatives exist (Louviere et al., 2000). Complexity with RP data arise since it is difficult to grasp the tradeoffs between attributes in real life, as alternatives are often highly correlated in real life, and also because the attribute values are often widely varied in real life (ibid). Thus, reliance on RP data alone can impose limitations on a researcher's ability to properly model behavior, especially when new variables are introduced that now explain choices, and especially when the product is not traded in the real market, or when the product is yet to be traded in the market (ibid). The features of RP and SP data are briefly summarized in table 3-1 below (adopted from Louviere et al., 2000, p. 24).

Table 3-1: RP data versus SP data (adopted from Louviere et al. 2000)

RP Data	SP Data
• Typically depicts the world as is.	• Typically describe hypothetical settings.
• Possesses inherent relationships between attributes	• Relationships between attributes are usually controlled
• Only existing alternatives are observable	• Can combine existing and/or proposed choice alternatives
• Market and personal constraints on the decision maker are embodied	• Usually very difficult to represent changes in market and personal constraints effectively
• Typically very reliable and visually valid	• Appear to be reliable when respondents understand and are able to respond to tasks
• Typically yields one observation per respondent at every observation point	• Usually yield multiple observations per respondent at each observation point

As Table 3-1 shows, the primary strength of SP data is that it allows for the control of relationships between attributes, which permits mapping of utility functions for scenarios different from existing ones (ibid). SP methods are also comparatively cheaper then RP data collection and the results of SP data are relatively easy to explain and to describe (Hensher et al., 2015). The use of SP data is furthermore wider than RP data. For instance, using SP data the analyst can explore the reasons behind preferences, and one can thus get "ranking", "rating" and "choice".

However, notwithstanding the numerous strengths of SP data (as table 3-1 shows), there are serious disadvantages in the form of reliability and hypothetical biases (Ben-Akiva et al., 1994). For instance, since the respondents answer under hypothetical situations in SP settings, there is always a possibility that the expressed preference is not consistent with actual behavior, and therefore one can never entirely rely on SP data. Also, during SP data collection respondents often try to justify their actual behavior and they often try to control policies. Therefor estimates of absolute demand levels derived from SP data alone require careful interpretation.

To compensate on the pros of both methods, RP and SP data can be combined and used jointly (Louvier et al., 2010). A key role in doing so is in data enrichment, which involves providing more robust parameter estimates for particular RP-based choice models, thereby increasing confidence in model predictions as analysts can stretch attribute spaces and choice sets of policy interests. The benefits of combing RP and SP data is discussed by Ben-Akiva et al. (1994), Louvier et al. (2010) and Hensher et al. (2015) and they include: efficiency from joint estimation, bias correction and estimation of preference for new attributes and levels that are not identifiable in RP data. Joint RP-SP estimation is especially beneficial in freight mode choice as the models developed can be employed to forecast (Hensher et al., 2015).

3.4.2 Experimental Design in Stated Choice settings

Seeing this study is concerned with SP data, to which as earlier alluded must be designed and developed; the next discussion is on experimental design.

Experimental design is the process of planning the study to meet the research objectives. Planning the experiment properly is critical to ensure the right type of data and power are available to meet the research objectives. In stated choice experiments (SCE), the experiment design process is the process by which a stated choice (SC) survey is developed; and to that end, it is the design of the experiments that explain the variation of information under the conditions that are hypothesized to reflect the variation.

In particular, this study is concerned with developing d-efficient stated choice designs. A stated choice experiment is considered efficient when it has small standard errors and accordingly derive more reliable parameter estimates (Rose et al, 2008). The standard error does not depend on the sample, but rather, it depends on the design (Zwerina et al., 1996). Subsequently, to get an efficient design, the analyst must adjust the experiment design in order to get small standard errors.

The prime consideration in efficient design is the relationship between the design and the model variance-covariance matrix (AVC), from the where the standard errors are obtained.[44] The elements within the AVC matrix can be minimized by manipulating the attribute levels of the alternatives for known parameters to cause lower standard errors. A reduced standard error would mean greater reliability in the estimates at a fixed or even a reduced sample size. For this reason; efficient design requires prior knowledge (priors) of the attribute levels and the expected parameter estimates. The efficiency of a design is then derived from the AVC matrix, based on a single value, the efficiency 'error' (i.e. the measure of inefficiency). The objective of design efficiency then becomes to minimize this error (Hensher et al., 2015, p. 269).

There are a number of ways in which the efficiency error may be reduced. The most widely used inefficiency measure (and the one employed in this study) is the D-error statistic, which takes the determinant of the AVC matrix Omega 1 (Ω_1) when we assume only a single respondent (Rose & Bliemer, 2009). The d-error is a function of the experiment design and the prior values, such that:

$$D - error = \det \left(\Omega_1\left(X, \tilde{\beta}\right)\right) |^{\frac{1}{H}} \tag{28}$$

where the AVC matrix is denoted by Ω_1 is, the prior parameters are denoted by $\tilde{\beta}$, and number of estimated parameters are denoted by *H.*

The d-error is not the only measure of inefficiency. Besides the d-error, there are two other measures of inefficiency, namely: the A-error, and the S-error (Hensher et al., 2015). The A-error considers only the variance and not the covariance of the AVC matrix. The S-

[44] See Hensher et al., 2015, Chapter 5 for extensive discussion on variance-covariance matrix (AVC) matrix.

error provides the theoretical minimum sample size required for a design. The reader is referred to Chapter 6 of Hensher et al., (2015) for detailed discussion on efficient designs.

Over the next few sections, the procedure to develop a d-efficient experiment design is discussed. For this purpose, six major steps and considerations are generalized: alternative identification and definition, attribute identification and definition, experiment design; and survey design.

3.4.2.1 Alternative Identification and Definition

Generally, in all SP designs, after the problem has been identified and defined, the first step is alternative identification. It entails the identification of the all alternatives available to the decision maker, and the definition of its service levels (Train, 2009).

As a first consideration, it is important during this step, to account for all alternatives; as failure to do this can later produce constraints on the utility maximization outcome (Bliemer, 2016). Once the alternatives are determined, the analyst must then decide on the actual number of alternatives to include in the SCE. There are limit suggestions as to the exact number of alternatives. According to Bliemer (2016), five to six alternatives is the optimum for labelled studies, while for unlabeled studies two to three alternatives is the optimum number. More alternatives generally mean more realistic scenarios; however more alternatives often leads to complex surveys and more error variance (Caussade et al., 2005). Hence as a solution, Caussade et al. (2005) recommends four alternatives as the optimal number to include. Where the researcher has identified too many alternatives, culling of alternatives may be had by randomly assigning attributes to every respondent, or by excluding “insignificant” alternatives,[45] or even reverting to an unlabeled design which typically include two to three alternatives (Bliemer, 2016).

3.4.2.2 Attribute identification and definition

Once the alternatives are identified, the next step is attribute definition. It entails the identification of attributes relevant to the stated research question and assigning levels for each of these attributes. This is a critical stage of the SCE and one that must be attended with due diligence and care, as the attributes and their levels are the ones that describe the hypothetical scenarios in the eventual SCE.

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[45] The alternatives presented to the respondent must always include the one chosen by the respondent in real life.

3.4.2.2.1 Attributes identification

To determine the attributes for a choice study, Hall et al., (2004) advices first the development of good understanding of the study population's experiences and perspectives (Hall et al., 2004). Typically, researchers employ literature reviews to identify the attributes, however more sophisticated empirical methods may be employed (Cullinane and Toy, 2000; Solakivi and Ojala, 2017).

Generally, the researcher is required to start with the end in mind when identifying attributes. Policy concerns for instance can be used to shape the choice of attributes (Baltussen and Niessen, 2006). Thus, at the inception of any study, the researcher must define the problem and the study objectives; that is, 'what is the problem?' and 'why is the research being undertaken?' This is done to ensure the researcher understands the problem and the objectives of the study and thereby, determine the questions that need to be asked (Punch, 2014).

Furthermore, secondary sources can be augmented to ensure the SCE is tailored to the study setting (Mangham et al., 2009). Once the process of attribute selection is done, Keeney & Raiffa, (1976) provides that the chosen attributes should have a number of properties including: completeness as to cover all important aspects of the issue in question; operational as to be meaningful, decomposable to smaller dimensions, non-redundant such that double counting is avoided, and they should be minimal in size.

3.4.2.2.2 Setting the number of attributes

Once the attributes are identified, the next consideration regards the number of attributes to include. The attributes may neither be too many nor may they be too few. They may not be too many because, the number of attributes in a choice experiment have an influence on the cognitive difficulty of completing the SCE (DeShazo and Fermo, 2002). Having a lot of attributes can overburden the respondent and can lead to the respondent satisficing or applying a simple decision rule in which they base their response on a subset of attributes (Mangham et al., 2009). They may also not be too few because, employing simplistic approaches wherein two or three significant attributes are employed may be unrealistic and bearing little resemblance to actual reality (Hess & Rose, 2010). A number of notable freight mode choice studies have employed five attributes (examples include: Kim, 2014; Puckett et al, 2011; Zambarini, 2011). Similarly, in this study, five attributes are employed in both the shipper behavior and carrier preference components.

3.4.2.2.3 Setting the attribute levels

Following attribute identification, the attribute levels must be set and labelled. The first step in this stage is to identify the extreme ranges of the attribute levels to use (Hensher, 2015: p.196). This is best done by examining the experiences (observed levels) of the respondent with regard to the attribute being studied. The observed levels act as guides, or as baselines, for the analyst to set attribute level ranges that are realistic. The levels chosen must be set so that they are realistic so as to depict the range of scenarios the respondent is likely to experience in real life, because doing this will likely increase the precision of parameter estimates that proceed from the SCE (Hall et al, 2004).

Once the attribute level ranges are set, a certain number of levels must then be assigned to each attribute. The more levels that are measured of an attribute, the more information is captured. This is because the ability of the design to detect non-linearities in the marginal utilities between the attribute levels is enhanced as more levels are added. However, more levels will entail bigger design, so the analyst must only add more levels when non-linear relationships in the attributes are suspected.

3.4.2.2.4 Setting attribute level ranges

Following this, the ranges between attribute levels must be set next. Attribute ranges should be fairly and evenly spaced (Bliemer, 2016). Ranges that are very wide (i.e. 1~10) provide more tradeoffs and better estimations but often lead to dominant and unrealistic alternatives. On the other hand, ranges that are too narrow (i.e. 1~2) are not ideal as they provide less tradeoffs and poor estimation results. Therefore, attribute level ranges should be fairly spaced (i.e. 3~6, 5~10, etc.) to provide optimal estimation results.

3.4.2.3 Experiment Design and interrogation

Having specified the alternatives, the attributes and the attribute levels, the choice sets are generated through an experiment. This is typically done in specialized software packages. For this study, the *Ngene software*[46] was employed for designing stated choice experiments.

Experiment design typically requires the specification of the utility functions for the different alternatives before a design is produced. Before doing so however, the size for the choice set and the sample has to be set, seeing a d-efficient design is considered. In

[46] *Ngene* is available at www.choice-metrics.com

terms of choice set, Bliemer (2016) provides that 18 is the maximum number of choice tasks, but this depends on the number of attributes and the attribute levels. Typically, the more scenarios, the better, however the respondent can suffer from fatigue if the scenarios are too many as earlier alluded.

3.5 Chapter Conclusion

Discussion in this chapter provides both a review of discrete choice modeling and associate stated preference methods. The chapter started by considering the use of DCM to model shipper behavior as a tool under freight demand modeling, and then it considered stated choice experiments as a method for developing data for DCM. The formulation of DCM was subsequently done followed by preference data. The chapter serves as a platform for subsequent chapters. In particular, it highlighted the suitability of the DCM to the problem statement.

"All our studies, history is best qualified to reward our research. And when you see that you've got problems, all you have to do is examine the historic method used by others who have problems similar to yours. And once you see how they get theirs [problems] straight, then you know how to get yours straight."

~ Malcolm X

4 DCM AND SSS

This chapter reviews literature of behavioral modeling on SSS development. Special focus is accorded to literature that employs DCM. The chapter proceeds as follow: first the application of DCM in freight transport is considered; then different SP design approaches are considered, in particular: the different modeling approaches, the experiment designs, study units, the decision maker employed and the choice attributes employed.

4.1 Freight Transport Demand and Behavioral Modeling

Most studies of urban freight describe freight transportation in terms of Freight and Service Activity (FSA) generated. FSA encompasses freight flows in volume, freight flows in vehicle trips, commodity flows and service flows (Holguín-veras et al., 2016; Nuzzolo and Comi, 2014). Typical presentations include origin-destination (OD) matrices that contain: the type of freight activity, type and quantity of goods moved, and the modes employed. In line with this, Ortúzar and Willumsen (2011) mentions six factors that influence freight movement, which include:

1. **Physical factors:** the nature and characteristics of materials and products.
2. **Operational factors:** business size, geographic dispersion and distribution channels.
3. **Geographic factors:** the density and location of target market population
4. **Dynamic factors:** seasonality in demand and consumer tastes
5. **Pricing factors:** flexibility of product retail prices and subject to negotiations.
6. **Location factors:** location of inputs to production, final markets for products and proximity to transport infrastructure influence the level of freight activity.

To that end, behavioral modeling has been extensively employed in freight transport demand (Ben-Akiva et al. 2008). When employed, DCM typically assists transport planners to assess the impact of different elements in the mode choice, and they allow for testing and evaluation of various transportation schemes (Ortúzar and Willumsen, 2011).

Winston (1983) provided one of the early behavioral modeling approaches when he researched on "the critical determinants of mode choice in freight transport" in the USA. The study highlighted how freight mode choice is complicated by issues pertaining to determining the "decision maker"; the difficulties in allowing for heterogeneity during modelling; and the tedious process of determining the mode choice attributes. That study also provided a foundational framework for many freight mode choice studies that would later ensue. In particular, it distinguished between aggregate and disaggregate freight demand models; and further branched disaggregate freight demand models into behavioral models and inventory models. It also provided that disaggregate choice models offer a much richer econometric specification and they yield more precise estimates in terms of market elasticities than aggregate or inventory models; whereas aggregate models maybe employed to forecast the behaviour of an entire transport system, disaggregate models such as DCMs maybe employed to predict the individual behaviour of agents within a specific transport system.

Unlike passenger transport were behavioural models have been widely applied for some time, the use of DCM in freight transport has been more limited. The reason put forward is primarily the difficulties associated with data collection. More recent works of behavioral research in freight, include: Feo-Valero et al., (2016), Kim et al (2014), Bergantino et al, (2013) Masiero & Hensher, (2010), De Jong et al., (2013), Masiero & Hensher, (2010), Feo et al. (2011), de Jong & Ben-Akiva, (2007), Shinghal & Fowkes, (2002) and Fowkes, Nash, & Tweddle, (1991) most of them employing SP data.

4.2 Behavioral Modeling and SSS Development

In Europe, were SSS has been aggressively pursued, extensive literature of SSS and DCM is found. Psaraftis & Schinas, (1996) conducted an extensive review of literature on SSS in Europe between the times spanning 1990 and 1996. Their review was mostly centered around the papers presented at the three European Research Roundtable on SSS conferences (1992, 1994, and 1996) and the three FAST international conferences on fast waterborne transport (1991, 1993, and 1995); however, none of the cited studies employed DCM. Contrarily, during this time, the research extensively looked at technical and commercial aspects of ships and carrier considerations.

Subsequent this, Papadimitriou, (2001) conducted a review of research conducted per European country up to 2000, and similarly indicated a wide range of research conducted across sectors in the SSS domain, and once again no cited studies were found to employ DCM. However, subsequent the year 2000, a number of behavioral studies have emerged that study the development of SSS, the majority of them being shipper behavioral studies.

Over the next few sections, some of these behavioral studies and their approaches are considered. Table 4-1 offers a summary of some of these studies, and an expanded explanation is offered subsequently in the following sub-sections.

Table 4-1: Behavioral research to develop SSS

Author	Region	SSS Unit	Base modal attributes	DCM	Model	Sample	DM	Data	Design	SP Method
Jiang et al (1999)	Europe	-	Frequency, Distance, Shipment size	NL	Aggr	5110	Shipper	RP	-	-
Zachcial, (2001)	Europe	-	Cost	LR	Aggr	700	Shipper	-	-	-
Bergantino & Bolis (2003)	Europe	Ro-ro	Cost, Time, Reliability, Frequency	TM	Dis-aggr	239	FF	RP, SP	Orthogonal	Adaptive conjoint
García-Menéndez et al., (2004)	Europe	Container, Truck	Cost, Time, Damage, Distance, Delay, Frequency, Environment	CL	Dis-aggr	157	Shipper, FF	RP	-	-
Brooks et al., (2006)	N-America	Truck	Reliability, Distance, Frequency	-	Aggr	276	Shipper	SP	Orthogonal	Conjoint
Brooks & Trifts (2008)	N-America	Truck	Reliability, Distance, Frequency	GLM	Aggr	276	Shipper	SP	Orthogonal	Conjoint
García-Menéndez & Feo-Valero, (2009)	Europe	Truck, Container	Cost, Time, Reliability, Distance	BL	Dis-aggr	238	Shipper	RP	-	-
Puckett et al. (2011)	N-America	Truck	Reliability, Distance, Frequency, Cost	MNL, ML, SML	Dis-aggr	276	Shipper	SP	Orthogonal	Conjoint
Feo-Valero et al (2011)	Europe	Container	Time, Cost, Reliability, Frequency	ML	Dis-aggr	64	FF	SP	Orthogonal	Pivot-choice
Brooks et al (2012)	Australasia	Container, Truck	Time, Cost, Reliability, Frequency	MNL, ML, GML	Dis-aggr	70	Shipper, FF	SP	D-efficient	Choice Experiment
Bergantino et al., (2013)	Europe	Ro-ro, Truck	Time, Cost, Punctuality, Damage,	ML, NL	Dis-aggr	90	Shipper, Carrier	RP, SP	Factorial	Choice Experiment
Kim (2014)	Australasia	Container	Time, Cost, Reliability, Frequency, Damage	MNL, ML, SML, GML	Dis-aggr		Shippers	RP, SP	Orthogonal	Choice Experiment
Arencibia et al, (2015)	Europe	-	Time, Cost, Punctuality, Frequency	MNL, ML, NL	Dis-aggr	54	Shippers	SP	Orthogonal, D-efficient	Choice Experiment
Russo et al, (2016)	Europe, N-Africa	Ro-ro, Lo-lo	Time, cost, hub-port, service port	ACM	Aggr	-	Carrier	-	-	Choice Experiment
Meers et al., (2017)	Europe	Container	Time, Cost, Reliability, Frequency	HB	Dis-aggr	50	Shipper	SP	Orthogonal	Conjoint

** DM = Decision-maker, FF=Freight Forwarder, N-America = North America, N-Africa, Aggr= Aggregate, Dis-Aggr=Disaggregate, LR=Linear Regression, CL=Conditional Logit, BL=Binary Logit, GL=General Linear Model, TM=Tobit model, MNL=Multinomial Logit, GML=Generalized Mixed Logit, SML= Scaled Mixed Logit, ACM=Aggregated Choice Model, CBC=Choice Based Conjoint, HB=Hierarchical Bayes*

4.2.1 Carrier behavior versus Shipper behavior studies

In Europe, the first shipper behavior study on SSS we found to have employed DCM is Jiang et al, (1999), who employed RP data collected from a 1988 survey of French shippers to develop a nested logit (NL) model to study freight mode choice. Even though that study did not study the development of SSS per say, it did develop insides into thresholds distances at which the maximum probability of choosing road, rail and SSS took place. Subsequent to this, we note that an exponential growth of shipper behavior literature to develop SSS.

In North America, Brooks et al., (2006) examined the potential for SSS along the east coast of North America (USA and Canada) using a mix of mail, telephonic and online surveys, posed to shippers and carriers along the eastern seaboard of North America. That study identified that; to study the viability of SSS in a region, much depends on the investigation of the demand from the shipper side, the willingness of carriers to participate in SSS, and the political will by authorities to address regulatory and commercial impediments. To that end, Brookes et al., (2006) developed insights into freight flows and modal split along the east coast of North America, as well as the challenges that a modally integrated SSS would need to overcome to compete effectively with road, which included: improved demand, shipper needs, operator needs, and policy changes in favor of SSS. The unique study development approach taken by Brookes et al., (2006) in many aspects mirrors the approach taken in this study. In particular, by studying the freight flows to and from US ports, Brookes et al., (2006) identified corridors were SSS could be developed; and furthermore, by studying shipper preference, it identified the tradeoffs that a modally integrated SSS services needed to appeal to the shipper, and last the carrier component of Brooks et al.,(2006) examined the technical aspects of SSS operations of ships and ports to assess the viability of SSS from a carrier perspective,[48] as we do in this study.

With regard to carrier studies, there are no known studies that have studied the development of SSS in a DCM setting. Russo et al, (2016) recently provided an analyses of carrier preference in a choice context; however, they only considered competition

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[48] Three vessel types: container, roll-on, roll- off and high speed were analyzed. The purchase and time charter options for these vessels were also considered. These options were assessed and compared against basic operating costs and port charges, overall transit times for shipping versus road with cost of road transport at 50, 100 and 150 miles from each O-D port pair. In the technical aspects, Brooks et al.,(2006) assessed the purchase, time charter options and vessel operating costs for seven options of SSS vessels: the 396 TEU Shamrock, the Incat Evolution 112, the Damen 800, the Oceanex Avalon and two roll on, roll off vessels, Stena Foreteller and Altinia. That study also provided insight for the would-be operator, whether they should purchase or charter a vessel. In the port selection components, they also examined six US east coast options where SSS was viable

between two types of SSS services: roll on-roll off (ro-ro) and lift on-lift off (lo-lo) SSS services. They developed an aggregate DCM to simulate the split between ro-ro and lo-lo services between countries facing the Mediterranean basin. The data employed were obtained from EUROSTAT for the year 2010 and partly from literature. The attributes employed included: cost, time, freight volumes, and whether it's a hub or a service port in the O-D pairing. The results indicate that lo-lo services are more competitive over longer distance which exceed 900 nautical miles; and with regard to hub or service ports, the results show that service ports derive more utility due to high service frequency and turnaround times in the ports.

Note furthermore from Table 4-1 that the significant volume of literature on SSS development is concentrated mostly in in the global north and Australasia (New Zealand and Australia) where there is great economic development. Therefore, this study by assessing the take up of SSS both from a shipper and carrier behavioral component, and more so in a SADC context, which is regarding as developing, adds a new dimension to international freight research and SSS research.

4.2.2 Modeling Approach Considerations

In the review of SSS literature, there are a number of studies, particularly the earlier studies, that employ conjoint analysis and not DCM per say. For instance, in Europe, Bergantino & Bolis, (2003); employed adaptive conjoint analysis (similar to pivot choice designs in SCE) to assess the preferences of the freight forwarder to direct current on-land transport services to either a hypothetical SSS ro-ro, or lo-lo service alternatives in Italy. [49] Later, in North America, Brooks et al., (2006) examined the potential for SSS along the east coast of North America (USA and Canada) using conjoint analysis to assess the preference of shippers along the eastern seaboard of North America. More recently as well, Meers et al., (2017) employed choice based conjoint (CBC) to study mode shift potential from road to intermodal SSS for short distance inland container transport in Belgium.

It was earlier established that CA is not as accurate as DCM because it uses the profiles of choice alternatives to estimate underlying part worth utilities, while DCM presents experimental replications of the market with focus on market accurate predictions

[49] Lift-on - lift-off (lo-lo) ships are ships equipped with on-board cranes to load and unload cargo, mostly in the form of containers in the SSS context; whereas roll on – roll ships are ships designed to carry wheeled cargo, such as trucks and semi-trailer trucks that are driven on and off the ship on their own wheels.

(Louviere et al, 2010). As alluded earlier in Chapter 3 (section 3.4) CA is also inappropriate for economic evaluation as it is rooted in conjoint measurement theory, which is purely mathematical and more concerned with the behavior of systems as opposed to individual human preference in DCM. For this reason, DCM is better suited to provide insights into how people make choices, and thus the more suitable tool to inform political decisions.

4.2.3 Experiment Design Considerations

4.2.3.1 Factorial versus Fractional Designs

As earlier mention in section 3.4.2, the experiment design process plays a key role in the independent assessment of every attribute's contribution to the discrete choice observed; and it is also key in determining the statistical power of the experiment insofar as its ability to detect statistical relationships that may exist within the data.

What was not discussed earlier in Chapter 3 is that an experiment design may either be full-factorial[50] or fractional-factorial (fractional). In full-factorial design each level of every attribute is combined with every level of all other attributes such that all possible combinations of attribute levels are enumerated. In fractional designs however, a number of sampling methods are employed to select a subset of the full-factorial design in such a way as to lead to practical designs with particular statically properties (Bliemer and Rose, 2006). The three main types of sampling methods are: random designs whereby a subset of choice task is selected randomly from the full factorial; orthogonal designs whereby a subset is selected such that the attribute levels are uncorrelated; and efficient designs whereby a subset is selected such that standard errors are minimized (ibid).

On this backdrop, notice from Table 4-1, that with exception of Bergantino et al., (2013), all cited studies on SSS employ fractional designs, a majority being orthogonal designs. This is not surprising, given the difficulty associated with collecting data in freight related research. Full- factorial designs are too cost-prohibitive and tedious to have subjects consider all possible combinations, and so for most practical situations freight transport studies employ fractional design (Louviere et al., 2000).

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[50] In factorial design each level of every attribute is combined with every level of all other attributes such that all possible combinations of attribute levels are enumerated. Due to the nature of complete enumeration of attribute levels, factorial design has attractive statistical properties that guarantee that all attribute effects are independent and in aaddition, they allow the estimation of main effects and two-way or higher interactions, thus providing a lot of information. Notwithstanding the benefits of factorial design, such designs are too cost-prohibitive and tedious to have subjects consider all possible combinations, and so for most practical situations researchers resort to fractional design (Louviere et al., 2000).

4.2.3.2 Orthogonal designs versus Efficient designs

Even though most studies citied in Table 4-1 employed fractional designs, notice that only two studies (Arencibia et al., 2015; Brooks et al., 2012) employed d-efficient designs. The majority of studies employed orthogonal designs.

The derivation of the d-efficient experiment design was done in Chapter 3. To that effect, the intention of fractional designs is primarily to develop an efficient design. Huber and Zwerina, 1996 established four principles, which when jointly satisfied indicate when a design is efficient. These principles include: orthogonality, level balance, minimal overlap, and utility balance. Orthogonality is achieved when the levels of each attribute vary independently of one another. Level balance is achieved when the levels of each attribute appear with equal frequency. Minimal overlap is achieved when the alternatives within each choice set have nonoverlapping attribute levels. Lastly, utility balance is achieved when utilities of alternatives within choice sets are the same (Huber and Zwerina, 1996).

On the point of orthogonality, over the past decade, fundamental changes have occurred in experiment design methods that have revealed the weaknesses of orthogonal designs (Rose & Bliemer, 2005). For instance, dominant alternatives (where the design allows one alternative a higher probability of being chosen then others) are often present in orthogonal designs, a setting which leads to silly choice tasks. Orthogonality is furthermore easily lost when attribute levels are not evenly spaced or when missing data. In addition, Huber & Zwerina (1996) showed that more information can be captured when we let go of orthogonality. This has made a strong case for efficient designs, as they are able to produce more efficient designs with more reliable parameter estimates and these are often achieved with an equal or lower sample size then that of orthogonal design (Rose & Bliemer, 2009). The current state of affairs is thus efficient designs instead of orthogonal designs.

4.2.4 Modal Attributes

With regard to modal attributes, we notice from table 4-1 that different studies have employed different attributes in their models. This observation suggest that freight mode choice decisions are likely to vary (or at least in the weights attached to different attributes). These variations are bound to exist both in terms of sectors and in terms of geographical contexts. The use of freight mode choice attributes in what is considered standard in the existing corpus of largely western literature has become standard, and to that effect has been adapted without interrogation. This point is confirmed when Zamparini et al., (2011) employed mode choice attributes adapted from European literature to study freight mode choice decisions in Tanzania. In that study, SP data was collected from logistics managers of companies that produce and ship goods. The mode choice attributes employed were flexibility, frequency, loss and damage, reliability and transit time.

It was also earlier established that in DCM, each alternative in the defined choice set is characterized by a set of attributes (Koppelman and Bhat, 2006). The attractiveness of an alternative is determined by the value of its attributes in relation to the characteristics of the decision maker (ibid). From Table 4-1, note that most shipper behavioral studies that study SSS mostly employ: transport cost, transit time, reliability, frequency and distance. Distance is mostly considered when different O-D pairings are studying; however, when mode choice decisions are considered on specific corridors, the distance attribute falls away.

Studies by MacGinnis, (1990) and Murphy & Hall, (1995) who conducted reviews of shipper behavior literature in the US, identified that mode choice decisions are pretty much affected by six attributes: transport costs, reliability, transit time, rate of loss and damage to goods, shipper and carrier market considerations. A subsequent study by Cullinane & Toy, (2000) who applied content analysis to route and choice literature in freight in Europe, additionally identify flexibility, traceability and capability as common attributes in addition to the above. Bolis and Maggi (2003) further provide that frequency and flexibility are particularly important to modern logistic concepts (e.g. Just in time), and this finding is confirmed by a more recent study by Solakivi & Ojala, (2017) who found that tracking and traceability of shipment and flexibility of service have become more common in recent surveys of freight transport.

Furthermore, the list of modal attributes provided above is not exhaustive. The attractiveness of a mode is further determined by exogenous factors because shippers make decisions in a dynamic environment, where prices fluctuate rapidly, where customers have varying demands, and where both transport demand and supply characteristics can mitigate mode service benefits (Martinez-Lopez et al., 2015). The extensive literature on freight mode choice that spans at least 4 decades thus indicates a constantly changing landscape of mode choice attributes that varies both across geography and in time (Kim, 2014; Murphy and Hall, 1995).[51]

[51] See Chapter 3 for a review of literature on freight mode choice.

4.2.5 Study approaches: unimodal SSS versus intermodal SSS

Table 4-1 also shows that behavioral studies on SSS have considered both unimodal SSS and intermodal SSS options, however an explicit delineation between unimodal SSS and intermodal SSS is often clear.

The OECD definition for intermodal freight transport is "the movement of goods (in one and the same loading unit or vehicle) by successive modes of transport without handling of the goods themselves when changing modes" (OECD, 2010).[52] Intermodal transport must be differentiated from its counterpart multimodal transport, which refers to the carriage of goods by several modes of transport, each which has different carrier responsibilities, however carried under a single contract of carriage.

If intermodal SSS is considered, SSS is generally perceived to carry the longer leg of an intermodal transport journey where the journey either starts or end in the hinterland, far away from the port. In contrast, unimodal SSS typically refers to a transport journey where the entire transport is carried by and where both O-D pairings are within port or in the proximity of port cities. On the backdrop of this difference, literature indicates slight difference between intermodal SSS and unimodal SSS options.

In the case of intermodal SSS, Zachcial, (2001) employed SP data to assess mode shift potential from road to multimodal SSS, developed from a data set of 700 interviews with shippers and freight forwarders; and employed linear regression to estimate modal split ratios from the data. That study concluded that the market share of SSS could be increased if SSS was made cheaper by lowering freight rates, terminal handling charges and by exploiting economies of scale. In a similar context, Feo et al, (2011a) used SP data collected from freight forwarders in Spain to estimate a binary logit model as a support tool for designing an optimum promotion strategy for SSS for the MoS network of south-west Europe. The SP scenarios in that study considered two alternatives of freight transport; the first being a unimodal road alternative and the other an intermodal SSS alternative. The SSS alternative was presented as an improved alternative across three generic variables: transit time, transport cost, reliability and frequency of service. From the estimation results, Feo et al, (2011a) concluded that transport cost policies have the greatest effect on the probability of choosing the SSS alternative, and with regard to transit time, the probability of SSS being chosen depends on its own performance. More

[52] The Oxford 1999 dictionary gives the following definition: "a vehicle/container system involving two or more different modes".

recently, Bergantino et al., (2013) considered a unimodal road alternative to an intermodal SSS alternative, using both RP and SP data, from which they estimated mixed logit and nested logit models. In addition to estimating “perceived importance” of the most relevant service dimensions in determining the attractiveness of two alternatives, Bergantino et al., (2013) assessed the role played by latent preference of shippers towards specific service attributes in freight mode choices; and accordingly concluded that shippers’ attitudes towards time, punctuality and risk of loss/damage can significantly enhance the explanatory power of freight choice models. They found road to be most preferred by shippers who are concerned with the risk of loss/damage, mode flexibility and when consigning perishables.

In the case of unimodal SSS, a series of behavioral studies have focused on road versus SSS. García-Menéndez et al., (2004) developed a BL model for road versus SSS from RP data collected from personal interviews with shippers in four industry sectors in Valencia, Spain. They found shippers’ choice of SSS to be more sensitive to changes in road transport prices than to changes in SSS costs, thus concluding that a modal switch to SSS could only be induced by imposing an ‘ecotax’ on road. Similarly, García-Menéndez & Feo-Valero, (2009) investigated mode choice competition between road and SSS using RP data collected from Spanish shippers to the rest of Europe. The study found that variables including: accessibility of port infrastructure, INCOTERM employed, door-to-door distance, relative value of shipment, size of shipment and the type of company are all important determinants of freight mode choice as are the traditional cost and transit time variables.

Another European study is by Arencibia et al, (2015) who employed SP data collected from shippers who ship between Madrid, Belgium, Netherlands, Germany and France. They employed a d-efficient stated choice experiment design that was seeded with priors developed from an earlier orthogonal experiment conducted from a pilot study. From the data, they developed MNL and ML models. The conclusion is that the actions with the greatest impact are those that affect the cost of transportation.

In New Zealand, Kim (2014) developed a freight choice model using both RP and SP data from freight shippers to identify the possibility of mode substitution effects towards unimodal SSS (Kim, 2014). The outcomes of that study reveal that freight mode choice is a result of an array of interactions including transportation characteristics, logistics characteristics and product characteristics. In line with Brooks et al (2012) and studies conducted in north America and Europe, Kim (2014) submit that actions to force a modal shift to SSS may be induced by increasing the cost of road transport.

Given the difference between unimodal and intermodal SSS, it was opted to do both in this study (see Chapter 5). In SADC particularly, intermodality in SSS is imperative given the unique freight transport setting, where the major population centers are located mostly in land, away from maritime ports, and where the exist a huge proximity gap between sources of supply and demand (see Chapter 2). In such a setting, intermodal freight transport is favored because it capitalizes on the inherent advantages of modes, by minimizing the impact of mode disadvantages, it create cost and operating efficiencies, it offers capacity, and it is also environmentally friendly (Monios and Bergqvist, 2017).

4.2.6 Selecting the survey respondent: who is the decision-maker?

The last issue in our review regard the decision-maker in freight mode choice. This has been an issue of contention from the onset (Winston, 1983). Most choice studies have employed either shipper or freight forwarder depending on whom they believe is the decision maker. To a large extend, this is understandable seeing there are a large number of players in the freight transport chain and as such, it is often not clear who is charged with mode choice (Arencibia et al., 2015; Feo et al., 2011). Holguin-Veras (2018) additionally submits that freight mode choice is more complex and often a multi-stakeholder problem that is influenced by all parties in the supply-chain: the shipper, carrier and even the receiver.

In maritime law, the decision-maker is legally defined as the shipper. That is, the entity legally obliged to enter into a transport agreement with the carrier and thus who has a right to sue the carrier or be held liable for any non-performance of the contract terms (Hare, 2009). In maritime transport, when cargo is placed onboard a ship for carriage, the carrier becomes the bailee[53] of the cargo owner, and as bailee, they have a duty to keep cargo safe and must upon fulfilment of the contract of bailment; deliver the cargo as instructed by the bailor (shipper) (ibid). The common law requires the carrier to perform the obligations pronounced within the contract of carriage and a strict responsibility to properly and carefully perform these obligations (which include loading, stowing, caring and discharging). By virtue of this reasoning, one is inclined to believe the shipper to be the decision-maker seeing it is with them the carrier enters contract of carriage. However,

[53] Bailment is the process by which goods are transferred from the owner (bailor) to another (bailee) for a special purpose (ie for carriage by sea). In the law of carriage of goods by sea, the contract of carriage becomes a 'contract of bailment' when a bill of lading is issued.

as table 4-1 shows, research appears to suggest otherwise with at least 4 of the studies reviewed employing the freight forwarder.

Ensuing the above, the decision-maker as an entity in freight mode choice is generally described by three distinct characteristics: business characteristics, shipment characteristics, and spatial characteristics of freight (Jiang, 2013). [54] Business characteristics include the nature of business (manufacturing, retail, mining etc), the size of business (in terms of money or number of employees), location and resources at their exposal. Shipment characteristics include shipment size, value, weight, product, packaging, chemical properties and stowage requirements. Spatial characteristics include frequency of shipment, distance shipped, origin and destination (ibid).

4.3 Chapter Conclusion

Discussion in this chapter provides both a review of literature on DCM and associate stated preference methods and their application in SSS development. From this, key takeaways include: the significant volume of literature on SSS development is concentrated mostly in developed regions of the world; most behavioral studies on SSS are from a shipper perspective and little from a carrier perspective; and last, most SP studies employ orthogonal experiment designs, despite its limitations.

[54] These characteristics are also necessary to explain the heterogeneity of preferences among decision makers.

"Method is the arithmetic of success"
~Josh Billings

5 STUDY DEVELOPMENT

This chapter provides an overview of the steps taken to develop the study. It presents the study development processes of the choice experiments, the questionnaire designs, and the data collection processes. Accordingly, it proceeds as follow: first the research background is revisited, procedures for the three studies that make up the larger study are described: the SADC freight study, the shipper behavior study, and the carrier study.

5.1 The overall study outline

The research problem and aims were outlined in Chapter 1. The understanding of the problem (i.e. the need to develop SSS in SADC) led to the divide of the study into two independent, yet objectively related components; the first which assessed the take up of SSS by shippers (those who procure the freight transport service) and the second which assessed the take up of SSS by carriers (those who supply the SSS transport services). For ease of reference these were named 'Shipper Behavior' and 'Carrier Preference' studies. The second study was called carrier preference because, rightly so, it could only provide what carriers intended to do and not really how they behaved. This is different from shipper behavior where the study setting allows to see how shipper make mode choice decisions in reality.

The shipper behavior study was further delineated along two branches, the preliminary survey (now called the 'SADC freight study') and the shipper behavior study (now called the 'shipper behavior study'). The SADC freight study would later inform and guide the SP component in the shipper behavior study. The shipper behavior study was furthermore divided into two parts, the first that entailed freight trip mode choice studies in a unimodal SSS setting, and the other that entailed freight trip mode choice studies in an intermodal SSS setting. For each of these study components, individual studies were developed, each employing similar steps, but different models and data collection methods to achieve the respective study objectives they served to satisfy. Figure 5-1 shows the study development process, and how these components link to later stages of the study.

In short, Figure 5-1 shows the process as follow: the literature review revealed the determinants of SSS, as well as the models and SCE techniques employed in contemporary freight mode choice and SSS studies. From there on, the study was delineated along two study branches: shipper behavior and maritime carrier preference. Based on the study objectives, both branches required the development of unique SCE processes for both the carrier and shipper components, followed by the questionnaire development and data collection processes.

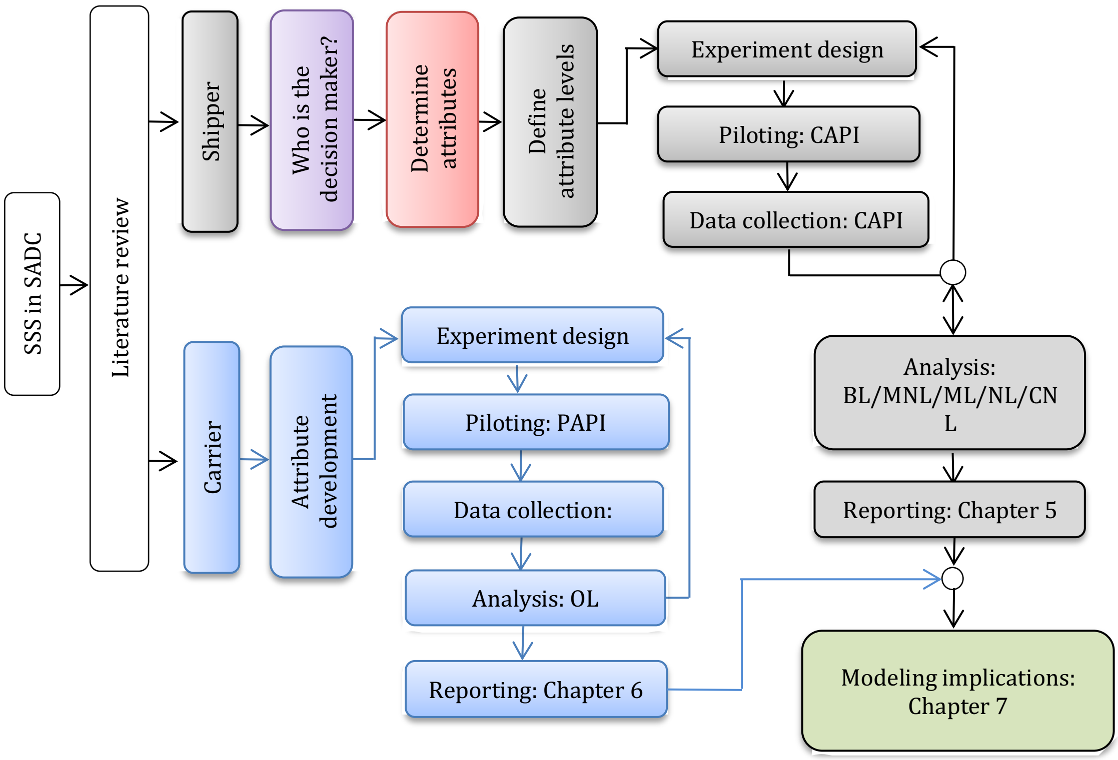

Figure 5-1 The study development process

The general SCE process is iterative involving experiment design, piloting, analyzing results and applying corrections, until a suitable design is achieved (Hensher et al., 2015). All the surveys developed, were first piloted in order to check the adequacy of the questions, in the case of shipper and carrier studies, the respondents' understanding of choice setting, the adequacy of attributes and levels and whether the number of choice tasks can be managed by the respondents (Hall et al. 2004). Particularly, considering that similar studies in SADC hadn't been done, the pilot surveys served as a priori surveys to determine the coefficient estimates that were employed to seed the respective final experiment designs.

The study development also considered the data collection methods. To that end, there are a number of established survey methods including: Computer Aided Personal Interviewing (CAPI), online surveys, Paper-and-Pencil Interviewing (PAPI), mail-back, and telephone survey methods (Ortúzar and Willumsen, 2011), all which can be employed for data collection. Thus, for each study component developed, a unique data collection method was employed.

Different sampling methods were also considered. In particular probability sampling and convenience sampling was considered. Convenience sampling is defined by Punch, (2014) as "a non-probability sampling technique where subjects are selected because of their convenient accessibility and proximity to the researcher".

5.2 The SADC Freight study

The SADC freight transport study was developed to serve as a priori to the general discussion of developing SSS within an integrated logistics space in SADC by providing knowledge required to design the study on SSS development in SADC. The study specifically addressed the questions:

- Who is the decision maker is in terms of freight mode choice in SADC? and,
- Which modal attributes are important to the SADC shipper?

5.2.1.1 Questionnaire Structure

Seeing the intention of the SADC Freight study was to describe the freight procurement landscape in SADC, the questionnaire was divided into six parts (see Annex 1 for the complete questionnaire):

Part 1. General information, which captures descriptive information of the respondent.
Part 2. Product Information, which captures information on the products traded.
Part 3. Modal Split, to determine who the decision maker is, which modes are used and the respective modal splits that the respondent assigns to each mode employed.
Part 4. Transport Reliability, which captures perceptions on reliability and how the effects of unreliable transport are addressed.
Part 5. Mode Choice Attributes, which obtains a ranking of modal attributes.

5.2.1.2 Focus Group Discussions

The questionnaire structure is both a result of focus group discussions and pilot surveys. In the focus group discussions, the survey was first piloted and afterwards the discussion about the survey was held. To that end, the questionnaire was piloted with three cargo principles and one freight forwarder in Cape Town. The method of survey during piloting was computer aided personal interviewing (CAPI), despite the survey intended to be an online survey. CAPI interviewing was necessary during piloting to determine how long the survey would take and ideally amend it to take no longer then 15 minutes; and it was also necessary to get immediate feedback on the survey.

The three major shortcomings identified required the (1) refinement of terminology to industry lingua, (2) the complete enumeration of all attributes in the ranking questions, and (3) to shorten the survey so as to avoid respondent fatigue. Some questions on cost of transport were also removed as they were considered sensitive and could potentially discourage participation. The costing variable was eventually secured by sourcing hypothetical invoices from shipping companies in the region. The above shortcomings were addressed and the final survey was hosted online using the sawtooth software.

To collect data for the SADC freight study, the online method was employed. The online method involves completing the survey online, and having the data synchronized with a mainframe computer instantaneously. The online method is cost and time efficient in terms of collecting large amounts of data in large geographically dispersed areas were respondents are far apart, but it often suffers from low response rates (Punch, 2014), as it would later be the case in the SADC freight study.

Initially, a sampling frame consisting 1500 shippers was created, with at least 50 respondents representing each SADC member country. Respondents' contacts were mainly obtained from trade associations within respective countries, and from web databases. Stratified sampling was then employed to populate two study sample groups, with the first comprising of 750 cargo principles (consigners and consignees such as retailers, mines etc), and the second comprising 750 freight forwarders and 3PL and freight agents. Efforts were made to have an even distribution of respondents amongst the SADC member countries, business sectors, company sizes and product type.[55]

Subsequently, data collection took place online between 1 March 2017 and 1 November 2017. The respondents were invited by email. In addition, random telephone calls were made from the sample list to invite shippers to the survey. Some respondents were also invited via national shipper and freight forwarder associations. In total, over 3000 emails were promulgated, but in the end, only 203 respondents attempted the survey, and only 86 completed the survey in full. To improve survey response rate, recipients were reminded via email to complete the survey every 2~3 weeks, until the deadline of the survey. Due to a very low response rate, the sample was enlarged to include any shipper who trades inter-regionally, ending up with 86 complete responses.

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[55] The businesses types were cited from South Africa Bureau of Standards (SABS) classification. Only represented business types are presented in the survey statistics.

5.3 The Shipper Behavior study

Unlike the SADC freight study, the process for the shipper behavior study was lengthier. It included corridor identification, alternative identification, and attribute identification and definition.

5.3.1 Corridor Identification

First, in-line with the research focus, certain freight transport corridors where the development of SSS was plausible were identified (See Annex III). The criterion to select these corridors was based on: the volume of freight flows along the corridors (current and projected), the plausibility of SSS along the corridor (i.e. availability of ports, the maritime leg of the journey is long enough for SSS to compete with road and rail); and the existence of fair to high levels of road congestion and or road accidents. Subsequently, two corridors were selected on the east and three corridors were selected on the west of the SADC region to achieve fair regional presentation. The final list of corridors was chosen in line with the study objectives to test both for unimodal and intermodal SSS. Therefore, two corridors had the origin or destination in the hinterland (i.e. inland city) and three corridors had both the origin-destination at port cities. Special consideration was also given to corridors were data collection was possible with considerable ease. The five corridors selected were thus: Walvis Bay ~ Luanda; Walvis Bay ~ Cape Town, Durban ~ Beira; Durban ~ Harare and Cape Town ~ Windhoek as shown in Figure 5-2 below.

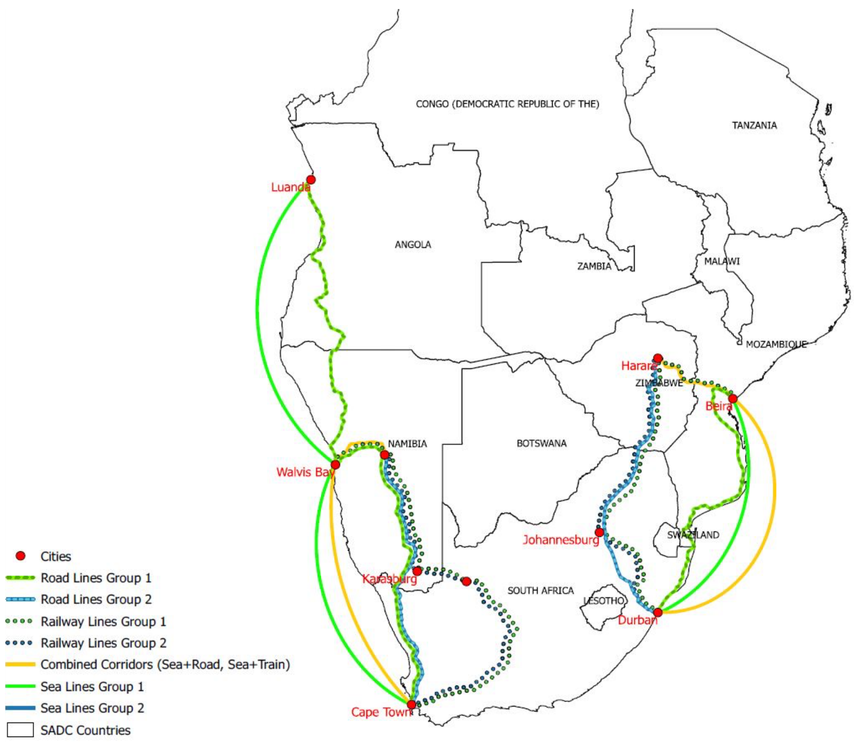

Figure 5-2: Study Corridors for the Shipper behavior study

5.3.2 Alternative Definition

5.3.2.1 Alternative Identification

The identification of the corridors allowed the identification of the transport alternatives by which bulk freight was carried in these corridors. Seeing these were between popular origin-destination pairings in the region, the identified alternatives were: road, air, rail and maritime (sea). To narrow the number of alternatives employed even further, the unit of shipment was limited to modes wherein twenty-foot containers (TEU) with average cargo weight of 9340 kg could be carried.[56] The transport alternatives were thus narrowed to 2~4 depending on the corridor, as only road, rail, SSS and intermodal options of SSS and rail and SSS and road could carry TEU containers on these corridors.

5.3.2.2 Attribute Identification and Definition

The modal attributes employed in the shipper study were first compiled from literature (see Chapter 4) and these were subsequently refined in the SADC freight study (i.e. by ranking them and using the top five attributes that are considered most important). The initial choice set thus contained the following attributes: *reliability, transport cost, risk of damage, frequency of service and transit time*. These attributes were further modified after the pilot survey revealed that 'customer service' even though perceived important during the SADC freight study was not statistically significant. Additionally, it also emerged that even though reliability was important, respondents wanted to know the extent of delay if a mode was not 100 percent reliable. The attributes were thus modified to include 'delay', whilst 'risk of damage was removed. The final choice set is depicted in figure 5-3.

5.3.2.3 Attribute levels

The current levels for these attributes were then determined from focus groups discussion, freight choice literature, and from consulting individual freight transport service providers such as ports, shipping companies and trucking and rail companies. For instance, for transport price and transit time, levels were obtained from quotations requested for transport service providers. Levels for reliability, extend of delay and frequency of service for road were mostly obtained from informal interviews with truck

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[56] The container is a general Intermodal Transport Unit (ITU) employed in most intermodal options. It has often been argued that African shippers should consider containerizing their bulk exports to reduce the transport cost in Africa (Pedersen, 2001). It also the view of the author that containerization of both primary and secondary commodities in SADC, can help achieve a balance between the inflow and outflow of containers in SADC. This will also improve inter-modal integration, which we find is key for the smooth functioning of logistics chains in SADC. It is particularly this quality of transferability that has led to the container to be widely adopted in freight transport (Vigarié, 1999). The use of the container will also lead to lower standardized freight rates, lower insurance rates, lower storage, package and packing costs, as well as faster inventory turnover and higher frequency of service.

drivers, and border posts customs officials. For SSS and rail services, service levels were obtained from port authorities, rail operators and coastal shipping operators. Table 5-1 presents the results of current service levels on the O-D paired routes.

The attribute levels for the SCE were subsequently set after reviewing related literature (particularly the actions taken in Europe to develop SSS) and after consultation with regional transport service providers and government officials as to the possible levels ideal for SSS development. Table 5-2 to 5-7 provides a depiction of the modal attributes and levels specified for the experiment design (see Annex 4 for actual depiction). In all the SCEs the SSS alternative was set in such a way that the SSS and SSS alternatives conditions are constantly improving whereas the road alternative is set in such a way as to constantly grow worse.

5.3.2.4 Focus Group Discussions

Focus group discussions were held extensively both before and after the design of the survey. Two runs of meetings were held at three venues in Cape Town, and one was done via Skype with a cargo principle in Namibia. In total seven freight forwarders two shippers were consulted and interviewed. The meetings involved Q&A sessions in which the 'freight experts' were asked about their perceptions, opinions, beliefs, and attitudes towards freight transport in general, and how they would welcome the SSS idea. The meeting also involved gathering feedback on the survey instrument. The objectives of these focus group meetings were:

- First, to make sense of the survey instrument and to determine the realism of the SP scenarios.
- Secondly, to find aspects of the shipment that could influence mode choice,
- Thirdly, to find aspects of the existing modes which could act as attraction or repulsive factors.
- Thirdly, to identify potential attitudinal aspects that could be included in the choice experiments.

The meeting sessions were held as follow: from 1 March - 29 August 2017, ad hoc telephonic meetings were held with the Namport, OCL, Maersk Line to ascertain the attribute levels. Subsequently from 15-20 September 2017, the first cycle of face-face meetings were held with the first version of the questionnaire (the first run). From 20-27 September 2017, changes were applied to the survey and the Version 2 of the survey was presented to two respondents on the 29th of September 2017.

Key lessons were taken from the focus group meetings a number of ways. First, some of the attribute levels were found to be unrealistic. For instance, the door to door transport costs and transit times for the SSS alternative were in some instances found to be under specified and this made some choice scenarios too unrealistic. To remedy the problem, a set of invoices were requested from two freight firms, one based in Cape Town, and another based in Durban, that indicated willingness to assist. It was also decided to incorporate a revealed preference component wherein respondents are asked questions about a previous trip they undertook on this corridor. The base levels for the alternatives were subsequently set as the average of the figures obtained from the quotations.

Secondly, the intervals between levels for some attributes were found to be too narrowly defined for respondents to make trade-offs. For instance many shippers said they wouldn't feel a six hour delay but they would feel a 24 hour delay; so the extend of delay had to be specified at intervals of 24 hours for respondents to make trade-offs. On the Cape Town ~ Luanda corridor the freight experts indicated that the transit can be cut down by as much as six days if custom bureaucracy were taken care off so the levels had to be widened to this extend.

Fourthly, it was noticed in the first run that respondent were mostly considering the top ranked attributes (cost and time) and were not going through all the attributes with the same intensity of concentration. This was remedied by inversing the attributes so that the least considered attributes are displayed on top in the choice scenarios. So, in the final survey, attributes were presented in the following order: Frequency of service, Reliability of mode, Potential extend of delay, Door to door transport cost, Door to door transit time.

Lastly, an issue uncovered was the 'criticality' of the shipped cargo. Two respondents indicated that how critical a shipment is, has a certain level of influence on mode choice, because some of the major shippers are factories and mines, whose operations often hinge on a certain level of stock. A selection question was thus incorporated, wherein a respondent is asked to select the urgency or criticality of the shipment.

Table 5-1 shows the transport conditions as audited in the study development process; tables 5-2 to 5-6 shows the covariates ad developed in the above enumerated process and table 5-7 shows the list of covariates employed during the study. Samples of the survey are attached in Annex 2.

Table 5-1: Current transport conditions to transport TEU (20' container) in SADC

Attribute	CT–WHK	CT–WB	CT - Lua	WB-Lua	Dur-Bei	Dur–Har
Integrated SSS (road)						
Sea Freight	$1150	$1150	$950	$1250	$650	$650
Port Costs	$300	$300	$550	$350	$550	$550
Port Health	$300	$300	$400	$350	$400	$400
Road	$500	$250	$400	$250	$400	$2500
ΣCost D2D	$2250	$2000	$2300	$2200	$2000	$4100
Sea leg	3 day	3 day	4 days	3 days	2 days	2 days
Port transit	3 days	3 days	5 days	4 days	4 days	4 days
Road leg	1 days	-	-	2 days		2 days
ΣTransit time	7 days	6 days	9 days	9 days	6 days	8 days
Sea leg (km)	1300 km	1300 km	2963 km	2060 km	1178 km	1178 km
Road	400 km	-	-	551 km	-	557 km
ΣDistance (km)	1700 km	1300 km	3544 km	2611 km	1178 km	1735 km
Frequency	-	1 p/wk	1 times	1 p/wk	2 p/wk	-
Reliability	75%	75%	75%	50%	50%	75%
Damage/Loss	Low	Low	Med	High	Med	Low
Integrated SSS (Rail)						
Sea Freight	$1150	-	-	$1595	-	$650
Port Costs	$300	-	-	$500	-	$550
Port Health	$300			$300	-	$300
Rail Freight	$450	-	-	$800	-	$800
Σ Cost (D2D)	$2200	-		$3195	-	$2300
Sea leg	3 day	-	-	3 days	-	3 days
Port stay	2 days	-	-	3 days	-	3 days
Rail Leg	3 days	-	-	4 days	-	4 days
Σ Transit time	8 days	-	-	10 days	-	10 days
Sea leg (km)	1300 km	-	-	2060 km	-	1300
Rail leg	400 km	-	-	557	-	557
Σ Distance	1700 km	-	-	2617 km	-	1857 km
Frequency	1 p/wk	-	-	1 p/wk	2 p/wk	1 p/wk
Delay	50%	-	-	25%	-	25%
Damage/Loss	Med	-	-	High	-	High
Rail						
Total Cost	-	-	-	-	-	*$3300*
Transit time	-	-	-	-	-	*14 days*
Distance	-	-	-	-	-	*2191*
Frequency	-	-	-	-	-	*1 p/wk*
Reliability	-	-	-	-	-	*65%*
Damage/Loss	-	-	-	-	-	*High*
Road						
Total Cost	$3000	$3500	$9000	$5250	$4500	$3700
Transit	2	4 days	8 days	4 days	4 days	6 days
Distance (km)	1500 km	1720 km	3544 km	2218 km	1792 km	1680 km
Frequency	Everyday	Everyday	Everyday	Everyday	Everyday	Everyday
Reliability (%)	100%	100%	75%	75%	75%	100%
Damage/Loss	Low	Low	Med	Med	Med	Low

Table 5-2: Attributes and levels for Cape Town ~Walvis Bay

Attribute	Current	Road			SSS		
Cost ($)	3000	3000	350	400	2500	2000	1500
Time (days)	4	4	5	6	6 days	7	8
Reliability	1/3	0/3	1/3	2/3	1/3	2/3	3/3
Delay (hrs)	0	0	12	24	0	6	12
Freq days/wk	7	7	5	6	1	1	2

Table 5-3: Attributes and levels for Walvis Bay ~Luanda

Attribute	Current	Road			SSS		
Cost ($)	3500	3500	400	450	1900	2200	2500
Time (days)	6	5	6	7	7	8	9
Reliability	1/3	0/3	1/3	2/3	1/3	2/3	3/3
Delay (hrs)	24	24	48	72	0	24	48
Freq days/wk	7	7	5	6	1 /2	1	2

Table 5-4: Attributes and levels for Durban ~Beira

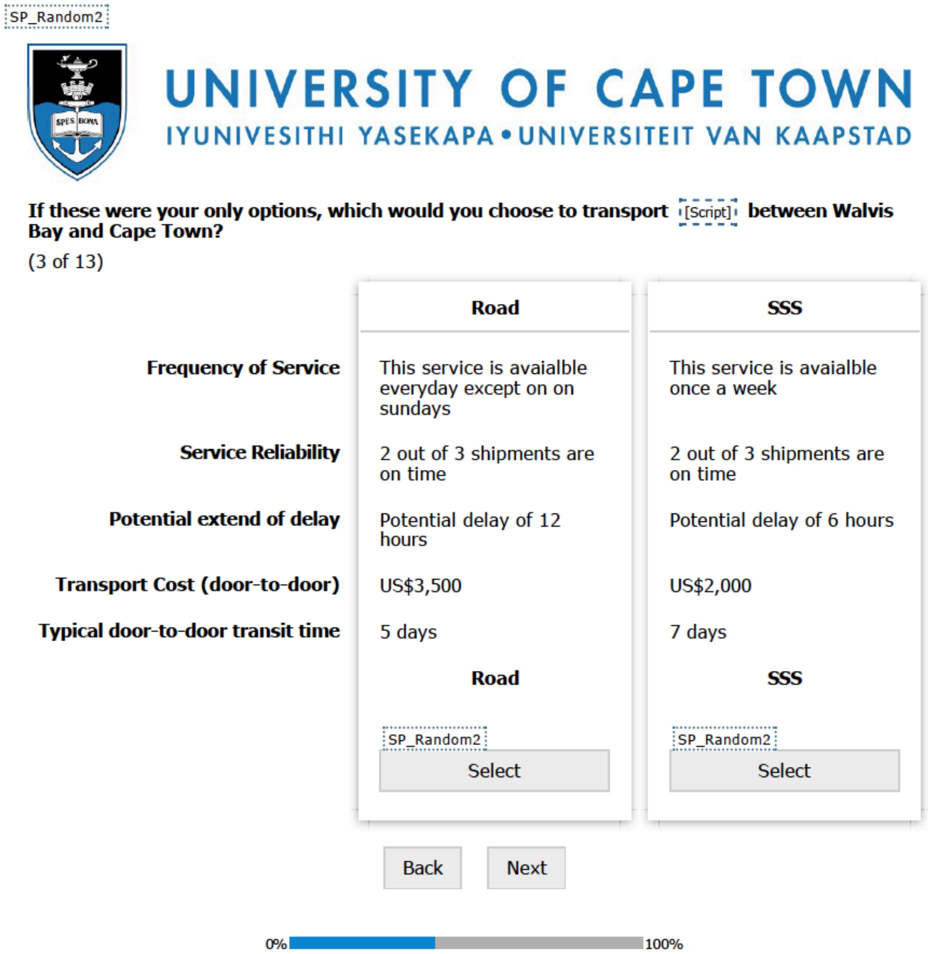
Attribute	Current	Road			SSS		
Cost ($)	4500	4000	450	500	3400	2700	2000
Time (days)	5	5	6	7	5	7 days	9
Reliability	1/3	0/3	1/3	-	1/3	2/3	3/3
Delay (hrs)	18	48	96	144	24	48	72
Freq days/wk	7	7	5	6	1/2	1	2

Table 5-5: Attributes and levels for Cape Town ~Windhoek

Attribute	Current	Road			SRD			SRL		
Cost ($)	3000	3000	3250	3500	2250	2650	3000	2200	2500	2800
Time (days)	3	3	4	5	7	8	9	8	10	12
Reliability (*x*/3)	2/3	0/3	1/3	2/3	1/3	2/3	3/3	1/3	2/3	3/3
Delay (hrs)	0	0	12	24	0	6	12	0	3	6
Freq days/wk	7	7	6	5	1	1	2	1	1	2

Table 5-6: Attributes and levels for Durban ~Harare

Attribute	Current	Road			Rail			SRD			SRL		
Cost ($)	3500	3500	4000	4500	3000	2000	1000	2700	3200	3700	2400	2700	3000
Time (days)	6	6	7	8	12	14	16	8	11	14	12	14	16
Reliability (*x*/3)	0/3	0/3	1/3	-	0/3	1/3	2/3	3/3	1/3	2/3	3/3	1/3	2/3
Delay (hrs)	24	24	48	72	0	48	96	0	24h	48	0h	48	96
Freq days/wk	7	7	6	5	1	3	5	1	1	2	1	1	2



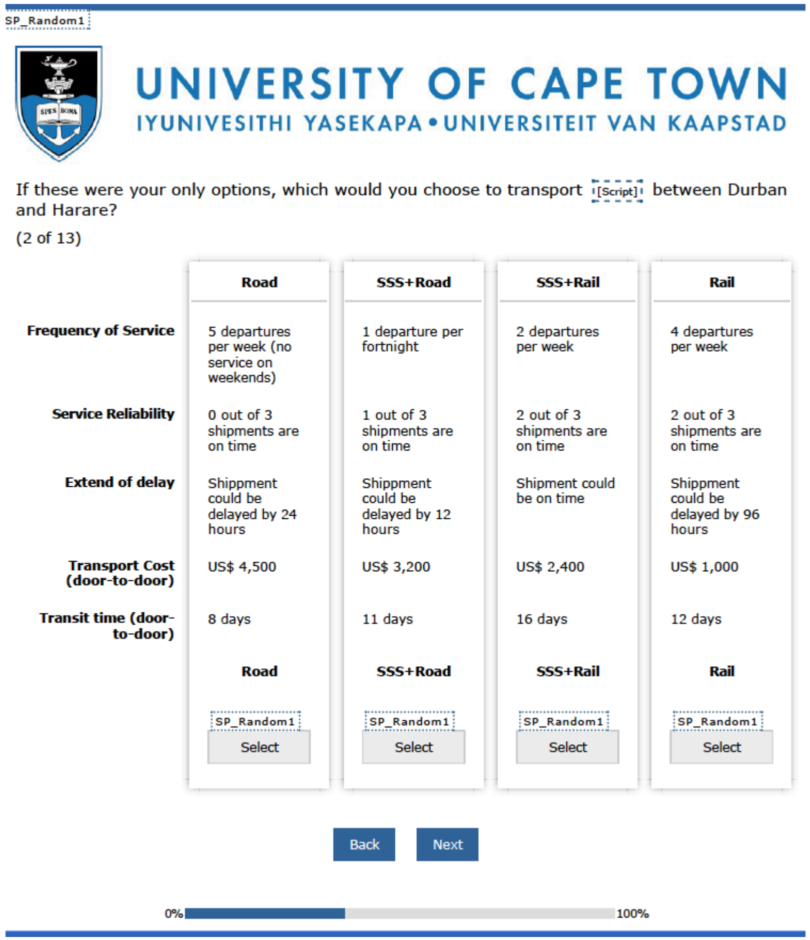


Figure 5-3: Examples of Choice game for the shipper study for the unimodal SSS study (left) and intermodal SSS study (right)

In line with Feo et al (2011a) covariates to capture the decision makers' characteristics, the shipment characteristics and the trip characteristics were also captured. Covariates allow the investigation of heterogeneity, and the latent factors allow the investigation of perceptions on mode choice. The covariates were a mix of dummy coded and continuous variables defined such that they were exhaustive, measurable with room for trade-offs. Table 5-7 provides a summary of the covariates which include: decision maker attributes, product characteristics, trip characteristics and latent variables.

Table 5-7: Covariate Attribute and Corresponding Variables

Attributes	Description	Levels description	Levels
Decision Maker Characteristics			
Corridor	The origin-destination pairing between which the shipper ships a fully laden TEU	• Cape Town~Walvis Bay • Walvis Bay ~ Luanda • Durban ~ Beira • Durban ~ Harare • Cape Town~Windhoek	1 3 4
Own transport	Shipper employs own transport	No - Yes	0 - 1
Lead time	Time allocated in days for shipment between ordering to delivery.	Continuous	-
Transport contract	Long-term transport contract in place	No - Yes	0 - 1
Shipping frequency	The number of shipments dispatched per week by shipper on this corridor	• Daily • At least once a week • At least once a month • At least once a year	1 2 3 4
Product Characteristics			
Product type	The type of product shipped.	Raw ~ Semi-finished ~ Finished	1-2-3
Perishability	Indicates whether product is perishable	No - Yes	0 - 1
Product Value	Value of full container (TEU) in USD	Continuous	-
Situational Variables			
Direction	The direction of shipment is from source city to destination?	Headway ~ Backway	1 - 0
Urgency of shipment	Is the shipment needed in a shorter time then what is usual the lead time?	• Urgent • Non-Urgent	1 0
Latent Variables (Qualitative Variables)			
Conditions of roads on corridor	Captures the perceived levels of road conditions on the corridor	• Very Poor • Poor • Average • Good • Very Good	1 2 3 4 5
Could use SSS to improve road safety	Likelihood of employing SSS to reduce road accidents as per CSR policy	• Strongly Agree • Agree • Not sure • Disagree • Strongly Disagree	1 2 3 4 5

5.3.2.5 Questionnaire Structure

The study setting considered mode choice to ship a fully laden TEU unit along the identified study corridors. To that end, competition between a hypothetical SSS and other freight transport alternatives was studied in a choice game. In order to do this effectively, five questionnaires were developed, each for every corridor. The questionnaire was divided into six parts as follow:

Part 1. General information, which captures descriptive information of the respondent. In particular whether it was a freight forwarder or a shipper, the size of the company and the industry.

Part 2. Transport Information, which captures their shipping activity on the corridor, such how often they ship on the corridor, the INCOTERM used, use of own transport and in particular to specify a primary product the respondent ships on this corridor. All subsequent questions would be based on this product.

Part 3. Product Information, which captures information on product specified in Part 2, such as lead time required, perishability and value per unit of shipment.

Part 4. Revealed Preference, to capture information about a previous trip conducted of the product specified in Part 2 and 3. Information was captured along the same attributes in the SP component such as transport cost, transit time, reliability, and in addition any damage or loss experienced was also captured.

Part 5. SP game, which contained 13 choice tasks, one of which was a fixed task incorporated for diagnostics purposes. Between two and four freight mode choice alternatives were employed: SSS, road, rail, a combination of road and SSS (SRD), and a combination of rail and SSS (SRL). Rail however is available only for the *Dur~Har* corridor and is considered unavailable for the *CT~WHK* corridor, given the big detour the rail track makes which renders it very unattractive on this corridor.

Part 6. Diagnostics questions, which assessed whether the SP tasks were understood, whether they were realistic, and to confirm which attributes were indeed considered.

Part 7. Attitudes and Perceptions, which captures the attitudes and perceptions towards freight transport modes in SADC.

Part 8. Conclusion: captures the comments and suggestions and survey ends. In particular comments were sought from respondents regarding how we can improve freight transport in SADC.

5.3.2.6 Data Collection

For the shipper study, a sampling frame similar to the one employed in the SADC freight study was created however specific to the study corridors; convenient sampling was employed to recruit respondents. This means, any shipper who ships or at one time shipped along this corridor, willing to participate in the survey was interviewed. The CAPI method entailed an interviewer administered personal interview, wherein the interviewer asks the question and immediately enters the responses on a computer. The CAPI interviews were conducted by five specially trained interviewers who had a working background in shipping and logistics. The interviews were conducted with aid of tablet computers which were programmed with the sawtooth offline interview software (lighthouse) and connected to a mainframe server (sawtooth software, 2017).[57] In Beira and Luanda, in addition to the required background in shipping and logistics, interviewers were also required to be fluent in Portuguese.

Data collection took place in Cape Town (CT), Windhoek (WHK), Walvis Bay (WB), Luanda (Lua), Ondangwa (Ond), Johannesburg (Jhb), Durban (Dur) and Beira (Bei) in the time period spanning between 1 November 2017 to 31 May 2018. Resultant from the experiment design, the target sample size was set to 50 shippers per corridor, ideally half of which was meant to be shippers and the other freight forwarders and 3PL. Additional effort was invested to have a diverse sample in terms of industry, business, company sizes and product types.

The interviews were conducted by appointment, with each interview lasting an average of 20~30 minutes. The interviewee was first emailed and then called by telephone to invite them for the interview. The initial correspondence also ascertained whether the conducted person was the decision maker in terms of freight mode choice and whether they transported cargo for the respective study corridor in question. The majority of telephonic calls were made from a centralized office at the Centre of Transport Studies in Cape Town and the successful appointments were passed onto the interviewers who were on the ground in the different locations. Most invitations were turned down, roughly only 1 in 100 emails and 1 in 20 calls yielded a response; however, once an appointment was confirmed a majority of the interviews were successful. The sample statistics are described in chapters 6 and 7 respectively.

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[57] See www.sawtoothsoftware.com

5.4 The Carrier Stated intentions study

The carrier preference study was not a stated choice study per se; but rather, it was a stated intention study. Stated intentions are often captured were respondents are asked to indicate the action they would take given certain scenarios which they haven't taken before (Sun and Morwitz, 2010). Despite the fact that intentions may change with time and so may not predict actual behavior, there are strong assumptions that intentions are good indicators of actual choice behavior (ibid).

5.4.1.1.1 The study setting

The choice setting in the carrier preference survey aimed to capture the intentions of carriers. Carriers are shipowners and ship operators who currently employ, represent, manage, operate or own ships that operate in SADC, whether they would participate in a hypothetical SSS system for SADC. As figure 5-4 shows, the envisioned SSS service, would offer a regular door-to-door service between the following port cities: Luanda, Walvis Bay, Cape Town, Port Elizabeth, Durban, Beira, Dares Salam with competitive levels of freight rates, freight volumes terminal handling charges, port dues and flag requirements.

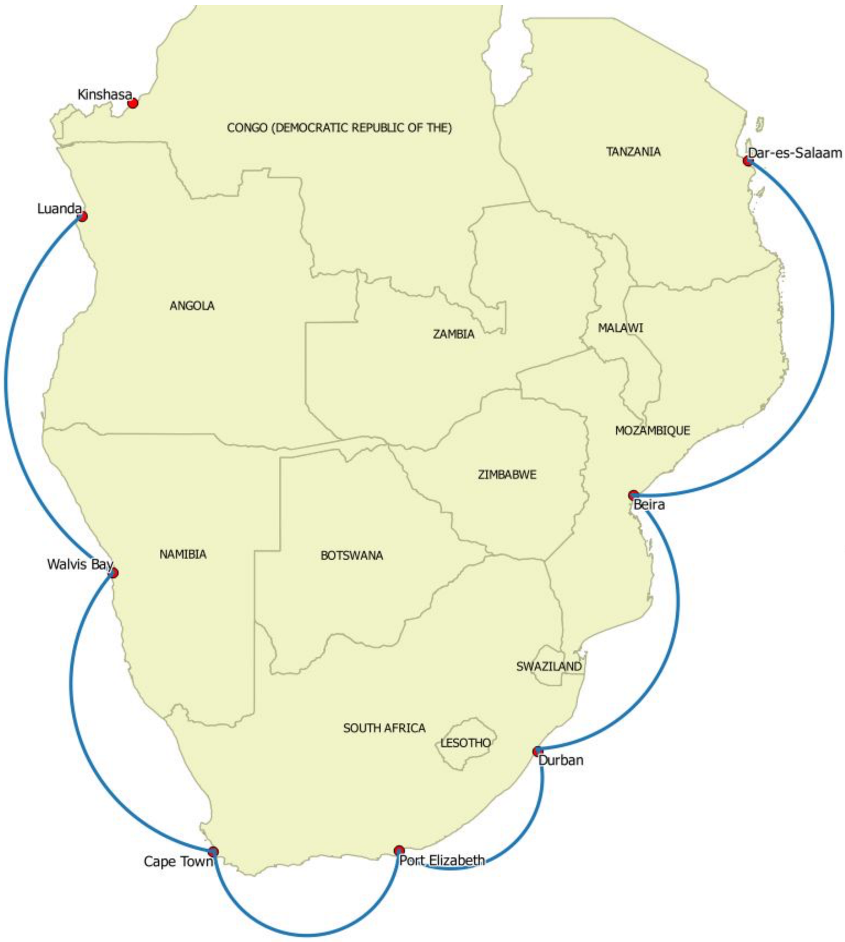

Figure 5-4: SSS operations network

The average distance between the selected ports of the proposed SSS network is 1400km, which is roundabout the threshold level at which SSS becomes competitive. The shortest distance was between Durban and Port Elizabeth and between Port Elizabeth, but their inclusion in the network was justified by the freight volumes on this route. In this SSS system, containerized (and general cargo) shipments would be transported by sea for the longer legs of the journey, and by road or rail for the remainder of the journey. The carrier for the entire transport chain) would be single entity, which is also responsible for all costs pertaining to the transportation of the container (except customs and import duties which the shipper bears).

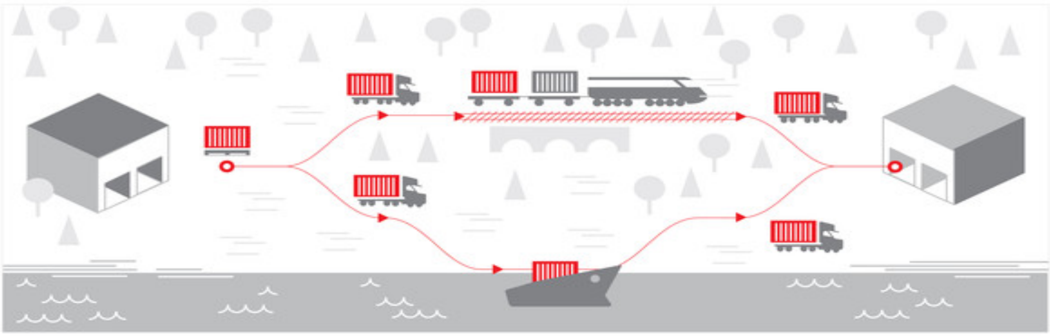

Figure 5-5: SSS as part of the freight transport supply chain

Participation in the proposed SSS system would be voluntary, however carriers who are willing to participate could be offered discounts and numerous incentives by governments in SADC. For instance, carriers could be offered discount on port dues and terminal handling fees, and they might also be offered a quota of TEUs to ensure they have a minimum quota to operate their vessels.

5.4.1.1.2 The choice task

To mimic the envisioned SSS system, carriers were asked to choose the extent to which they will participate in the specified SSS system, given varying levels of transport charge, cargo volumes, port dues discount, terminal handling charge discount and flag requirements. Table 5-8 offers an example of one of twelve choice tasks employed in the study.

Table 5-8: Sample Choice scenario

Attribute	Value		
Transport Charge (door-door):	US$ 2,000		
Dedicated Container Volumes per week:	200 TEU units		
Port Dues discounted by:	15 %		
Terminal Handling Charge discounted by:	15 %		
Flag requirement:	Ship must register in SADC		
Would you operate your vessel?	No	Unsure	Yes

In addition to the above, the study setting furthermore recognized a permanent setting, which was explained to the respondent before the choice game to reduce ambiguity and to focus on key issues which the study intended to study, as follow:

- Frequency of service was set to 1 weekly departure and arrival per port in the network.
- Ships in SSS would dock on arrival at a dedicated SSS port terminal.
- The ship specification for SSS is a container ship with capacity of 400 TEUS, with a maximum loaded draft of 5m, propelled by controllable pitch propeller with bow and stern thrusters to allow self-docking.

5.4.1.1.3 Focus group discussion: Carrier studies

One focus group discussion was held before the design of the surveys in the Cape Town Industrial area. Subsequently, two focus group discussions were held after the first version of the survey was developed. The focus group discussions helped extensively in refinement of the SCE and the survey instrument.

The focus group discussion was held with local three maritime experts from shipping lines and port authorities. The meeting helped to design the survey, set attributes and the attribute levels. Particularly the base levels for the attributes were refined during these focus group discussions. A local coastal shipping company Ocean Africa Lines and the Namibia Ports Authority further assisted set the attribute ranges, as they availed their current service levels and also advised by how much these levels could be adjusted if SSS became a political initiative.

The questionnaires were tested for ease of understanding, and the length of time it took to complete. The focus group discussions were also meant to ascertain the best approach for ordering and structuring the questionnaire. The initial twelve choice tasks appeared to work well with the respondents; and in addition, diagnostics questions were added to assess the extent to which respondents understood and found the SP game realistic.

Subsequently, the attribute levels for the choice attributes were chosen in line with suggestions by maritime experts during the focus group discussions. There was particular input from maritime carriers and port authorities in the region. The flag requirement attribute was the only attribute developed from literature. Together these attributes, should allow the carrier to get some profit while encouraging the growth of a seamless SSS system in SADC. Table 5-8 presents the attributes and attribute levels for the study.

Table 5-9:Attributes and levels for Carrier study

Attribute	**Description**	**Attribute levels***
Choice attributes used in experiment design		
Transport charge	Income per TEU in USD for door to door transport between 2 adjacent port locations	$1500 - $2000 - $ 2500
Freight volumes	Dedicated freight volumes in TEU numbers given to carrier per week	50-150-200-250 TEU's
Terminal handling discount	Percentage discounted from terminal handling charge	0% - 15% - 30% - 45%
Port dues discount	Percentage discounted from port dues	0% - 15% - 30% - 45%
Flag requirements	Ship registration restriction. Carriers are allowed only the presented	• Flag of convenience (FOC) • Any closed registry
Carrier characteristics		
Decision maker ID	Respondent is either owner or charterer	• Owner (*base*) • Charterer/Operator
Sea service	Sea service currently engaged in in: Deep sea (DS), Coastal shipping (CS)	• CS (*base*) • DS • DS-CS
Shipping sector	The shipping sector currently involved in.	• Container shipping • General cargo • Offshore • Dry Bulk • Wet Bulk • Ro-ro
Flag	Type of register with which fleet is registered.	• Any register in SADC • FOC • Closed register • Wet Bulk
Nationality	Country of origin for mother company.	Direct input of company nationality
Carrier characteristics		
Decision maker ID	Respondent is either owner or charterer	• Owner (*base*) • Charterer/Operator
Sea service	Sea service currently engaged in in: Deep sea (DS), Coastal shipping (CS)	• CS (*base*) • DS • DS-CS

Notes Attributes are represented by a mix of continuous and dummy variables in SCE*

5.4.1.2 Questionnaire structure

Unlike the shipper survey which started with personal information and introduced the choice scenarios vary much later in the survey, the carrier survey started the survey with primer questions and then proceeded straight into the choice questions. The reason for doing this was to avoid interview disinterest in the survey, particularly seeing maritime carriers are known to be conservative, secretive and very politically sensitive. The questionnaire structure for the carrier study was divided into four parts as follow:

Part 1. Priming questions, to capture the respondents' perceptions on the factors that encourages and discourages the development of maritime transport in SADC, and to capture their opinions maritime transport conditions in SADC.

Part 2. SP game, which contained twelve choice tasks.

Part 3. Diagnostics questions, which assessed whether the SP tasks were understood, whether they were realistic, and to confirm which attributes were indeed considered.

Part 4. Personal Information such as fleet size, nationality.

5.4.1.3 Data Collection

For the carrier study, PAPI interviews were employed for data collection. PAPI interviewing involves the respondent completing the survey on a printed questionnaire, and then submitted it to the interviewer, who later manually logs the data to a computer. Three interviewers were recruited for data collection. Seeing this was an industry specific survey, only candidates with experience as naval shipping officers were employed. They were then trained so not to let their behavior influence the sample respondent (Punch, 2014). This training occurred ahead of the main survey which took place between November 2017 - May 2018. Additionally, given the language barrier that exist across different countries in SADC, the interviewers had to be conversant in Swahili, English or Portuguese, in some parts of the region.

Data collection occurred in Durban, Cape Town, Walvis Bay, Luanda, Matadi, Dar es Salam and Zanzibar; yielding 30 complete responses. These cities, with the exception of Windhoek, are areas known to be major shipping hubs for maritime operations in SADC. Due to the extreme difficulty of getting an audience with the respondents, convenient sampling was employed during data collection. There is anyway a very small population of ship owners and operators in SADC and thus convenience sampling was helpful to gather data that would not have been possible using probability sampling.

5.5 Survey Considerations

5.5.1 Survey Methods

For the SADC freight study, the online method was employed, for the shipper behavior study, CAPI was employed, and for the carrier study, PAPI was employed. Despite being suitable for stated preference surveys, CAPI and PAPI tend to be costly (Louviere et al., 2000). The CAPI method is particularly suitable for freight mode choice because of the ability to incorporate multi-media effects to the choice setting. CAPI, particularly, is attractive because it may be combined with Computer Assisted Self Interview (CASI) wherein some sections of the survey are completed by the respondent themselves, especially the selection of SP scenarios. However our experienced showed that some respondents like carriers want to see the survey in paper beforehand, and for this PAPI was most ideal.

5.5.2 Avoiding survey Bias and Ambiguity

An important consideration when programming the questionnaire, is care must be had to avoid any biases (Kjaer et al, 2006). In this study instance, to avoid random order bias, the choice tasks and the order of attributes in the shipper study were randomized to vary per respondent. This was not possible in the carrier study because it was a PAPI study. Furthermore, to capture any biases in the survey, diagnostic questions were incorporated in both studies. The SP game in the shipper study was furthermore presented in an interactive platform, which allowed the alternatives and the attribute values to vary to alternate literary and vertically. The unit of analysis for the SP parts was also limited to containerized cargo, specific to a certain product. This avoided any potential misunderstandings and insinuations in the choice tasks.

According to Hensher et al., (2015, p.200) the researcher must also take good care to ensure that attributes are defined appropriately and are not in any way ambiguous. Particularly, the labels assigned to the attributes should be appropriate to the setting and the questionnaire should be clearly presented and should contain a standard introduction to the SC setting. (Hess & Rose, 2010). This was particularly verified during the pilot studies for both studies, were respondents were first asked to indicate their understanding of the wording and then how they understood the question. It was also resolved that interviewers were to use the same precise wording for all interviews. Finally, three diagnostic questions were included in both the shipper and carrier study that captured the extent to which they thought the choice tasks were understandable and realistic, and to indicate the attributes they considered. The descriptive statistics to these questions are respectively discussed in Annex VI.

5.5.3 Truth and Consequentiality

To increase the probability that respondents reflect their true preference during the SP part, the opening statement of the choice scenarios was phrased such to incorporate the theory of 'truth in consequentiality'. This theory suggests that truthful preference revelation is possible, provided that participants view their decisions as having chance of influencing policy (Vossler et al., 2012). Respondents were thus reminded that their choices could actually influence transport policies, and so they were asked to make their choices in earnest.

5.5.4 Ethics Clearance

For this entire study, ethics clearance was applied for and obtained on the 17th of May 2017 from the University of Cape Town Ethics in Research Committee (EiRC) before any data collection was conducted. Ethics is the study of what are good, right or virtuous courses of action in research (Punch, 2016). According to the University of Cape Town, ethics in research guidelines:

> "*All research conducted in or under the auspices of the EBE Faculty that proposes to involve the collection of data from human participants must be submitted for review by the EiRC, a sub-committee of the Faculty Board. No research may begin unless clearance has been granted by the EiRC*" (Ethics in Research Committee, 2012).

Furthermore, the EBE ethics in research guideline provides that, research involving human subjects is required to guarantee confidentiality and respect of privacy and dignity. Questions asked should furthermore not be intrusive, damaging or compromising; and participants must be informed of the nature of information that will elicited. Any data collected should be protected from the use beyond the research for which it was intended. Lastly, only adults (18 years +) may participate in the research.

5.6 Conclusion

This chapter provided an overview of the study development process from conception to data collection. It detailed the stated preference components which includes alternative identification to experiment design. Subsequently, it discussed the survey methods and considerations in their use. It also details how the data was collected. The implication of this discussion to the study is that a platform is now created for subsequent chapters that discusses how the data collected was analysed. Additional material is also provided in the Annexures to supplement this Chapter.

“The line between disorder and order lies in logistics”

~ Sun Tsu, (Art of War, 500 BC)

6 AN INVESTIGATION INTO THE FACTORS INFLUENCING FREIGHT MODE CHOICE IN SADC *

The aim of this chapter is to describe the freight transport landscape of the SADC region. It reports the results of a study conducted online with freight interests from around SADC. The chapter proceeds as follow: first, a background to the study is provided, followed by a description of the sample statistics, followed by two sections wherein factors that influence freight mode choice are assessed.

6.1 Sample Description

6.1.1 Background

As indicated in Chapter 5 (section 5.2), the SADC freight transport study was developed to serve as a priori to the general discussion of developing SSS within an integrated logistics space in SADC. This was done by sourcing knowledge required to design the study on SSS development in the SADC region. Despite the SADC freight survey having a number of questions on freight transport; in this chapter, we specifically address the questions: “who is the decision maker in terms of freight mode choice in SADC?”; and, “Which modal attributes are important to the SADC shipper?” The intention in doing so is to describe: how freight interests (shippers, freight forwarders and agents) in SADC procure freight and the factors they consider when they make these decisions. The reader is further referred to Annex 2, were some other questions of the SADC freight survey are addressed.

The online SADC freight transport survey was conducted in SADC between May 2017 - November 2017 (See Chapter 5, i.e. the SADC freight survey). A sample frame of 2987 addresses consisting of freight forwarders, shippers, freight agents and 3PL from all SADC member states was compiled. From this, calls and email invitations were sent out for the survey. Qualified respondents yielded 86 complete surveys representing a large spectrum of company sizes, industry, product type, and shipper types from a number of SADC nationalities.[58] See further Chapter 5, section 5.2 for details.

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* *Parts of this Chapter were presented by the author at the 2018 VREF Urban freight conference in Gothenburg on 20 October 2018. The presentation won the VREF award for best poster presentation.*

[58] The low response rate was not surprising because it is a shortcoming inherent to many freight studies. The high response rates from Namibia, South Africa, Zimbabwe and Angola is primarily due to aid by NAMPORT, the Namibia Logistics Association (NLA), Walvis Corridor Group (WBC), PORTNET in South Africa and SFAAZ in Zimbabwe who assisted with promulgation of the email with the survey request to their members. Respondents in DRC and Mozambique indicated a language barrier and hence participation was low from

6.1.2 Sample Statistics

The sample data set was composed of a wide range of respondents. As figure 6-1 shows, cargo principles made up 37%, freight forwarders 30% and Agents/3PL (presented as 'other' in the questionnaire) made up 33% of the respondent pool. In terms of respondent position, respondents weighted heavily on the managerial level at 55% followed by the director level at 22%, while juniors and supervisors formed 10% and 8% respectively. Figure 6-2 shows that company sizes ranged from under 19 employees to over 500, with half (50%) of the responses coming from small companies with 1~19 employees. Figure 6-3 shows that industry serviced encompassed a range of industries within which respondents operate,[59] and with regard to nationality, figure 6-4 shows most respondents came from Namibia (37%), followed by South Africa (28%), and Angola 7%.

Due to the time-intensive nature of collecting the data as well as the monetary expenses involved in contacting the respondents, it was not feasible to collect data from all countries. That said however, the sample obtained was generally representative of the larger population as it captured the major industries and decision-makers in proportion.

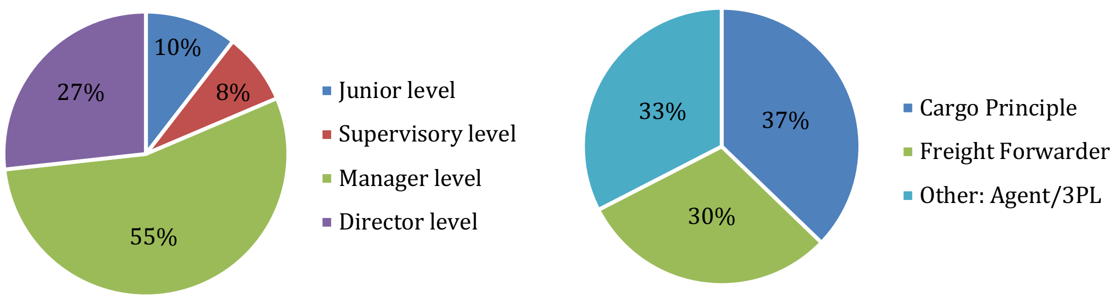

Figure 6-1: Survey responses by position to the left and by decision-maker type to the right

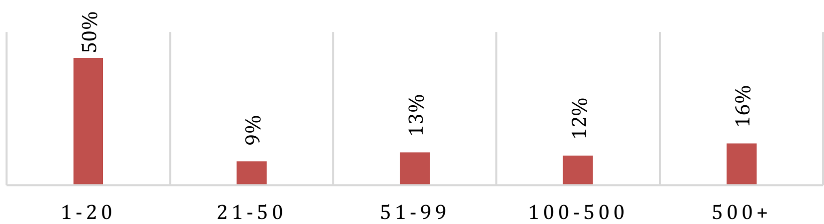

Figure 6-2: Company sizes in terms of employee numbers

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these countries. We received requests from Angola and DRC to present the survey in French and Portuguese, however due to limited time and resources, this was not possible.

[59] The businesses types were cited from South Africa Bureau of Standards (SABS) classification, however for ease of presentation, the industries are clustered together. Only represented business types were presented in the survey statistics.

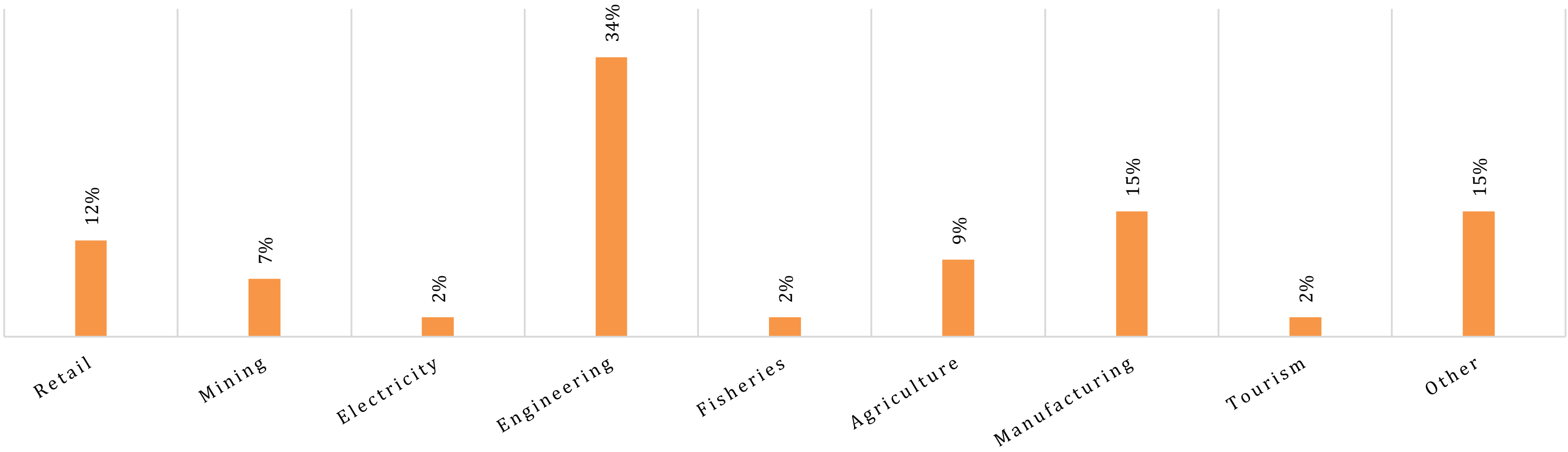

Figure 6-3: Responses by industry serviced

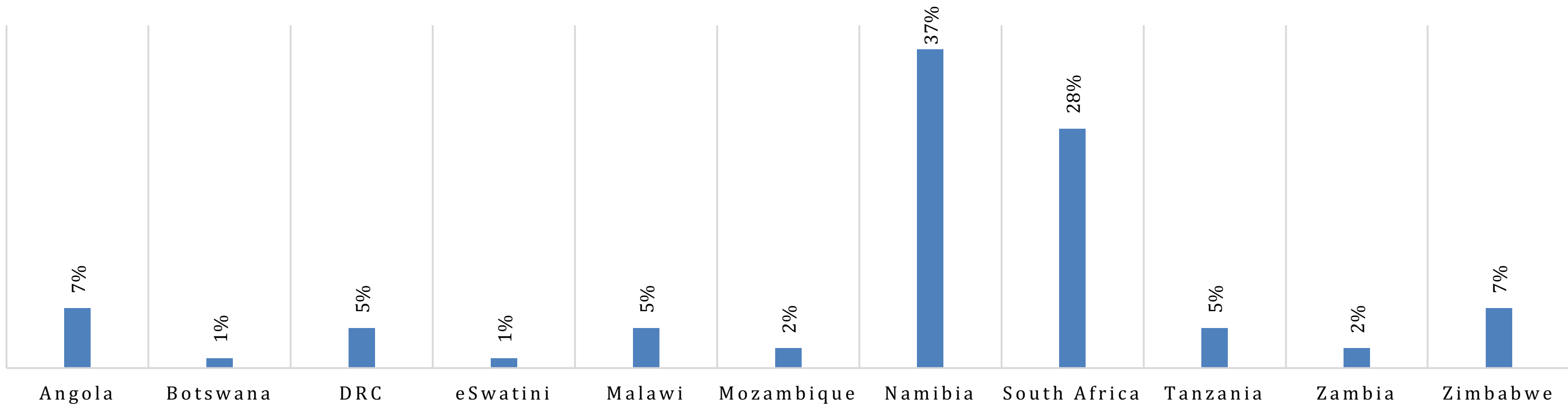

Figure 6-4: Responses by SADC Nationality

6.2 Who is the decision-maker in SADC?

A contentious issue when modeling freight demand is that regarding who the decision maker is (Feo-Valero, 2011). To date, literature continue to deliberate whom the actual decision maker is. For instance, De Jong (2000) in his review of time valuation in freight transport submits that shippers are the decision makers while freight forwarders are mostly responsible for route selection. Contrarily, Bergandino and Bolis (2004), submits that more than half of mode choice decisions are made by freight forwarders, and by implication therefore the freight forwarder is the decision-maker. Accordingly, most freight studies have composed samples depending on who the research team believes really makes the mode choice decisions.

Therefore, as a build up to the anticipated discrete choice experiments in the study, the survey included a question to determine who the decision maker in SADC is. In the survey, respondents were asked, "who is the decision maker in terms of freight mode choice?" The survey distinguished between 4 options: the manager in charge of logistics, top management jointly, the freight forwarder[60] and others (which included agents, 3PL & 4PL). The first and second options (logistics manager and top management) represent the shipper, and the other two (freight forwarder and other) represented decisions made on behalf of shippers. Respondents were furthermore given the option to elaborate further in a follow up open question as to how mode choice decisions are made in their business. Figure 6-5 shows a summary of the results.

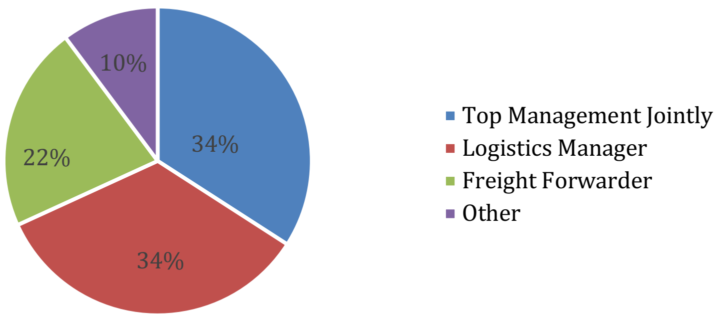

Figure 6-5: Decision-maker in the sample

[60] The freight forwarder is an intermediary between a shipper and various transportation services. 3PL is where the shipper outsources its logistical operations to specialist firms (3rd party logistics), and 4PL is were another specialist firm (4th party) is hired to coordinate the activities of the 3rd parties.

The results show that cargo principles in the sample have a strong tendency for internal decision making. Most respondents (68%) indicated that mode choice decisions in their business are taken either by the manager in charge of logistics (34%) or by top management jointly (34%). Most respondents furthermore commented that freight forwarders are typically used as advisors and are usually given the power to make mode choice decisions on a selective basis, for instance when the cargo is urgent or when there is an allocated budget limit.

To draw conclusive inference in terms of who the decision maker is, the decision-maker variable was modified as follow: the attribute levels *manager in charge of logistics* and *top management jointly* were clustered together representing the shipper; freight forwarder remained as is, and 'Other' was changed to Third Party Logistics (3PL) or Agent. The difference between freight forwarding and 3PL is that freight forwarders act as intermediaries between shippers and carriers, whereas 3PL is the outsourcing of some of the supply chain and logistics functions (Marasco, 2008). Freight forwarders typically have good relations and typically negotiate the best rates for their clients (i.e. the shippers). The use of 3PL allow businesses to focus on their core business, and it's a practice that is becoming more common as the logistics industry continue to become more complex (Gupta et al., 2011).

The reason for changing 'Other' to 3PL/Agent is because from the survey, it emerged that some respondents outsource some of their logistics functions to 3rd and 4th party logistics. Figure 6-6 shows the modified pie-chart of the responses.

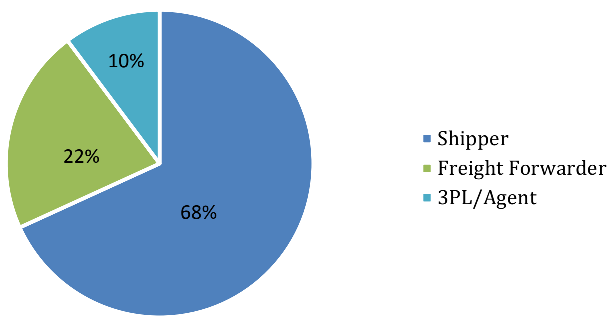

Figure 6-6: Decision-maker in the sample (simplified)

Given the complex nature of transport decisions, and the presence of heterogeneity in choice decisions, the decision maker variable was further cross tabulated with company size, business industry and respondent nationality to see how different segments make mode choice decisions. It was also necessary to test whether these distributions occurred by chance or by design. The Chi-Square (χ^2) statistic was employed to test the hypothesis that the distribution of observation frequencies (i.e. for shipper, freight forwarder and 3PL) across the different segments are the same. The χ^2 statistic is given by:

$$\chi^2 = \sum \frac{(\text{Observed} - \text{Expected})^2}{\text{Expected}} \tag{29}$$

Where 'observed' is the observed frequencies of the different decision-maker options, and where 'expected' is an equal distribution of the different decision-maker options.

In all instances, the null hypothesis (H_o) is that the observed frequencies of decision-maker across segments are the same as the expected frequencies. If the observed and expected frequencies are the same, we expect χ^2 to be 0. If however the frequencies observed are significantly different from expected frequencies, we expected the value of χ^2 to go up. The larger the value of χ^2, the more likely it is that the distributions are significantly different. Fittingly, the decision to reject or fail to reject H_o is based on the p-value at the 95% significance level, thus if the p-value is less then or equal to 0.05, H_o is rejected, otherwise if the p-value is greater then 0.05, H_o is not rejected. The results for different decision maker characteristics are shown in figures 6-7, 6-8, and 6-9.

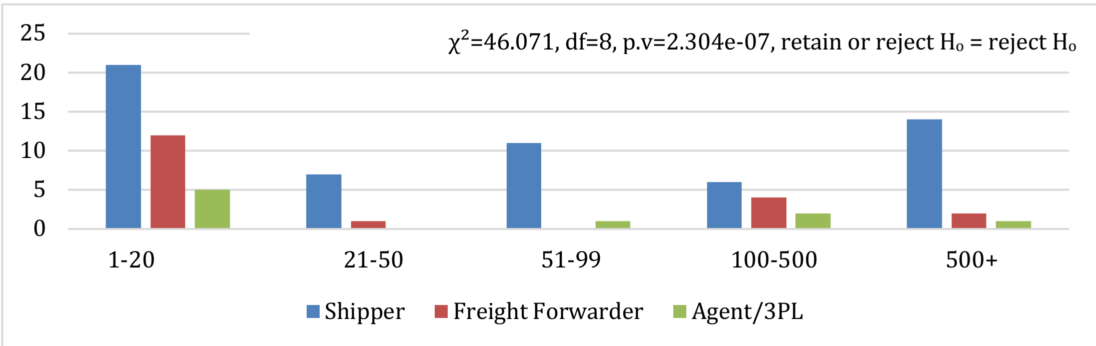

Figure 6-7: Decision-maker by company size

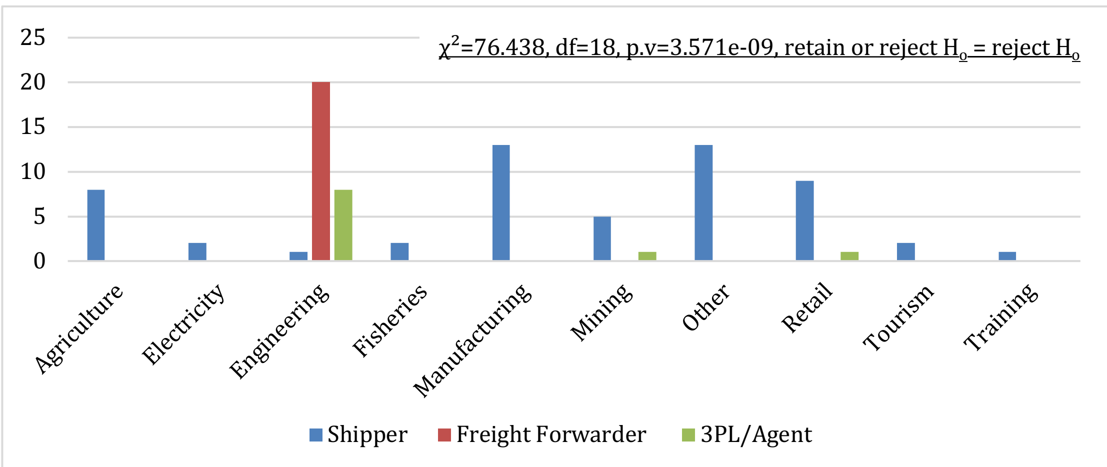

Figure 6-8: Decision-maker by business industry

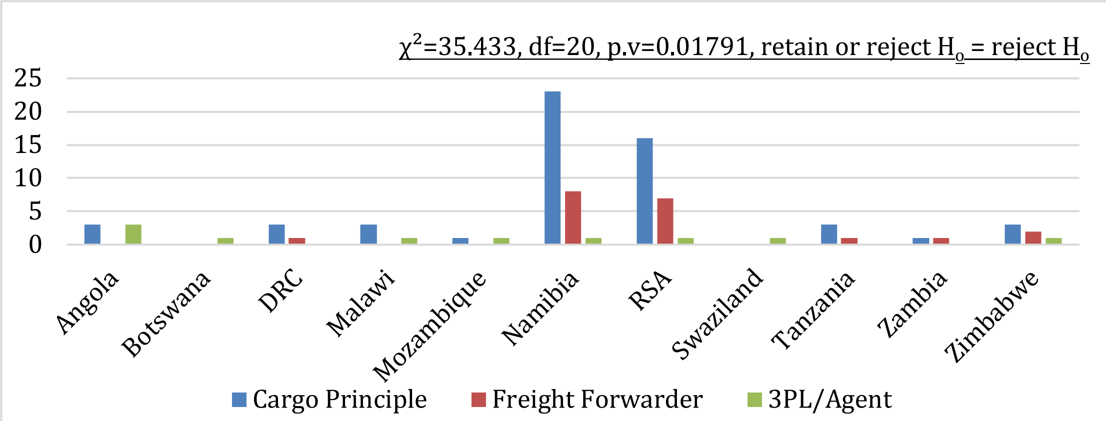

Figure 6-9: Decision-maker by SADC nationality

Figure 6-7 shows the results partitioned according to company size. The company size variable was a categorical variable grouped into 5 levels, and accordingly shows how companies of different size categories makes mode choice decisions. The results show that it is the shipper ('cargo') who mostly makes the freight mode choice decision. This was confirmed by an χ^2 statistic of 46.071 with a p-value less than 0.05 in figure 6-7, indicating that the distribution of who the decision-maker across the different segments are significantly different.

Across nationalities, the results also show the shipper as the dominant decision-maker, followed by the freight forwarder and then a small proportion of respondents indicating 3PL or agents as decision-maker. With an χ^2 statistic of 35.433 and an associate p-value of less than 0.05, the results indicate that the distribution of who the decision-maker is across the different SADC countries are significantly different, confirming indeed that the distribution of who the decision-maker is did not happen by chance but rather, the shipper is the general decision-maker in terms of mode choice.

Notwithstanding the above outcomes however, the overall number (22%) of respondents who indicated the freight forwarder as the decision-maker is still a substantial number. Woxenius et al 2004, confirms that freight forwarders should be consulted to set the requirements on freight transport because they control large freight flows, they act as proxies for multiple shippers, and they have structured consolidated networks with strict time requirements, which makes them, as in our case, extremely knowledgeable on freight flows in SADC. Furthermore, freight forwarders are market oriented, unlike shippers who appear to be production oriented on issues of freight transport (Woxenius et al., 2004). This therefore makes the freight forwarder an important element to incorporate in freight demand studies.

6.3 Attributes affecting freight mode choice in SADC

6.3.1 Sample statistics

To reiterate the context, the attribute ranking question was a drag and drop ranking question whereby respondents were asked to rank the attributes from first to least; first being important and ninth being least important. The following attributes were presented: frequency of service, transport cost, transit time, reliability in terms of arriving on time, customer service, ability to track and monitor, risk of loss and damage, environmental friendliness and flexibility of mode .[61] To reduce bias and satisficing, the attributes were randomized to vary across respondents.

These attributes were determined from literature and were further refined in the pilot survey and focus group discussions (see Chapter 2, section 2.3, Chapter 3, Section 3.4.2.2, and Chapter 5, section 5.2). The descriptions attributed to the modal attributes are provided in Annex II and Figure 6-10 presents the sample statistics.

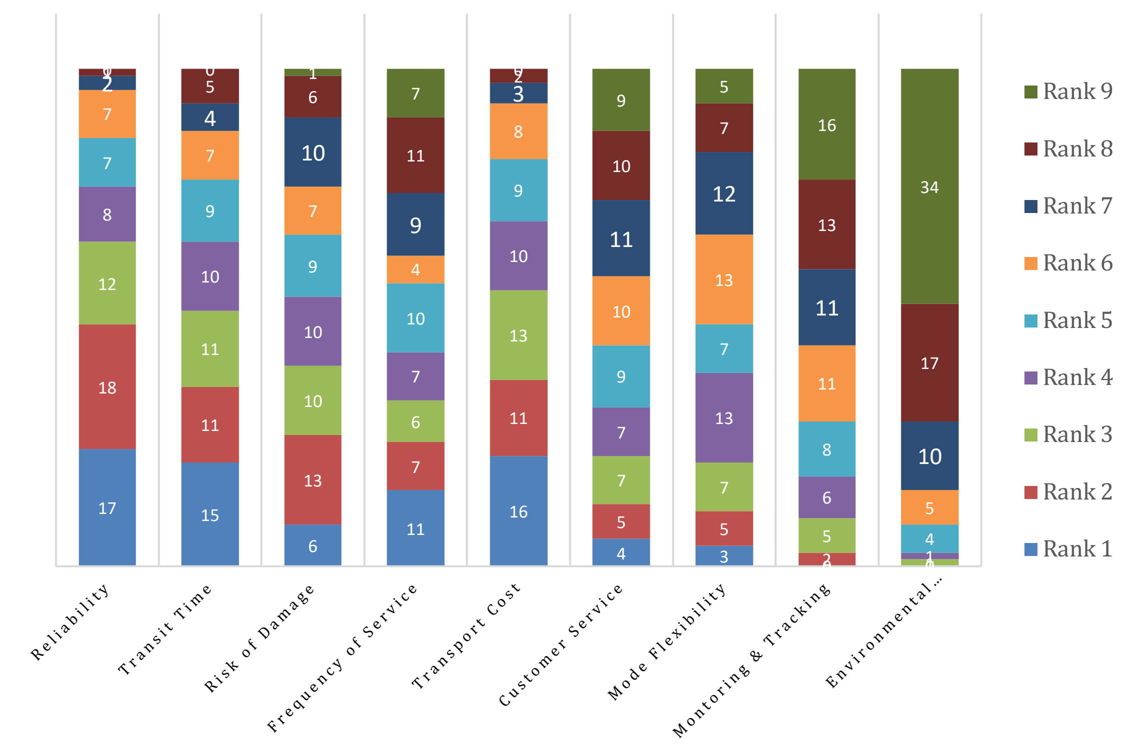

Figure 6-10: Summary of rankings for modal attributes

Within the grids in Figure 6-10: , the number of times an attribute was ranked at a certain rank is shown. In summary, reliability was accorded 17 times to Rank 1, transport cost 16 times and transit time 15 times, and least of all, environmental friendliness was accorded

[61] The attributes were determined from literature and from focus group discussions.

0 times to Rank 1. It is interesting to note that environmental friendliness was ranked 9th a record number 34 times, meaning it is was overall considered as least important.

6.3.2 Developing the Exploded Logit model

In order to estimate the EL model, the database of the full ranking of mode choice attributes was arranged in such a way to present both the aggregate rankings of attributes per rank number, and per individual ranking per attribute for every observation (see Figure 6-1). This modification made it possible to observe when an attribute was ranked at a certain position, and thus allowed to determine the extent to which a certain rank score was contributed by a certain attribute. In the EL model, the distance between ranks was captured by the scale parameter, and the aggregate ranking for the respective attribute was captured by the parameter coefficients of the attributes with the ranked attributes now termed as 'alternatives' in the choice context.

Table 6-1:Data table showing ranking of reliability for respondents 1-4

1st	2nd	3rd	4th	5th	6th	7th	8th	9th	rel1	rel2	rel3	rel4	rel5	rel6	rel7	rel8	rel9
1	4	2	3	5	6	7	8	9	1	0	0	0	0	0	0	0	0
6	7	2	1	5	9	8	4	3	0	0	0	1	0	0	0	0	0
5	1	8	4	6	2	3	7	9	0	1	0	0	0	0	0	0	0
1	6	5	3	2	8	7	4	9	1	0	0	0	0	0	0	0	0

From the data presentation, it can be seen why the model is denoted "exploded logit". It is because the ranking probability is written as a product of first choice probabilities for successive remaining alternatives (Skondral and Rabe-Hesketh, 2003). The rankings can be assumed to be obtained successively such that the best choice is selected first, then the second best among the remaining choices, etc. At the k-th successive selection step the contribution to (1) takes the form of a multinomial probability with sample size one and number of categories determined by the remaining choices.

The likelihood sequence of observing a certain rank observation are obtained by calculating the probability of observing a certain ranking order. Therefore, with J different alternatives for individual n in choice situation s, we observe the ranking $R_{ns} = \{R_{ns,1}, \dots ,R_{ns,J}\}$ where $R_{ns,1}$ is the index for the alternative which is ranked the highest. The probability of observing a certain rank is then:

$$P(R_n|A_n) = \prod_{k=1}^{A_n-1} \frac{\exp\,(V_n^{r_j^k})}{\exp(V_n^{r_n^s})} \qquad (30)$$

where r_j^k is the alternative given rank k.

With the above formulation, the utility for the for alternative j in choice situation s for individual n is given by:

$$V_{nsj} = \beta_{cost}(cost_{nsj}) + \beta_{time}(time_{nsj}) + \beta_{freq}(frequency_{nsj}) + \beta_{rel}(reliability_{nsj}) + \beta_{customer\_service}(customer\_service_{nsj}) + \beta_{env\_friendliness}(env\_friendliness_{nsj}) + \beta_{flexibility}(flexibility_{jns}) + \beta_{monitoring}(monitoring_{nsj}) + \varepsilon_{nsj} \quad (31)$$

Where $\beta_{rel}(reliability_{nsj})$ is the reference alternative in the utility function.

The development and estimation of the EL model was subsequently done in R (R Core Team, 2013), using the Apollo package (Hess and Palma, 2019). The results of the exploded logit modeling exercise are presented in Table 6-2.

Table 6-2: Ranking of attributes: Results of the EL model

Attribute	*coeff.*	*r.s.e*	*r.t.r*
$\beta_{Reliability}$	0	NA	NA
$\beta_{transit\_time}$	-0.8759	0.7928	-1.1*
β_{damage_risk}	-0.6127	0.6909	-0.89*
$\beta_{service\_frequency}$	-0.6202	0.5114	-1.21*
$\beta_{transport\_cost}$	-0.557	0.5422	-1.03*
$\beta_{customer\_service}$	-1.1174	0.6761	-1.65
$\beta_{flexibility}$	-1.5745	0.8029	-1.96
$\beta_{monitor}$	-2.4492	1.1224	-2.18
$\beta_{env\_friendly}$	-3.9027	1.7001	-2.3
Scale_2	0.4106	0.3442	1.19*
Scale_3	0.5418	0.407	1.33*
Scale_4	0.7017	0.336	2.09
Scale_5	1.0246	0.469	2.18
Scale_6	0.734	0.3746	1.96
Scale_7	0.9798	0.4143	2.36
Scale_8	1.035	0.5004	2.07
Model statistics			
LL(start)	-1100.957		
LL(final)	-949.0692		
Rho-square (0)	0.138		
Adj.Rho-square (0)	0.1243		
AIC	1928.14		
BIC	1964.95		

Notes: coeff = coefficient, rob.s.e = robust standard error, rob.t-r = robust t-ratio, *insignificant

According to the results, the aggregate ranking of modal attributes in *the* sample is in the following order of importance: reliability, transport cost, risk of damage, frequency of service, transit time, customer service, service flexibility, monitoring and environmental friendliness. The parameter estimates for transit_time, damage_risk, service_frequency and transport_cost were however statistically insignificant, prompting us to consider the parameter estimates with care. The statistically insignificant attributes could not be omitted as doing so would provide a partial ranking of attributes. Furthermore, related to the above, the coefficients for scale_2 and scale_3 were also insignificant, a sign that there was strong competition between alternatives for rank 2 and rank 3.

There was no bas*e* to compare the model goodness of fit, so the first avenue was to compare the loglikelihood improvement between the start loglikelihood and the final loglikelihood. The overall model significance can be assessed by log likelihood function. The model yielded a final loglikelihood of -949.07 from a start loglikelihood of -1100.96 indicating a good job done by the model.

The ranking of reliability as most important and environmental friendliness as least important is consistent with a number of freight studies performed around the world including India (Mitchell, 2005); Europe (Zachcial, 2001) and New Zealand (Rockport Corporate Finance et al., 2009). This is substantiated in SADC by Ragoobur, (2008) who report that unreliability and inefficiency in transport networks form a major obstacle to doing business within SADC. Unreliability causes delays in the logistics supply chain, and these delays in turn lead to additional costs in the form of excess holding costs, additional labour costs, losses due to stock-out, and the risk of losing customers. It is further important to note that reliability is closely related to resilience, which in transportation, is the ability for a transport system to withstand negative incidence and still remain operational to a certain level (Taylor and D'Este 2003). The implication of this is that the impact of strategies to improve the levels of reliability are most severe on transport systems that must develop capabilities to respond effectively to the challenges such as rail and SSS. Subsequently reliability remains a competitive edge for road transport in many parts of the world.

Similarly, the ranking of environmental friendliness as least important shows that the pressure of environmental value is not yet great enough to affect the decisions of shippers. Therefore, when it comes to the question of interventions to reduce environmental impact, it is argued in line with European, Australian and American literature on freight mode choice that environmental impact is likely to be effective if presented as an incentive cost to shippers or as a tax under such as carbon pricing (Garcıa-Menendez et al., 2004; Bendall and Brooks, 2011; Puckett et al., 2011), seeing the transport cost attribute was highly ranked.

Furthermore, notwithstanding the results above, it is important to note that some modal attributes are random variables, which are subject to variability. For instance, note that transit time and transport costs both received ranks 1 and 2 a couple of times. It is also clear from the standard errors that difference in modal attribute preference exist in SADC. Globalization and technology advancement are fueling most of these changes; leading towards greater supply-chain integration geographically and at internal and external company levels of shippers (Paixão Casaca and Marlow, 2005). As a consequence of these changes, freight interests are constantly changing the way they do business, and the perceptual attributes of transport modes from which they derive maximum utility are constantly changing.

Lastly, individual attitudes and latent preference and perceptions of shippers towards specific modes play a role in determining their mode choice (Bergantino et al., 2013). For instance, it is claimed that the low modal preference for SSS is often because it is perceived as slow and more unreliable than road (Paixão Casaca and Marlow, 2005; Zachcial, 2001). Shippers also tend to have unobserved biases (Bolis & Maggi, 2003; Puckett et al., 2011; Zachcial, 2001). Garcia and Menendez (2009) revealed that shippers made negative remarks about the documentation and administrative procedures that the SSS alternative was subject to, and the associate complexity as well as the number large number of people involved in the process. Evers et al. (1996) also highlights the importance of perceptions in understanding freight mode choice decisions in freight transport. The above attracted attention to incorporate attitudinal questions and perceptions on the current service levels of transport modes as separate arguments in the questionnaire. There is reason to believe that SADC shippers may have unobserved biases towards SSS and rail as previous literature has indicated so (Rennie, 2002; Ombo, 2012). Therefore, these have been included as part of the methodology, to examine the impact of latent factors in freight mode choice in order to capture these biases.

6.4 Chapter Conclusion

The foundation discussion to freight mode choice decisions was critical prior to the study on shipper behavior. From this chapter the key take away is that the shipper is pretty much the decision-maker in terms of mode choice in SADC, and the freight forwarder occupies a position of advisor. With regard to the most important attributes in terms of mode choice, the top five attributes are: reliability, transport cost, risk of damage, frequency of service, and transit time, while the least important attribute is environmental friendliness. The top five attributes will now be used as generic attributes in the stated choice experiments of the shipper behavior studies in Chapter 7.

"If we drive down the cost of transportation in space, we can do great things."

~ Elon Musk

7 SHIPPER & FORWARDER PREFERENCE FOR SSS IN SADC

It was explained in Chapter 5 that in order to model shipper behavior and to assess the conditions under which SSS becomes preferred, the study considers competition between hypothetical SSS and other freight transport alternatives along key freight transport routes in SADC. To that end, trip specific mode choice data was collected across certain origin-destination (O-D) pairings. This chapter reports on how this data was analyzed. Accordingly, the chapter proceeds as follow: in the first section, the chapter provides a study background and describes the sample data. Following this discrete choice models are developed, and the results interpreted. All model estimation in this chapter is done in *R* (R Core Team, 2013), and estimated using the Apollo package(Hess and Palma, 2019).

7.1 Study Background

Shipper preference for SSS in SADC is studied along two instances: unimodal SSS and intermodal SSS. For this purpose, identical surveys were developed for each corridor; except, the SP game component which had unique values adopted to each corridor.

In the first instance, where preference for unimodal SSS is studied, freight trip mode choice between road and a hypothetical SSS alternative is modelled in order to assess the conditions under which SSS becomes preferred in SADC. The population of interest were shippers that trade containerized freight along 3 corridors: Walvis Bay ~ Cape Town, Walvis Bay ~ Luanda and Durban ~ Beira (see figure 7-1). Seeing the journeys ran only between port cities, where no rail alternative is available, the unimodal SSS study setting considered only a binary choice between road and a hypothetical SSS option.

In the second instance, the preference for intermodal SSS is studied. Particularly, there was interest to assess for correlations among intermodal alternatives and to assess the preference for intermodal SSS. To do this, hypothetical freight trip mode choice data was collected along two corridors with O-D pairings between a port city and a city in the hinterland: *Cape Town ~ Windhoek* and *Durban ~ Harare*; where a combination of modes could be employed (Figure 7-2). The intermodal SSS study setting considered three and four alternatives, were a combination of intermodal SSS options were set to compete against rail and road.

On the Durban ~ Harare corridors four transport alternatives were presented: road, rail, a combination of SSS and road (SRD), and a combination of SSS and rail (SRL). On this route, the road alternative has one border checkpoint crossing at Beitbridge and the SSS alternatives has two border checkpoint crossings; Durban/Beira and the Forbes border posts between Mozambique and Zimbabwe. On the Cape Town ~ Windhoek (*CT~WHK*) corridor, only three alternatives are employed: road, a combination of road and SSS (SRD), and a combination of rail and SSS (SRL). Rail is considered unavailable for this corridor, given the big detour the rail track makes which renders it unattractive. The road alternative has one border checkpoint crossing at Violsdrift/Noordoewer between Namibia and South Africa and the SSS alternatives also has one border crossings; at Cape Town/ Walvis Bay. In addition, see Annex IV for corridor descriptions.

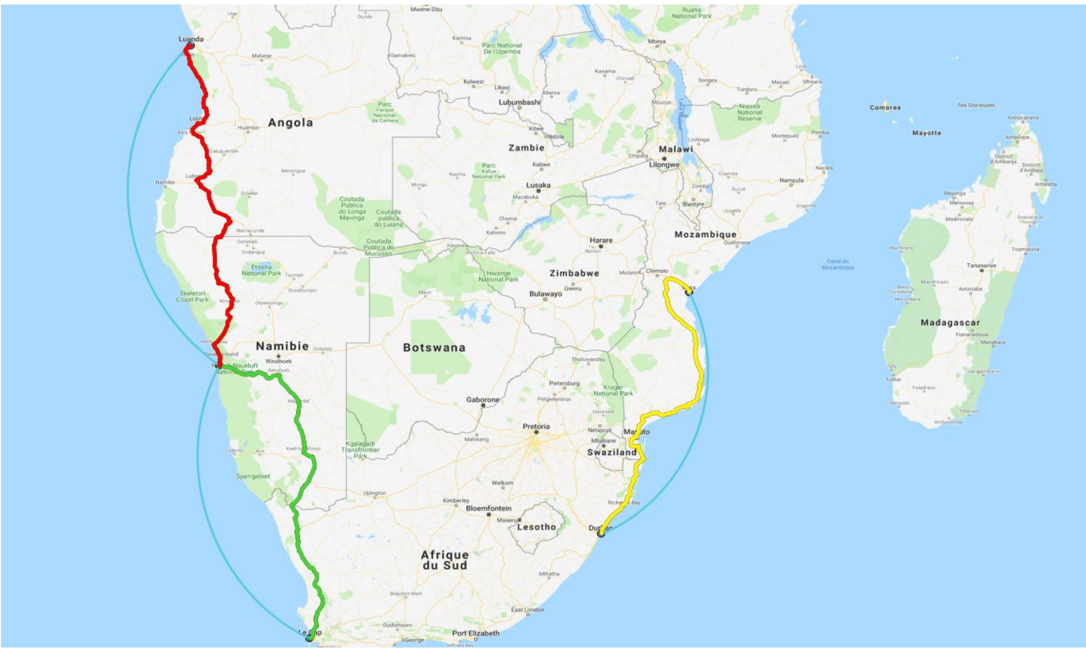

Figure 7-1: Unimodal SSS transport corridors studied (source: author)

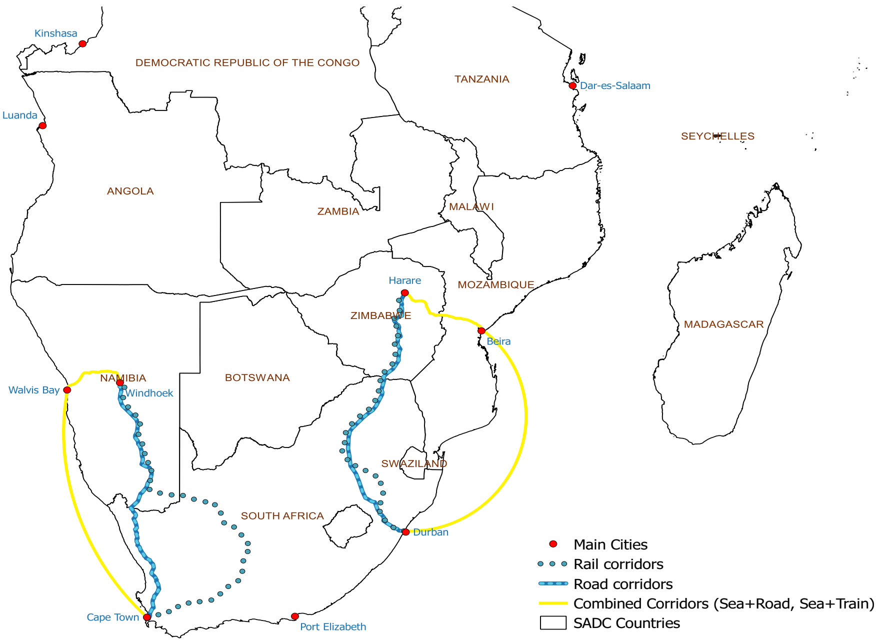

Figure 7-2: Intermodal SSS transport corridors studied (source: author)

7.2 Data Collection and Sample Description

7.2.1 Data collection and Sample Description: Unimodal SSS

Data collection took place in Cape Town (South Africa), Windhoek (Namibia), Walvis Bay (Namibia), Luanda (Angola), Ondangwa (Namibia), Johannesburg (South Africa), Durban (South Africa) and Beira (Mozambique) in the time period spanning between 1 November 2017 to 31 May 2018. Resultant from the SP designs, the target sample size was 50 respondents per corridor, ideally half of which was meant to be shippers and the other freight forwarders and 3PL. Additional effort was invested to have a diverse sample in terms of industry, business and company sizes.

As table 7-1 shows, respondents covered a wide spectrum ranging by company size, type of decision maker (i.e. freight forwarder or shipper), business industry, frequency of shipments, product type, freight lead times, value of products and product urgency. It was established during the chapter 6, that freight transport procurement in SADC is generally done by different parties, consisting majorly of shippers and freight forwarders. Attempt was therefore made in this component to have a fifty-fifty distribution between freight forwarders and shippers in the sample (see figure 7-3). This was deemed necessary seeing there exist a possibility of assessing whether differences exist between the modal preference of cargo principles and freight forwarders.

It is perhaps a point to note that during data collection, freight forwarders were easier to access compared to shippers. This was primarily because, the contact details of freight forwarders were readily accessible from online databases and national shipper associations, and also, most of these databases were up to date. Freight forwarders also seemed more knowledgeful of freight corridors as opposed to some shippers who seemed hesitant in answering, primarily in fear of divulging private sensitive information. Shippers also took longer to complete surveys compared to freight forwarders.

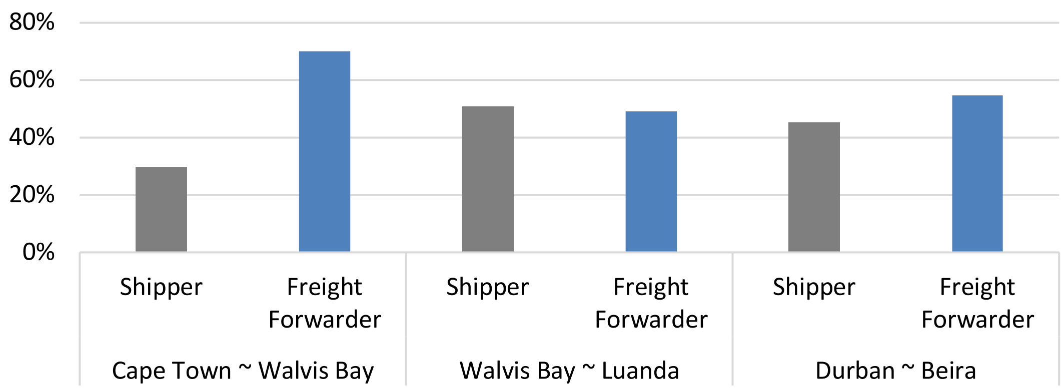

Figure 7-3 Decision-makers by corridor

In terms of capturing business size, respondents were measured in terms of number of employees. The number of employees ranged from 2 to 800, with an overall mean of 85 employees. That said however more than 50% of respondents where in small companies that had 14 employees or less. With regard to the associate business industry classification, this was based on South African Bureau of Standards (SABS) and is consistent with the classification of the preliminary survey described in Chapter 5. The biggest share (26%) of respondents came from logistics companies, followed by retailing (25%), mining (11%) agriculture (9%) and automobile trade industry (8%). Energy, fisheries, manufacturing and other industries formed the remainder of the sample. The high presence of retailers and logistics companies explains the high frequency of shipments reported. Also, of the sample, daily shippers made up 22%, weekly shippers made up 27%, monthly shippers made up 17%, and annual shippers made up 34%.

With regard to product type, the primary product was classified by raw, semi-finished and finished products. Finished products made up 64%, followed by semi-finished at 20%, and raw products at 16%. Of these products, 34% were shipped as urgent shipments requiring urgent dispatch and 66% were shipped as normal operating stock following an associated normal lead time (see figure 7-4). Upon further investigations, we discovered that the majority of urgent shipments were from the retail and automobile trade industries in the form of urgent orders or critical stocks.

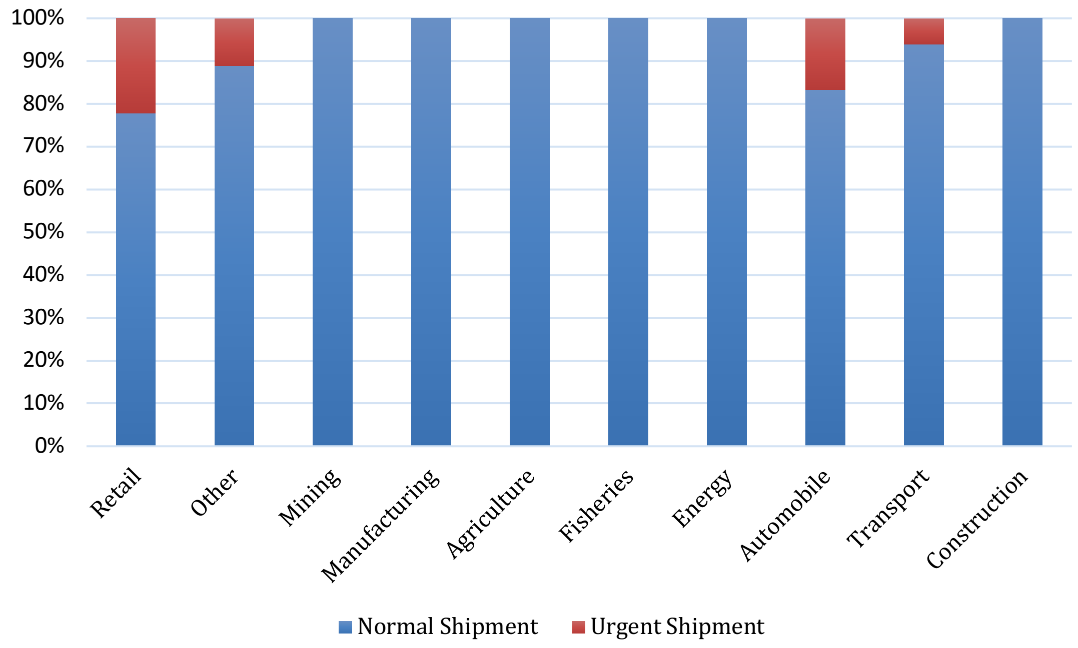

Figure 7-4: Shipment urgency by service industry

Table 7-1: Sample statistics

Attribute	Characteristics	*N*	Percent (%)
Type of decision maker	Shipper	62	41%
	Freight Forwarder	89	59%
Company Sizes in terms of number of employees	Minimum	2	-
	Maximum	800	-
	Mean	92	-
	1st Interquartile range	8	-
	3rd Interquartile range	62	-
Business Industry	Retail	41	25%
	Mining	18	11%
	Energy	4	3%
	Fisheries	1	1%
	Agriculture	14	9%
	Manufacturing	5	3%
	Transport and Storage	42	26%
	Automobile	12	8%
	Construction	5	3%
	Other	20	12%
Shipping frequency	Daily	35	22%
	Weekly	43	27%
	Monthly	28	17%
	Annually or less	56	34%
Product Type	Raw	25	15%
	Semi-finished	32	20%
	Finished	106	65%
Product Urgency	A: Urgent Stock	58	31%
	B: Non-urgent Stock	130	69%
Value (US$) of Full container load of primary product	Minimum	2025	-
	Maximum	100,000	-
	Mean	7500	-
	1QR	6000	-
	3QR	43,500	-
Lead time of primary product measured in days	Minimum	2	-
	Maximum	30	-
	Mean	7.7	-
	1QR	4	-
	3QR	7	-
Total number of respondents		151	

7.2.2 Data collection and Sample Description: intermodal SSS

Similar to the unimodal SSS surveys, respondents in the intermodal SSS component covered a wide spectrum ranging by company size, type of decision maker (i.e. freight forwarder or shipper), business industry, frequency of shipments, product type, freight lead times, value of products and product urgency (see Table 7-2).

Attempt was also made to have a fair distribution between freight forwarders and shippers in the sample. This was not possible across respective corridors, however over the general sample, there was a fair representation from both shipper and freight forwarder. As depicted in Table 7-2, the overall sample consisted of 57% freight forwarders and 43% shippers. This ratio was spread per corridor studied as follow: on the Cape Town ~ Windhoek corridor, 85% of the respondents were shippers and 15% were freight forwarders; and on the Durban ~ Beira corridor, 30% were shippers and 70% were freight forwarders as figure 7-5 shows.

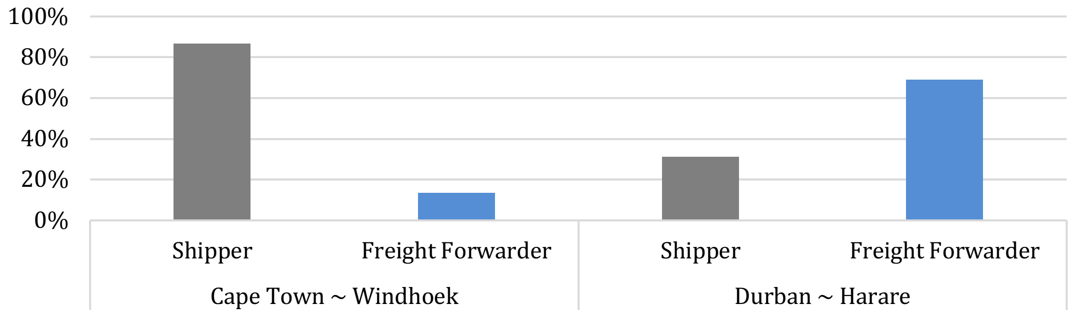

Figure 7-5 Decision-makers by corridor

In terms of capturing business size, the number of employees ranged from 1 to 1300, with an overall mean of 104 employees. Still the majority of respondents were in small companies with an interquartile range of 15 employees in terms of company sizes. With regard to the associate business industry classification, we achieved a nice spread of responses across industry. An interesting finding emerged; similar to the unimodal SSS study, the biggest share (24%) of respondents came from logistics companies, followed by retailing (27%), mining (12%) agriculture (11%). Indeed these industries, are the dominant industries which characterizes the SADC economy (Sandrey, 2013).

A similar spread of shipment frequencies to the unimodal SSS data was also achieved. Daily shippers made up 16%, weekly shippers made up 41%, monthly shippers made up 31%, and annual shippers made up 12%. The high level of shipping activity on intermodal corridors compared to the unimodal SSS corridors is character of freight transport in SADC, were most shipments originate from port cities and move towards the hinterland were the greater populations is concentrated (see Chapter 2). Finally, with regard to product type, the majority of products were finished products (64%), followed by semi-finished at 20%, and raw products at 16%. Of these products, 20% were shipped as urgent shipments requiring urgent dispatch, 63% were shipped as normal operating stock following an associated normal lead time, and 17% were shipped safety stock.

Table 7-2: Summary statistics Survey for Intermodal SSS

Attribute	Characteristics	Count	Percent (%)
Type of decision maker	Shipper	60	57%
	Freight Forwarder	46	43%
Company Sizes in terms of number of number of employees	Minimum	1	-
	Maximum	1300	-
	Mean	104	-
	1st interquartile range	15	-
	3rd interquartile range	80	-
Business Industry	Retail	29	27%
	Mining	13	12%
	Energy	4	4%
	Fisheries	0	0%
	Agriculture	12	11%
	Manufacturing	2	2%
	Transport and Storage	25	24%
	Automobile	8	8%
	Construction	11	10%
	Other	3	3%
Shipping frequency	Daily	17	16%
	Weekly	43	41%
	Monthly	33	31%
	Annually or less	13	12%
Product Type	Raw	11	10%
	Semi-finished	12	11%
	Finished	83	79%
Product Urgency	A: Urgent Stock	21	20%
	B: Operating Stock	67	63%
	C: Safety Stock	18	17%
Total number of respondents		106	100%

7.3 Modeling Shipper Behavior in SADC

Classical utility theory relies on the presence of preference which materializes into utility functions. In freight mode choice, the process involves tradeoffs between factors that characterize the transport alternatives and the decision maker (Cullinane and Toy, 2000). In this study, the following base attributes were employed to develop stated choice experiments (SCE): reliability, transport cost, transit time, extend of delay, and frequency of service. To assess tradeoffs between these attributes and other factors, the binary logit (BL), mixed logit (ML) models were employed for the unimodal SSS component; and the multinomial logit (MNL), nested logit (NL) and cross-nested logit (CNL) models were employed for the intermodal SSS component.

The modeling procedure for both components were identical as follow: first, modeling started with a minimal specification of the DCM with a 'constants only' model, which employs only the alternative specific constants (ASCs) and no attributes. The *constants only* model holds very little explanatory power of shipper behavior. It is only estimated to act as reference for subsequent models during model diagnosis. This is followed by the estimation of the 'base' model which contains only the generic attributes. Subsequently, covariates are added to account for heterogeneity in order to improve the model in terms of behavioral realism and empirical fit to the data while avoiding excessive complexity of the model. The utility function for the constants only models was specified as follow:

$$U_{nsj} = \delta_j + \varepsilon_{nsj} \tag{32}$$

where δ_j represents the alternative specific constants (ASC) capturing a baseline desire or dislike for the labelled alternative *j* with road fixed as reference alternative, and ε_{nsj} is the error term Gumbel-distributed across individuals *n* and alternatives *j*. The likelihood of sequence of choices for respondent *n* is subsequently given by:

$$L_n = \prod_{s=1}^{12} P_{j^*_{ns}ns}(\delta) \tag{33}$$

where j^*_{ns} represents the alternative (either road or SSS) chosen by respondent *n* in choice situation *s* (out of 12 choice situations). To review the estimation results from the models, informal judgement-based tests, goodness-of-fit measures and statistical tests are employed as the basis to evaluate the models and to compare models with different specifications (Train, 2009). Notably, the likelihood ratio (LR) test is first employed to test for nested models. It is calculated as twice the difference of the log likelihood of the unrestricted model to the restricted model (Koppelman and Bhat, 2006).

$$LR = 2(\log L|\text{unrestricted model} - \log L|\text{restricted model}) \quad (34)$$

In addition, the rho-square (R^2) measures are employed for goodness of fit testing. The rho-square value ranges between 0 and 1 and depends on the values of the loglikelihood for the estimated models. R^2 is derived from the ratio between the estimated model ($LL(\hat{\beta})$) and the constants only model ($LL(0)$) divided by the difference between of the constants only model (LL(0)) and the perfect model (LL(*)) (Koppelman and Bhat, 2006).

$$R^2 = \frac{LL(\hat{\beta}) - LL(0)}{LL(*) - LL(0)} \quad (35)$$

Furthermore, the Akaike and Bayesian Information Criterion (AIC, BIC) are employed to compare models with different number of parameters, where, the model with the lower AIC and BIC is to be preferred as the best fitting model (see Hensher et al., 2015, Chapter 6 for further derivation). For differences in the AIC and BIC indices, there are differences in the level of support. The BIC index is purported to impose a harsh penalty then the AIC index, however both indices are often criticized for having questionable validity for real world data (Burnham and Anderson, 2004).

7.4 Modeling preference for unimodal SSS

7.4.1 Developing the binary logit (BL) model

In the binary logit (BL) utility specification, all the base attributes are employed generically across attributes and are entered as continuous variables. This implies that an increase of any of these attributes have the same impact on the modal utility for all alternatives. In a random utility context, the utility that characterizes the appeal of a certain alternative *j* is thus given by:

$$U_{nsj} = V_{nsj} + \varepsilon_{nsj} = \beta_k X_{nsj} + \varepsilon_{nsj} \quad (36)$$

where U_{nsj} (later just U_j) is the utility of respondent *n* in choice situation *s* for alternative *j*, which is made up of a deterministic component, V_{nsj}, and the error term ε_{nsj}. This utility characterises the appeal of this alternative, where β_k is a vector of parameters that are to be estimated, while X_{jns} is a vector of the attributes of alternative *j*, as faced by respondent *n* in choice situation *s*.

Subsequent the base model, socio-demographic interactions or covariates were gradually added to the utility specification and more complex models were specified. The covariates as outlined in Table 3-1, were all tested for heterogeneity, and the significant ones were included as specific attributes to each alternative. In SADC particularly, two concerning issues in freight transport have been the directionally imbalanced traffic flows which emanate mostly from South Africa to the rest of the SADC region (Vilakazi et al., 2014); and a high share of shippers who employ own transport as a reliability enhancing measure (see Annex II). Accordingly, six covariates that capture decision maker characteristics, product characteristics, and the trip context (situational variables) were introduced to the base model as follow: *corridor studied, urgency of shipment, and shipping direction.* These covariates (Δ) were selected for inclusion based on the statistical fit and predictive performance of the model. Seeing road was fixed as the reference alternative, the random utility function for the BL model was specified as follow:

$$U_{sss,ns} = \delta_{sss} + \beta_{cost}\, Cost_{ns} + \beta_{time} Time_{ns} + \beta_{freq}\, Frequency_{ns} + \beta_{rel}\, Reliability_{ns} + \beta_{del} Delay\ Extend_{ns} + \beta_{CTWB} Corridor_{CT\_WB} + \beta_{WBLua} Corridor_{WB_{Lua},ns} + \beta_{DurBei} Corridor_{Dur_{Bei},ns} + \beta_{urgent}\, Urgent\_shipment_{urgent,ns} + \beta_{head}\, Ship\_Direction_{head,ns} + \xi_{sss,ns} \quad (37)$$

where $U_{nsj} =$ *is either road or SSS, with road fixed as the reference alternative;* β_{Cost}, β_{time}, β_{rel}, β_{freq} and β_{Del} are the coefficients associated with the attributes: Transport cost, Transit time, Reliability, Frequency and Expected Delay.

Since, the choice setting considers only two alternatives (road and SSS) and road was fixed as the reference alternative, and subsequently the coefficients of the ASC's and the covariates are interpreted as the change in utility, moving from road to SSS.

7.4.2 Developing the mixed logit (ML) model

To better account the presence of correlation in the error terms and heterogeneity across preferences, the mixed logit (*ML)* model was further developed. The *ML model* can approximate any random utility model (McFadden and Train, 2000), and to that end, it has been extensively employed in freight mode choice particularly to analyze random heterogeneity in choice preference (Brooks et al., 2012a; Feo et al., 2011a; Kim et al., 2014; Puckett et al., 2011).

The *ML model* allows for random taste variation and thus makes it possible to specify correlation made across individuals (see Section 3.3.4). This was considered important in the study seeing the data was SP data were twelve scenarios were presented to a single responded. Thus, in line with the formulation of the ML model in section 7.4.2, random heterogeneity was incorporated in the baseline sensitivity for SSS allowing, to capture additional differences across respondents not captured by the socio-demographic interactions (Δ). This random heterogeneity is incorporated in the ASC parameter (δ_{SSS})as follow:

$$\delta_{SSS} = \mu_{SSS} + \sigma_{SSS} + \xi_{SSS} \qquad (38)$$

where the random component ξ_{SSS} follows a standard Normal distribution across individuals but is held constant across choice situations *s*. This means the estimates of μ_{SSS} and σ_{SSS} now provide the mean and standard deviation, respectively, of the baseline preference for SSS. The standard normal distribution is employed because most of the variables are distributed normally, and the ML model allows tastes to vary over the population as per analyst defined distribution (Hensher et al, 2015). The loglikelihood function is accordingly modified as specified in equation (19) such that the integral over the distribution of the error term is incorporated in this function; where the error term now follows the standard normal density function. Subsequently, a simulation-based estimation was employed for the likelihood function. In particular the Halton sequence-based simulation was employed, and the random draws required for simulation were set at 500 (as done in Dada et al., 2019). For estimation, the normal distribution function was used to signify the distribution of the random parameters.

7.4.3 Developing the ICLV model

The ML model was specified to assess for the presence of unexplained variation in preferences across respondents. Literature reveals that some of this variation is linked to psychometric factors, such as attitudes and perceptions (Ben-Akiva et al., 1999). Accordingly, to assess the effects of attitudes and perceptions on the development of SSS in SADC, an ICLV model was estimated. Specifically, three latent variables were defined and incorporated, one captured the subjective perception of road conditions, the other captured the extent to which the responded is road captive and the third captured the subjective feelings towards employing SSS to reduce transport related crashes on roads.

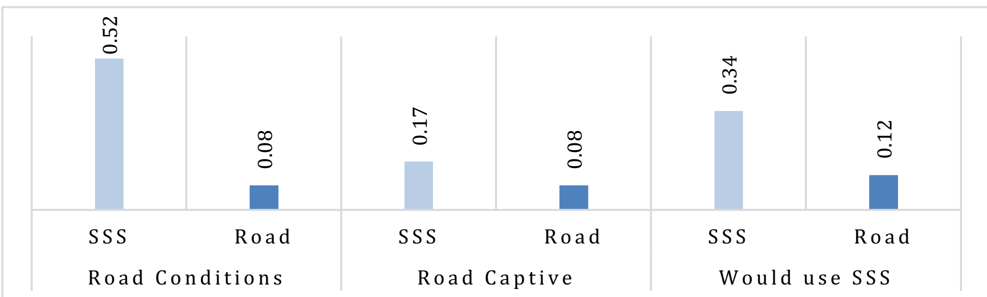

Figure 7-6 Mean score above 2.5 for attitudinal attributes per mode choice observed

Figure 7-6 shows the mean score levels above 2.5 (50% of 5) of the attitudinal attributes per mode choice observed.

Seeing the latent attributes were kept invariant across choices and captured as a function of the characteristics of the respondent and the changing choice attributes, the latent attributes were incorporated in the utility function of the ICLV model as detailed in the following manner: the latent variable α_{jns} was incorporated with alternative *j* for respondent *n* in choice task *s* such that:

$$\alpha_{nsj} = \lambda_j X_{jns} + \gamma_j z_n + \eta_{jn} \tag{39}$$

Where: λ_j is a vector of estimated parameters that measures the impact of the modal attributes of alternative *j* in choice task *s* for respondent *n* on the latent variable towards that alternative. The setting modifies the utility function and so the utility function is now written as:

$$\delta_{nsj} = \mu_j + \sigma_j \xi_{ns} + \tau_x \alpha_{ns} + \tau_y \alpha_{ns} + \tau_z \alpha_{ns} \tag{40}$$

where the impact of the latent perception of using SSS is captured by the three additional parameters τ_x, τ_y and τ_z with *x* denoting 'road conditions', *y* denoting 'road captive' and *z* denoting 'would use SSS' respectively.

Subsequently, following Dada et al., (2019) the ordered logit model was employed to capture the effect of the latent variables. These three latent variables were used in the measurement model component of the overall framework to explain the responses to the latent perceptions, with I_{jn} referring to the response by respondent *n* to the perception for alternative *j*. Accordingly, the likelihood of the actual observed value of I_{jn} as LI_{jn} was now specified as follow:

$$LI_{jn}(\alpha_{jn}, \zeta_j) = \sum_{p=1}^{5} x_{I_{jn},p} \left(\frac{e^{s_{I_j,p} - \zeta_j \alpha_{jn}}}{1 + e^{s_{I_j,p} - \zeta_j \alpha_{jn}}} - \frac{e^{s_{I_j,p-1} - \zeta_j \alpha_{jn}}}{1 + e^{s_{\mathrm{j},p-1} - \zeta_j \alpha_{jn}}} \right) \tag{41}$$

where: $x_{I_{jns},p}$=1 if and only if respondent *n* chooses answer *p* on the lickert scale for alternative *j*; the impact of the latent variable α_{jn} on I_j captured by ζ_j; and the parameter $s_{I_j,p}$ denoting the limits that will be estimated, as per normalisation that $s_{I_j,0} = -\infty$ and $s_{I_j,5} = +\infty$.

The results for all the estimated models are shown in Table 7-3 below and the interpretations follow subsequently thereafter in Section 7.4.4.

Table 7-3: Modeling results for the Unimodal SSS dataset

	BL model (base)			*BL model (covariates)*			*ML model*			*ICLV model*		
Attribute	Coeff.	r.s.e	r.t-r	Coeff.	r.s.e	r.t-r	Coeff.	r.s.e	r.t-r	Coeff.	r.s.e	r.t-r
Randomized parameters												
ASC_{Road} (μ_{road})	0.000	NA	NA	0.000	NA	NA	0.0000	NA	NA	0.0000	NA	NA
Mean_con (μ_{SSS})	0.0229	0.1445	0.16*	-0.215	0.4069	-0.53*	-0.1622	0.515	-0.31*	-0.2319	0.5813	-0.4*
Std_dev (σ_{SSS})				-	-	-	1.3072	0.176	7.43	1.2259	0.4559	2.69
Non-randomized parameters												
Transit time (β_{time})	-0.2992	0.0387	-7.73	-0.3171	0.0417	-7.6	-0.3997	0.052	-7.68	-0.4014	0.0519	-7.73
Transport cost (β_{Cost})	-0.001	0.0001	-8.29	-0.0012	0.0001	-8.92	-0.0015	0.0002	-8.97	-0.0015	0.0002	-8.98
Delay extend (β_{Del})	-0.0113	0.0036	-3.16	-0.0151	0.0039	-3.82	-0.0149	0.0036	-4.09	-0.0151	0.0036	-4.19
Frequency of service (β_{freq})	0.1215	0.0185	6.56	0.1457	0.0201	7.27	0.1850	0.0248	7.46	0.1855	0.0248	7.47
Reliability of service (β_{rel})	0.0031	0.0015	2.11	0.0023	0.0012	1.86*	0.0033	0.0016	2.13	0.0033	0.0016	2.1
Decision-maker characteristics												
Dur~ Bei Corridor ($\Delta_{Dur\sim Bei}$)				0.3776	0.3681	1.03*	0.5248	0.4633	1.13*	0.59	0.5103	1.16*
WB~Lua Corridor ($\Delta_{WB\sim Lua}$)				0	NA	NA	0	NA	NA	0	NA	NA
CT~ WB Corridor $\Delta_{CT\sim WB}$ (versus WB ~				0.8543	0.2903	2.94	0.9704	0.3575	2.71	0.9953	0.4893	2.03
Situational variables												
Shipping direction ($\Delta_{Head\ leg}$)				-0.4321	0.2351	-1.84*	-0.5035	0.3199	-1.57*	-0.454	0.33	-1.38*
Shipment urgency ($\Delta_{Urgent\ shipment}$)				-1.9884	0.265	-7.5	-2.4888	0.3328	-7.48	-2.5238	0.3645	-6.92
Attitudinal variables												
Tau_SSS_LV_RD (ζ_{road})										-0.0925	0.1661	-0.56*
Tau_SSS_LV (ζ_{sss})										0.3987	1.17	0.34*
Road Conditions (τ_{x_road})										0.1967	0.102	1.93
Road Conditions (τ_{x_sss})										0.9038	0.0485	18.64
Road Captive (τ_{y_road})										-0.8406	0.0831	-10.12
Road Captive (τ_{y_sss})										0.3973	0.1317	3.02
Use SSS to reduce crashes (τ_{z_road})										-0.3914	0.0962	-4.07
Use SSS to reduce crashes (τ_{z_sss})										0.8969	0.056	16.01
Model Statistics												
Observations	1668			1668			1668			1668		
Parameters	6			10			11			19		
LL(0)	-1156.169			-1156.169			-925.7527					
LL(start)	-1156.169			-1156.17			-1156.169			-2019.527		
LL(final)	-994.321			-921.099			-841.1715			-1394.713		
Rho-square (0)	0.14			0.2033			0.2724					
Adj.Rho-square (0)	0.1348			0.1947			0.2629					
AIC	2000.64			1862.2			1704.34			2827.43		
BIC	2033.16			1916.39			1763.96			2930.39		

Notes: coeff = coefficient, rob.s.e = robust standard error, rob.t-r = robust t-ratio, * insignificant to 90% CI

7.4.4 Modeling interpretation

7.4.4.1 Choice model component

Table 7-3 shows the results for the estimated binary logit, mixed logit and ICLV models. The parameters for all the base attributes, in all the models, had the expected signs and projected reasonable differences in the magnitude in terms coefficient magnitudes. The parameters for *transit time, transport cost and expected delay* were negative, and in line with economic logic, means an increment in these attributes will result in proportional disutility to the alternatives. Similarly, the parameter estimates for *frequency* and *reliability* were positive, implying an increase in these will result in improved utility in the alternative where the increment is applied.

In terms of statistical significands, the robust t-values provide the measure of significands for individual parameters, and accordingly, all the attributes were statistically significant to the 95% confidence interval, the exception being r*eliability* in the final BL model which was significant to the 90% confidence interval. The high coefficients observed in the model agree with Feo et al (2011b) who investigated for SSS in south-west Europe using stated preference analysis of Spanish freight forwarders modal choice preference, and accordingly provides that if governments are to make policy decisions about road pricing schemes to induce modal shift towards SSS; then only value of time, reliability and frequency are needed. These variables are also important to induce modal shift to SSS because they can be influenced by direct actions and intervention from political action.

With regard to socio-economic factors, the lower part of Table 7-6 shows the covariates classified according to decision-maker and situational characteristics. In the *decision-maker characteristics,* a non-linear coding scheme in the form of dummy coding was used for the *corridor* attribute to capture corridor specific baseline preference for SSS. To that end, the attribute level for *WB ~ Lua* was fixed as the reference level. Accordingly, it is deduced that holding all else equal, shippers on the *Dur ~ Bei* route have more preference for SSS then shippers on the *WB ~ Lua* route. Moreover, shippers on the *CT ~ WB* corridor have more preference for SSS then on both the *WB ~ Lua* and Dur ~ Bei corridors. The inclusion of this variable was important in the discussion of developing SSS in SADC because some key freight transport corridors in SADC are constrained by inefficient ports. For example the *Dur ~ Bei* corridor is burden with port congestion in both the ports Durban and Beira (Parida, 2014), and the frequent occurrences of bad weather exacerbates the port inefficiency (Rennie, 2002).

With regard to situational variables; the negative coefficient for *shipment_urgency* shows that when a shipment is urgent, road becomes the preferred mode, and so, by a huge margin. Shippers under duress to send a shipment would typically consider only how quick the shipment will arrive at the destination, therefore SSS with its comparatively long transit time and process becomes less appealing. On the question of shipment direction, the attribute *direction of shipment* captures the *head leg* journey. The *head leg* is the trip from source to demand, which in our case is from South African cities to other SADC cities. In the special case of the WB ~ Lua corridor, the head leg was specified Walvis Bay to Luanda. The negative coefficient for direction of shipments means shippers prefer road over SSS on the head leg. This is understandable in SADC as most shipments from source to demand have a minimum lead time within which they need to arrive. In SADC particularly, two concerning issues in freight transport have been the directionally imbalanced traffic flows which emanate mostly from South Africa to the rest of the SADC region (Vilakazi et al., 2014); and a high share of shippers who employ own transport as a reliability enhancing measure (Konstantinus and Zuidgeest, 2018).

Additionally, with regard to the results of the ML model results, the statistically significant standard deviations of the randomized coefficients in the *ML model* suggests the existence of heterogeneity in response to the ASC for SSS. In particular, the standard deviation of a random parameter in the ML model relates to the amount of dispersion around the mean that exist in the sample data.

7.4.4.2 Impact of Latent Perceptions on utility

Subsequent to the interpretation of the model results above, the effect of the latent attributes on freight mode choice are captured in the ICLV model as follows: the overall contribution to the respective utilities of SSS and road is given by:

$$\mu_{nsj} + \Delta z_n + \sigma_j \xi_n + \tau_x \alpha_{nsj}. \qquad (42)$$

where Δz_n captures the overall contribution of a *direct* effect of the covariates to the utility; pure random effect is captured by $\sigma_j \xi_n$, and the random effect is captured both by the latent variable, with the $\tau_x \eta_{jn}$, a subcomponent of $\tau_x \alpha_{nsj}$ (see equation 17).

In line with this formulation, the results of the *ICLV model* in table 4 shows that the latent attributes had significant impact on modal utility. Seeing, road was selected only 32.4 percent of the time (and not half the time), the interpretation of these results are done with reference to the mean scores of the latent variables (shown in figure 7-7).

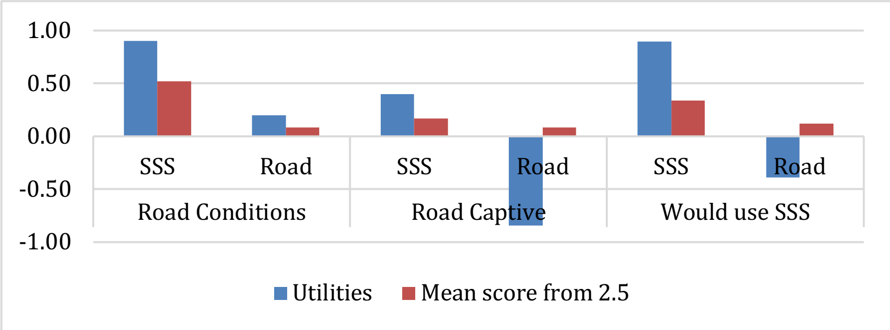

Figure 7-7 Mean scores versus estimated utilities for latent variables

From Figure 7-7, it is observed that despite the low marginal differences in the mean scores of the latent variables, the weights of the associate coefficients are significantly different, thus implying that latent perceptions contributed significantly to the modal preferences of freight interests in SADC. The impact of these attributes on modal utility can be summarized as follow:

- Improved perceptions in road conditions led to positive utility for both SSS and road. However, seeing the contribution to road was comparatively higher (from a modal split of only 32.4 percent), it can be deduced that positive conditions in roads will contribute positively to road and not SSS per.
- Road captivity led to negative utility for road and positive utility for SSS. On the onset, this looked counter intuitive, but the negative utility observed for road is an indication that road captivity is generally low in SADC. This is observed firstly in the low marginal differences in this attribute when road is selected versus when SSS is selected, and later in the low mean scores of the latent attribute which were around 2.58 and 2.67 out of 5 for road and SSS respectively.
- Improved perceptions in employing SSS to reduce road crashes lead to positive utility for SSS and negative utility for road. This is furthermore substantiated by a similar mean scores in the mean scores of the latent attribute. The results thus show that sentiments towards road safety are dire and might induce traffic towards SSS.

The results thus show that despite SSS being unlikely to succeed as a greenhouse gas mitigation strategy (Bendall and Brooks, 2011; Puckett et al., 2011), sentiments towards road safety in areas plagued with high rates of rate fatalities could form a campaign strategy for SSS. It is common for businesses to make decisions based on the environmental and societal benefits (Bernhut Foundation, 2003).

7.4.4.3 Comparing model goodness of fit

The model fit for the estimated models were after every subsequent iteration compared to the *constants only* model, and every lesser nest of it. The likelihood ratio test (LR *t*-statistic) was then employed to compare the fit of two related models (see section 7.3). The LR *t*-statistic has chi-square distribution with degrees of freedom equal to the number of restrictions, and the test requires the lesser nest model to have fewer estimated parameters (cf. Koppelman and Bhat, 2006). Accordingly, table 7-4 show that the models with covariates record most improvement from the constants only model in terms of goodness of fit. Most improvements come from the *ML model* which captures random heterogeneity. In particular, the results highlight the presence of heterogeneity in mode choice preference across covariates as identified in *Table 5-7*. The ICLV model which had two model components, the choice component which yielded a LL value of -841.2381 and the combined model which yielded a LL value of -1394.7130, also recorded significant results; however due to a different start LL value it had compared to the other models, it was omitted from comparison in this exercise.

Table 7-4: Comparing goodness of fit

	BL model (*Constants*)	BL model (base)	BL model (covariates)	ML model
Log likelihood	-1122.907	-994.321	-916.2407	-839.9225
Pseudo R2	0.0288	0.14	0.2075	0.2735
Adjusted R2	0.0279	0.1348	0.1971	0.2623
AIC	2247.81	2000.64	1856.48	1705.84
BIC	2253.23	2033.16	1921.51	1776.3
Parameters	1	6	12	13
Likelihood ratio test				
BL model (*Constants*)	-	*X^2 = 253.93 df = 5; P-v = 0.000*	*X^2 = 403.62 df = 9; P-v = 0.000*	*X^2 = 563.47 df = 10; P-v = 0.000*
Binary Logit (base)	-	-	*X^2 = 146.44 df = 4; P-v = 0.000*	*X^2 = 306.3 df = 5; P-v = 0.000*
Binary Logit (heterogeneity)	-	-	-	*X^2 = 159.85 df = 1; P-v = 0.000*

7.4.5 Section conclusion

In this section, the take up of unimodal SSS was assessed. The estimated models, showed that intra-urban freight mode is influenced by transit time, transport cost, reliability, expected delay time and frequency of service. Moreover, socio-economic factors such decision-maker characteristics situational variables were also influential. In particular, shippers with an urgent shipment and those transporting on the head leg of a transport journey would derive negative utility from employing SSS. Subsequently, there are variations in shipper preference with better goodness of fit yielded from the *ML model*. Lastly, the incorporation of latent attributes reveals that respondents who are road captive would yield less utility from SSS, whereas good road conditions and environmental sentiments towards employing SSS could improve the use of SSS.

7.5 Modeling preference for Intermodal SSS

7.5.1 Developing the multinomial logit (MNL) model

The base model for the intermodal SSS dataset was estimated similar to the unimodal setting, were all the base attributes were employed generically across attributes. This time however, the attribute *Extend of delay* (β_{Del}) was found to perform better under log transformation and was accordingly specified. Furthermore, to account for heterogeneity, covariates were tested and selected for inclusion based on the statistical fit and predictive performance of resultant choice models. The attributes: *shipment_frequency, corridor and own_transport* were included. The utility function thus read as follow:

$$U_{nsj} = \delta_j + \beta_{cost}Cost_{ns} + \beta_{time}\,Time_{ns} + \beta_{freq}Frequency_{ns} + \beta_{rel}(Reliability)_{ns} + \beta_{del}\ln(Delay)_{ns} + \beta_{ct_{whk}}Corridor_{CTWHK} + \beta_{dur_{har}}Corridor_{DurHar} + \beta_{own_{tr}}Own_{Yes,ns} + \beta_{ship_{freq}}Shipment_{ns} + \varepsilon_{nsj} \quad (43)$$

where: *j represents* the alternatives: Road (RD), Rail (RL), SSS & Rail (SRL), and SSS & Road (SRD); $\delta_{RD}\,\delta_{\mathrm{RL}}\,\delta_{\mathrm{SRD}}$ and δ_{RL} are the alternative specific constants capturing a baseline desire for RD, SRD, SRL and RL.

The results of the final MNL model are reported in Table 7-8; and they show that the estimated parameters in the two MNL models had the expected signs and projected similar differences in magnitude to the choice models employed in the unimodal SSS setting. Thus, in line with economic logic, the attributes rightly imply a directly proportional relationship to the utility of the alternative where the change is applied. The differences in magnitude of estimated parameters also follow intuition and are similar to the unimodal SSS setting.

Armed with these results, , the IIA property of the MNL model must be considered. The IIA property, which is tantamount the MNL model, restricts the ratio of choice probabilities for any pair of alternatives to be independent of the existence and characteristics of other alternatives in the choice set (Koppelman and Bhat, 2006). Particularly for this study, the IIA property was expected to be a limitation of the MNL model because it implies equal competition between all pairs of alternatives, an inappropriate assumption in many choice situations given the expected correlation between the SSS intermodal alternatives. The two intermodal SSS alternatives, SRD and SRL are likely to be more similar to each other than they are to road and rail due to shared attributes which are not included in the measured portion of the utility function. For example, SRD and SRL may have the same cost structure and operating policies, given the combined length of the maritime freight leg of SRD and SRL. Such similarities, if not included in the measured portion of the utility function, may lead to correlation between the errors associated with these alternatives, a violation of the assumptions which underlie the derivation of the MNL. Cross-correlations between Road, SRD, SRL and RL were subsequently tested and accounted for using NL and CNL models. Henceforward discuss resorts to the NL model which is discussed next.

7.5.2 Developing the NL model

The NL model represents important deviations from the IIA property but retains most of the computational advantages of the MNL model (Koppelman and Bhat, 2006). In this study, a NL model with two level of nest structures was developed to account for correlations between unobserved factors amongst the SSS alternatives nest. This was expected, given the combined length of the maritime leg of SRD and SRL was longer than individual road and rail legs of SRD and SRL. To that end, four NL specifications corresponding to nesting configurations were specified and tested:

- NL_SSS: SRD & SRL nested, and rail and road are un-nested (Figure 7-12).
- NL_SSS_1: RD & SRD nested with rail and SRL un-nested (Figure 7-13);
- NL_SSS_2: RD & SRD nested and SRL & RL nested (Figure 7-14); and,
- NL_SSS_3: SRL& RL nested and RD & SRD un-nested (Figure 7-15).

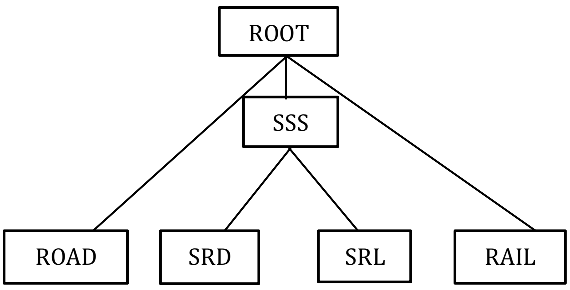

Figure 7-8: NL_SSS

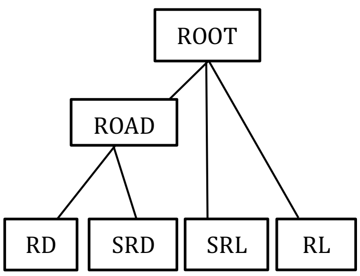

Figure 7-9: NL_SSS_1

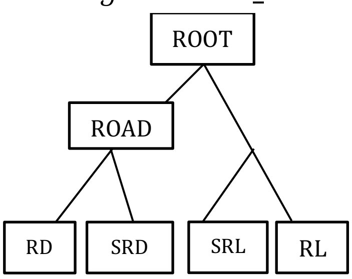

Figure 7-10: NL_SSS_2

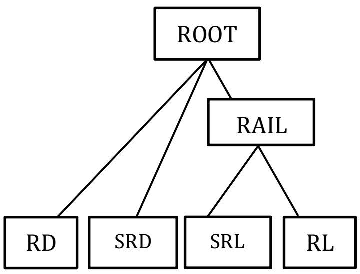

Figure 7-11: NL_SSS_3

With the presence of such nesting correlations, the utility for alternative *j* nested with alternative *j* within nest *b* is given by:

$$U_{nsj} = \mu_{(j|\,b)} \sum_{k=1}^{K} \beta_j \, x_{nsj} + \varepsilon_{nsj} \tag{44}$$

Where: $\mu_{(j\,|\,b)}$ is the nested parameter indicating the degree of nesting between SRD and SRL within the SSS nest as opposed to outside the nest.

The link between mode choice probabilities is subsequently capture by the probability function as specified in Chapter 3, section 3.3.2. wherein the values of λ are restricted between 0 and 1. The *Apollo code* gives values for λ (lamda) with the constraint to normalize μ set to 1. The parameter estimate for lambda λ is interpreted as the nest parameter, captured by the attribute LAMBDA_SSS in the model specification. For instance, the nesting coefficient captured by *LAMBDA_ SRD_SRL* in the *NL_SSS* specification is a function of the underlying correlation between the unobserved components for SRD and SRL, and it characterizes the degree of substitutability between those alternatives.

The four NL specifications corresponding to the possible nesting structures were estimated and tested to see which configuration to employ. This required a combination of judgment and hypothesis testing (as detailed in Koppelman & Bhat, 2006). In particular, we looked at the value of lambda and the final loglikelihood function. Table 7-5 contains a comparison of the modeling outcomes for various specifications of the NL model (the full results for NL_SSS_1 are presented in table 7-8). As expected, the *NL_SSS_2* model yielded superior results compared to the other nesting structures. It yielded both a superior final loglikelihood function, and the values of lambda for the RD_SRD and RL_SRL nest were statistically significant, (Koppelman and Bhat, 2006). The *NL_SSS* specification also yielded good model fit compared to the MNL model and a high correlation between SRD and SRL yielded indicates potential for cross correlation among RD, SRD and SRL. This relationship is further investigated in the CNL model.

Table 7-5:Different NL model specifications and outcomes

Nest	λ_{RD_SRD}	λ_{RL_SRL}	λ_{SRD_SRL}	LL	LR vs MNL (p_value)
NL_SSS			0.5518	-1383.445	0
NL_SSS_1	0.6775			-1398.02	0
NL_SSS_2	0.8425	3.0769		-1369.466	0
NL_SSS_3		3.2059		-1370.112	0

**LL* = Loglikelihood, *LR* = Loglikelihood ratio

7.5.3 Developing the CNL model

Apart from overcoming the IIA property in the NL model, there was research interest to overcome the expected cross correlations amongst the different branches of RD, SRD, SRL and RL. Therefore, to simultaneously account for correlations between alternatives within nests and across nests, the CNL was employed.

To that end, three CNL nesting structures were specified and tested as shown in figures 7-16, 7-17 and 7-18. Firstly, given the high correlations between SRD and SRL observed in *NL_SSS,* and between RD and SRD in *NL_SSS_2* it was necessary to test for all possible cross nesting combinations. Furthermore, two other nest structures were necessary to relax either arm of the unimodal alternatives (RD and RL). Thus, the nesting specifications were as follow:

- *CNL_SSS*: which involved nesting RD with SRD, SRD with SRL, and SRL with RL (see Figure 7-16);
- *CNL_SSS_1* which involved cross nesting of SRD with SRL and RD with RL left un-nested (see Figure 7-17);
- *CNL_SSS_2* which involved cross nesting of SRD with SRL, SRL with RL and RD left un-nested (see Figure 7-18).

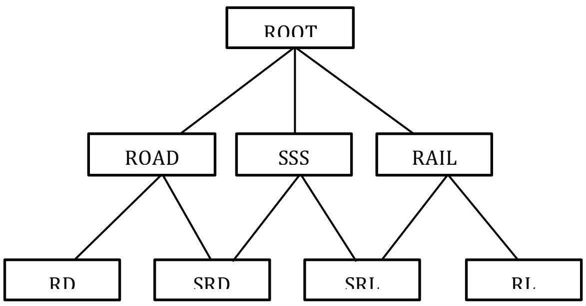

Figure 7-12: CNL SSS nesting structure

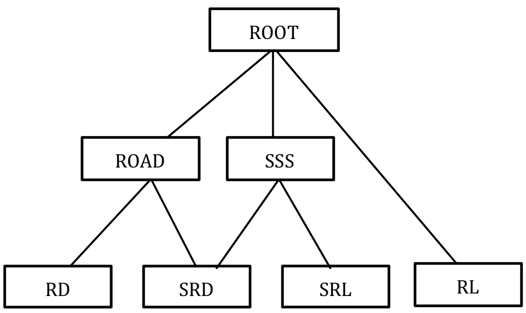

Figure 7-11: CNL_SSS_1

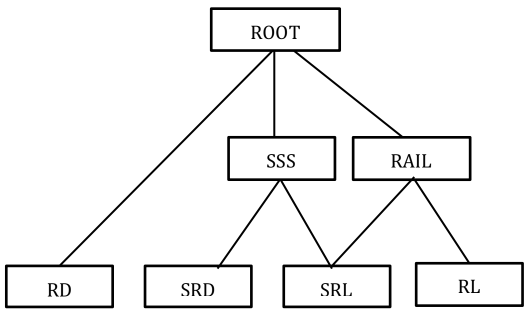

Figure 7-12: CNL_SSS_2

With such nesting configurations the utility function was specified as follow: In individual nests, the utility for alternative *j* nested within the nest *b* is given by:

$$U_{nsj} = \mu_{(j \mid b)} \sum_{k=1}^{K} \beta_j \, x_{nsj} + \varepsilon_{nsj} \tag{45}$$

where $\mu_{(j \mid b)} = \frac{\pi^2}{6var(\varepsilon_{nsj|b})}$. Is the nested parameter indicating the degree of nesting between alternatives within a nest as opposed to outside the nest, and;

$\sum_{k=1}^{K} \beta_j x_{nsj} + \varepsilon_{nsj}$ is the random utility component of the utility of alternative *j*

Similar to the NL model, the link between probabilities is best seen when examining the choice probabilities produced from the CNL model. Similarly, the *Apollo code* gives values for λ_l and λ_m which are interpreted as the nest parameters in nests m and *l*; and values for α_i, m interpreted as allocation parameters of alternative *i* to nest *m*. Table 7-6 present a summary of the CNL model results for the different CNL specifications. Subsequently, to select a single CNL structure, the different CNL structures were estimated and compared to each other. Similar to the NL model, the selection of a preferred CNL structure required a combination of judgment and hypothesis testing.

Table 7-6: Different CNL model specifications and outcomes

Nest	λ_{RD_SRD}	λ_{SRD_SRL}	λ_{RL_SRL}	α_{RD_SRD}	α_{RL_SRL}	LL	LR *vs* NL (p.v)
CNL_SSS	0.6009	0.012	3.2523	0.4318	-0.0648	-1360.440	0
CNL_SSS_1	0.3782	0.3126		-0.5295		-1377.501	15.06*
CNL_SSS_2		3.1978	0.8027		4.1103	-1370.057	5.87*

*Notes: *statistically insignificant, p.v=p.value, LR vs NL=final loglikelihood ratio of CNL versus NL model*

As expected, the results show that the *CNL_SSS* structure was the more superior of the three CNL structures. It yielded the more superior model goodness in terms of model goodness of fit, and the nest parameters were all less than 1 and statistically significant, implying that its structure is consistent with random utility theory.

Furthermore, the allocation parameters into the different nests in the *CNL*_SSS structure were all statistically significant (see table 7-7). The allocation parameters are calculated using the delta method and indicates the degree of membership of a certain alternative to a certain nest. An interesting finding is the SSS alternatives share larger correlations with their respective land-based partners then with each other.

Table 7-7: Allocation parameters in final CNL model

	α	Rob. s. e	Rob. t.ratio
RD_SRD	0.4429	0.0935	4.74
SRD_SRL	0.2695	0.0931	2.9
SRL_RL	0.2876	0.0718	4.01

The results for the base model, MNL, NL and CNL models are shown next in Table 7-8.

Table 7-8: Results of choice models for intermodal SSS

	MNL_base			*MNL_final*			*NL_SSS_2*			*CNL_SSS*		
Attribute	coeff	r.s.e	r.t-r	coeff	r.s.e	r.t-r	coeff	r.s.e	rob.t-r	coeff	r.s.e	r.t-r
ASC RD (δ_{RD})	0	NA	NA	0.000	NA	NA	0.0000	NA	NA	0	NA	NA
ASC SRD (δ_{SRD})	0.3887	0.156	2.49	0.5722	0.1845	3.1	0.3311	0.1788	1.85	0.3228	0.1406	2.3
ASC SRL (δ_{SRL})	0.2166	0.2038	1.06	0.3655	0.2471	1.48	-0.3882	0.3324	-1.17	-0.2814	0.2555	-1.1
ASC RL (δ_{RL})	-0.3097	0.2758	-1.12	0.627	0.3476	1.8	-0.1363	0.7148	-0.19	-0.4155	0.6978	-0.6
Transit time (β_{time})	-0.2501	0.0253	-9.88	-0.262	0.0266	-9.86	-0.2643	0.0408	-6.48	-0.1874	0.0329	-5.7
Transport cost (β_{Cost})	-0.0008	0.0001	-9.83	-0.0009	0.0001	-9.53	-0.001	0.0001	-8.21	-0.0008	0.0001	-8.29
Delay extend (β_{Del})	-0.0172	0.0147	-1.17*	-0.0191	0.0153	-1.25	-0.0398	0.0128	-3.11	-0.0318	0.0108	-2.94
Frequency of service (β_{freq})	0.0499	0.019	2.63	0.0695	0.021	3.31	0.0855	0.0226	3.78	0.0694	0.0144	4.83
Reliability of service (β_{rel})	0.0024	0.001	2.39	0.0025	0.0011	2.26	0.0039	0.0013	3.05	0.0020	0.0005	4.09
Decision maker characteristics												
ASC_{SRD} Dur_Har ($\Delta_{Dur\sim Har}$)				0	NA	NA	0	NA	NA	0	NA	NA
ASC_{SRD} CT_Whk ($\Delta_{CT\sim WHK}$)				0.591	0.2141	2.76	1.1492	0.3052	3.77	0.9065	0.2179	4.16
Own trans RD (Δ_{OT_RD})				0	NA	NA	0	NA	NA	0	NA	NA
Own trans SRD (Δ_{OT_SRD})				-0.3436	0.3362	-1.02	-0.6572	0.3068	-2.14	-0.3972	0.2629	-1.51
Own trans SRL (Δ_{OT_SRL})				0.985	0.3621	2.72	0.8526	0.3547	2.4	0.6227	0.2648	2.35
Own trans RL (Δ_{OT_RL})				-0.3405	0.4348	-0.78	-1.8104	0.7927	-2.28	-1.6208	0.6914	-2.34
Ship freq RD ($\Delta_{SHIP\_Freq\_RD}$)				0	NA	NA	0	NA	NA	0	NA	NA
Ship freq SRD ($\Delta_{SHIP\_Freq\_SRD}$)				-0.9056	0.4198	-2.16	-0.7599	0.3948	-1.92	-0.7969	0.3284	-2.43
Ship freq SRL ($\Delta_{SHIP\_Freq\_SRL}$)				-3.1224	0.5988	-5.21	-3.3739	0.7469	-4.52	-2.8342	0.7275	-3.9
Ship freq RL ($\Delta_{SHIP\_Freq\_RL}$)				-2.774	0.737	-3.76	-2.4407	1.1273	-2.17	-2.3656	1.1026	-2.15
Nest and Cross correlation parameters												
λ RD_SRD							0.8425	0.1335	6.31	0.6009	0.1311	4.58
λ _ SRD_SRL										0.012	0.0155	0.78
λ _SRL_RL							3.0769	0.7538	4.08	3.2523	0.7166	4.54
α_SRD_RD_BASE										0.4318	0.3846	1.12
α_SRL_RL_BASE										-0.0648	0.4971	-0.13
Model Statistics												
Observations		1344			1344			1344			1344	
Parameters		8			15			17			20	
LL (Start)		-1683.666			-1683.666			-1683.666			-1685.844	
LL(0)		-1683.666			-1683.666			-1683.666			-1683.666	
LL(final)		-1521.083			-1400.759			-1369.466			-1360.44	
Pseudo R2		0.0966			0.168			0.1866			0.192	
Adjusted R2		0.0918			0.1591			0.1765			0.1801	
AIC		3058.17			2831.52			2772.93			2760.88	
BIC		3099.79			2909.57			2861.39			2864.95	

Notes: coeff = coefficient, rob.s.e = robust standard error, rob.t-r = robust t-ratio, *insignificant

7.5.4 Model interpretations

The results show that all the base attributes, were statistically significant and they all had the expected signs. Furthermore, the model goodness of fit improved both with covariates and model complexity. The differences in magnitude of the estimated parameters also follow intuition and were similar to the unimodal SSS setting.

The lower part of Table 6-7 shows the decision-maker characteristics. From them, it is observed that holding all else equal, shippers on the *CT~WHK* corridor had comparatively more preference for SSS then shippers on the *Dur~Har* corridor. The difference in preference is understandable seeing the SRD alternative from Durban (South Africa) to (Harare) Zimbabwe would have to transit through Beira (Mozambique), which adds an additional border and probable charges to the journey (Posts, 2016). The result could be explained by the slow border crossings in SADC, which is often delays cargo at border crossings (Kamau, 2014).

Furthermore, the frequency which the shipper ships on the corridor (captured by *Ship_Freq*) had a high negative coefficient across alternatives, meaning more frequent shippers prefer road which naturally has a high frequency of service then SSS and rail. This can be interpreted as being indicative of intermodal SSS and rail freight becoming less desirable as a greater shipment frequency is required. This is also reasonable, given that rail freight is generally perceived as slow in SADC, particularly where freight crosses borders (Ranganathan & Foster, 2011). Furthermore, the negative coefficient of SRD and SRL are also consistent with the perception that coastal shipping is slow, and that administrative delays at ports and harbours (i.e. long dwell times) in SADC are significant relative to road freight (Ranganathan & Foster, 2011) which negatively affects the associated utility for respondents shipping at a high frequency.

With regard to shippers who employ own transport, the results confirm in line with intuition that shippers with own transport have strong preference road. This is understandable seeing that a shipper who have invested money into a truck would have bias towards employing their own transport. Notwithstanding this, shippers with own transport when compared to SRL appear to marginally prefer SRL. This perhaps might be for low value, high valume shipments which have no time constraints.

Finally, with regard to NL versus CNL model results, the NL model showed great improvement in model goodness fit from the MNL model. The nesting coefficients captured by λ *RD_SRD* and λ *SRL_RL* in the NL model outcomes are functions of the underlying correlation between the unobserved components for pairs of alternatives in that nest, and they characterize the degree of substitutability between those alternatives. The value of λ *SRL_RL* is not appropriate in both the NL and CNL given it lay beyond 1, however it was statistically significant across models (Koppelman and Bhat, 2006). Furthermore, the model improvement from the NL model to the CNL model structure where all possible correlation is accounted for, implies that the *CNL_SSS* structure is consistent with random utility theory.

7.5.5 Comparing model goodness of fit

Similar to the unimodal SSS setting, the likelihood ratio test was used to compare the estimated models. As Table 7-9 shows, the model fit for the more sophisticated models were compared to the simpler models after every subsequent iteration and using the likelihood ratio test, a chi-square statistic was produced. Starting from the constants only mode, all estimated models were compared against each other. The MNL model with the covariates recorded the greatest improvement in terms of measures for goodness of fit. Subsequently, the NL model recorded 31 units from the MNL model, and the CNL model recorded 9 points from the NL model. The superiority of the NL and CNL models confirm dependencies between linked choices particularly the intermodal SSS alternatives.

Table 7-9: Comparing model goodness of fit

	MNL (constants)	*MNL (base)*	*MNL (covariates)*	*NL_SSS_1 (SRL_SRD)*	*CNL_SSS (all)*
Log likelihood	-1672.928	-1522.155	-1400.759	-1369.466	-1360.44
Pseudo R2	0.0064	0.0959	0.168	0.1866	0.192
Adjusted R2	0.0046	0.0912	0.1591	0.1765	0.1801
AIC	3351.86	3060.31	2831.52	2772.93	2760.88
BIC	3367.47	3101.94	2909.57	2861.39	2864.95
Parameters	3	8	15	17	20
		Likelihood ratio test			
MNL (constants only)	-	*X^2 = 298.4, df = 5 P-v = 0.000*	*X^2 = 544.34 df = 12 P-v = 0.000*	*X^2 = 606.92, df = 14 P-v = 0.000*	*X^2 = 624.98, df = 17 P-v = 0.000*
MNL (base)	-	-	*X^2 = 242.79 df = 7 P-v = 0.000*	*X^2 = 305.38, df = 9 P-v = 0.000*	*X^2 = 323.43, df = 12 P-v = 0.000*
MNL (final)	-	-	-	*X^2 = 62.59, df = 2 P-v = 0*	*X^2 = 80.64, df = 5 P-v = 0.000*
NL (SRL_SRD)					*X^2 = 46.01, df = 4 P-v = 0.000*

7.5.6 Section Conclusion

The intermodal SSS dataset was analyzed with the MNL, NL and CNL models. These models revealed that:

- Similar to the unimodal SSS dataset, intra-urban freight mode choice is influenced by transit time, transport cost, reliability, extend of delay, and frequency.
- Socio-economic factors of shippers including own transport and shipping frequency shows that if unaccounted might hinder the development of SSS. Shippers with own transport have lesser preference for SSS, and similarly shippers with more frequent shippers have lesser preference for SSS.
- Similar to the unimodal SSS component, the intermodal SSS component had difference between the preference of shippers on the two routes. Shippers on the CT~WHK corridor are more receptive to SSS then shippers on the *Dur ~ Har corridor.* This is put down to the additional border cross on the *Dur ~ Har corridor.*
- Finally, the hypothesis that a CNL structure can capture more of the correlation patterns than the standard Nested Logit model structure in such a multi-dimensional choice process was confirmed by the superiority of the CNL model. The superiority of the CNL model, is an indication of the high correlation between intermodal alternatives and the individual modes that make up the intermodal alternatives.

7.6 Chapter Conclusion

The chapter studied the take up of SSS by assessing intra-urban mode choice preference along 5 freight transport routes in SADC. These routes were delineated by unimodal SSS and intermodal SSS; and accordingly, different models were developed; namely, the unimodal SSS dataset was analysed with the BL, ML and ICLV models, and the intermodal SSS dataset was analysed with the MNL, NL and CNL models.

Both datasets indicate that freight mode choice decisions are influenced by transit time, door-door transport cost, service reliability, delay time and service frequency. The individual results further show that, covariates such as shipper characteristics and situational variables also influence freight mode choice, albeit in different ways. For instance, in the unimodal SSS dataset it was observed that shipments on the headway direction and urgent shipments will prefer road over SSS, while in the intermodal dataset, shippers with own transport and the more frequent shipments preferred road over other alternatives. Additionally, the incorporation of latent factors in the unimodal SSS data set revealed that underlying latent perceptions towards transport modes influence mode choice decisions.

"Lempis the shipowner, on being asked how he acquired his great wealth, replied, my great wealth was acquired with no difficulty, but my first wealth, my first gains, with much labor."

~ Epictetus (AD 100)

8 MARITIME CARRIER PREFERENCE FOR SSS IN SADC

From chapters 6-7, shipper and freight forwarder behavior was assessed, and critical inference was drawn in terms of developing SSS in SADC. The discussion would however not be complete without looking at the drivers of maritime transport supply. Therefore, in this chapter, the preference of maritime carriers for SSS is modeled. The chapter proceeds as follow: the study background is first revisited, followed by a description of the data and the sample statistics; then the Ordered Logit (OL) model is developed, and accordingly, critical inference is drawn from the modeling exercise.

8.1 Background and Sample Statistics

8.1.1 A stated Intentions study on the preference of Carriers for SSS in SADC

Recalling the aim of the study captured in Chapter 1, the second part of the study aim was to gauge the perceptions of maritime carriers, and the conditions under which they would want to participate in an integrated SSS network that offers door-to-door intra-urban transport in SADC. Fittingly, in a fourth study conducted as part of the overall dissertation, a hypothetical SSS network (as described in Chapter 1, Section 1.2 and Chapter 4, Section 4.3) was presented to offer a regular door-to-door service between the following port cities: Luanda, Walvis Bay, Cape Town, Port Elizabeth, Durban, Beira, Dares Salam with varying levels of freight rates, freight volumes terminal handling charges, port dues and flag requirements (as depicted in Figure 8-1). Carriers were subsequently asked whether they would participate in the presented SSS system scenario, to which they had to indicate 'Yes', 'Not sure' or 'No'.

Figure 8-1: SSS operations network

The choice attributes were described as follow:

- **Transport Charge:** refers to earnings per container transported door-door. It is meant to cover the freight rate, Port Dues, Terminal-handling charges, land transport costs, and other expenses related to the entire journey of transportation.
- **Dedicated TEU Volumes:** is the number of TEU containers (or equivalent) general cargo volumes made available between every O-D pairing of ports. This amount may be natural or may be induced due to new policies to promote the use of SSS.
- **Flag Requirements:** refers to the ship registration requirements imposed on the SSS operator. To participate in the system, you could be required to register only in a SADC country (such as South Africa or Namibia), or you could be required to register in any country as long as it is not FOC, or you could be given an option to use any flag including FOC.
- **Port Dues Discount:** is the amount in % by which the respective original port dues will be discounted. You may consider your SADC experience when you answer this.
- **Terminal Handling Charge Discount:** is the amount in % by which the respective terminal handling charge will be discounted.

These attributes and their levels were developed from literature and focus group discussions. The first four SCE attributes were taken from a report compiled by the South Africa Department of Transport detailing the role of coastal shipping in the supply of transport services between SADC ports (NDoT, 2011). According to the report, coastal shipping in SADC is characterized by: high port charges, high ship turnaround times in port, low freight volumes, lack of infrastructure for SSS and a political landscape where road enjoys an unfair advantage over coastal shipping. These findings are confirmed by Ensor, (2013) who further provides that ports in SADC have some of the highest port charges in the world.

The last base attribute, flag requirement was included in recognition of the importance played by flagging provisions in the maritime transport industry. Ever since WWII, open registries or flags *of convenience (FOCs)* have become the subject of heated political debate in the global maritime transport domain (ITF, 2012; Richardson, 2012). There have consequently been numerous calls for SADC countries to adopt FOC status. A paper by Robert Knutzen at the 1995 Department of Transport – Shipping workshop in Pretoria, proposed the relaxation of ship registration provisions by South Africa and to assume FOC status (Knutzen, 1995). Correspondingly, Chasomeris (2006) argues, with regard to South African maritime policy, that the maritime fiscal environment is not level and there needs addressing for South African shipowners and operators to compete internationally.

8.1.2 Sample Statistics

Data collection yielded a sample population consisting of 30 shipowners, ship operators and ship agencies currently employed in SADC. Data collection was conducted by paper and pen interviews (PAPI) in Walvis Bay (Namibia), Cape Town (South Africa), Durban (South Africa), Dares Salam (Tanzania), Zanzibar (Tanzania, Luanda (Angola) and Matadi (DRC). Table 8-1 shows the sample result which consisted of a diverse sample of respondents, classed per nationality flag of ship, service sectors, size of companies in terms of number of employees and in terms of fleet sizes. Even though convenient sampling was employed, the generated sample is wide, diverse, qualities which allows us to minimise the sample bias that both stated intentions studies and convenient samples are known for, which also allows us to generalise the results to the larger population.

Table 8-1: Sample statistics: Carrier study

Attribute	**Characteristics**	**Count**	**Percent (%)**
Type of decision maker	Shipowner	22	73%
	Ship operator/agent	8	27%
Company Sizes in terms of number of number of employees	Minimum	0	
	Maximum	0	
	Mean	0	
	1st IQR	0	
	3rd IQR	0	
Company Sizes in terms of fleet sizes	Minimum	1	
	Maximum	5	
	Mean	3	
	1st IQR	1	
	3rd IQR	4	
Shipping Sector	Container	13	43%
	Dry Bulk	4	13%
	General Caro	2	7%
	Offshore	8	27%
	Wet Bulk	3	10%
maritime Service	Coastal	4	13%
	Deep sea	13	43%
	Deep sea & coastal	13	43%
Business Nationality	European	5	17%
	Asian	6	20%
	SADC	18	60%
	Other	1	3%
Ship Nationality	Flag of convenience	25	15%
	Closed	32	20%
	SADC	106	65%
Total number of respondents		30	100%

8.2 Model Development

From the total of 360 decisions made (30 respondents, twelve choice tasks each), a preliminary look at the data shows that 44% of respondents said 'yes' they would participate, 18% of respondents said they were 'not sure', and 39% of respondents said 'no', they would not participate in the envisioned SSS system.

Seeing these choice responses in the carrier survey were ordinal, the ordered logit (OL) model was deemed ideal to draw inference from the data. In this respect, the application of the OL model in the public transport domain has been extensive (Bekhor & Freund-Feinstein, 2006; Calfee, Winston, & Stempski, 2001; Kim, 2014; Wang & Kockelman, 2005), however this is not so SSS and more particularly for carrier preference studies.

It was earlier established in section 3.3.5 that the OL model is a regression model for ordinal response variables which is based on the cumulative probabilities of the response variable, where, the logit of each cumulative probability is assumed to be a linear function of the covariates with regression coefficients constant across response categories.

On this backdrop, the modeling of choice preference within the sample was done so against a set of utility functions corresponding to each choice option in the sample (see section 3.3.5):

$$U_{nsj} = \beta_k X_{nsj} + \varepsilon_{nsj} \quad (46)$$

where U_{jns} is the utility of respondent n in choice situation s for alternative j, which is made up of a deterministic component, $\beta_k X_{nsj}$, and the error term ε_{nsj}.

Given the choice options were 'yes', 'not sure' and 'no', the selected category was defined by the difference between 'yes' and 'no' (τ_1& τ_2 respectively). Apart from this, the model specification process was done in a similar fashion to the shipper behavior study (Chapter 7). The only difference however in this component, modeling started with the base model, followed by two more complex models to account for respondent characteristics.

The selection process of attributes for retainment entailed a successive elimination of parameters based on their significance and the overall goodness of fit parameters. The significance of parameters was tested with t-statistics at the 90% level of confidence and the measures of model goodness of fit (LL, R^2, AIC and BIC).

8.2.1 Developing Model 1 (Base Model)

The base model (model 1) was estimated using only the base attributes in the data set. The base attributes: freight volumes, transport charge, terminal handling charge discount and port dues discount were continuous variables, and the flag requirement attribute was a dummy variable with three levels: flag closed, flag SADC and flag open. The utility function for the base model was specified as follow:

$$\begin{aligned} U_{ns} = \tau_1 + \tau_2 &+ \beta_{Volumes} Volumes_{ns} + \beta_{charge} Charge_{ns} \\ &+ \beta_{THC} THC_{ns} + \beta_{PDues} Port\ Dues_{ns} \\ &+ \beta_{flag\_SADC} Flag_{SADC,ns} + \beta_{flag_{closed}} Flag_{closed,ns} \\ &+ \beta_{flag_{open}} Flag_{open,ns} \\ &+ \varepsilon_{nsj} \end{aligned} \qquad (47)$$

where *j represents* the ordinal alternatives, wherein the intervals are represented by τ_1 and τ_2 respectively, and β *represent* the parameter estimates for the base attributes respectively: Freight volume, transport charge, terminal handling charge discount, port dues discount and flag requirement. The parameters τ_1 and τ_2 respectively denote the preference intervals between the ordinal levels for 'no' and 'not sure' and between 'not sure' and 'yes' in the choice selection.

The maximum likelihood results presented in Table 8-2 shows that all base attributes were statistically significant and had the expected signs. The exception however was *port dues discount,* which was retained based on the researcher's intuition and because it contributed positively to model goodness of fit. Furthermore, the more positive coefficient obtained for τ_2 compared to τ_1 is indicative of a stronger utility for SSS and thus must be construed as a general preference for SSS.

8.2.2 Accounting for Heterogeneity

Subsequent *model 1,* additional parameters were specified and model *2* and *model 3* were developed to account for heterogeneity. Covariates (Δ_x) were selected for inclusion based on the statistical fit and predictive performance of resultant choice models. Specifically, there were two types of covariates that were specified: the decision-maker characteristics (*DM_characteristics*) and opinion polls on key maritime policies.

8.2.2.1 Developing Model 2

In model 2, all the decision maker characteristics as shown in Table 8-1 were tested for inclusion. From these only the type of decision-maker (shipowner or charterer) was significant. With the inclusion of *DM_characteristics* in the modeling specification, the modified utility function now read as follow:

$$\begin{aligned} U_{ns} = \ & \tau_1 + \tau_2 + \beta_{Volumes}\, Volumes_{\ ns} + \beta_{charge} Charge_{ns} \\ & + \beta_{THC}\, THC_{ns} + \beta_{PDues}\, Port\ Dues_{ns} \\ & + \beta_{flag\_SADC}\ Flag_{SADC,ns} + \beta_{flag_{closed}}\ Flag_{closed,ns} \\ & + \beta_{flag_{open}}\ Flag_{open,ns} + \beta_{DM}\ Shipowner_{SO,ns} \\ & + \varepsilon_{nsj} \end{aligned} \tag{48}$$

where for the decision-maker attribute (Δ_x), the shipowner variable was fixed as the reference level.

The results as reported in Table 8-2, show that adding the decision maker variable improves the model goodness of fit. Interestingly however, no significant improvement was added to the model when differentiating between company sizes, shipping sectors and maritime service, indicating that respondents did not hold distinct preference for SSS with respect to these characteristics.

8.2.2.2 Developing Model 3

Subsequent model 2, model 3 was estimated. Specifically, two variables were added that capture opinion polls on two maritime policies (see figure 8-2), namely: whether maritime cabotage should be introduced to the SADC region and whether SADC members should become international registers (flags of convenience). The earlier is justified by the Africa Integrated Maritime Charter (AU, 2010) and the Africa Integrated Maritime Strategy (AU, 2015), both instruments of the African Union (AU) that strongly advocate for maritime cabotage in Africa. The latter is justified by increasing sentiments against stringent maritime policies in SADC member states, which often have been criticized to hamper the growth of the maritime industry (Rennie, 2002; NDoT, 2011; Ombo, 2012).

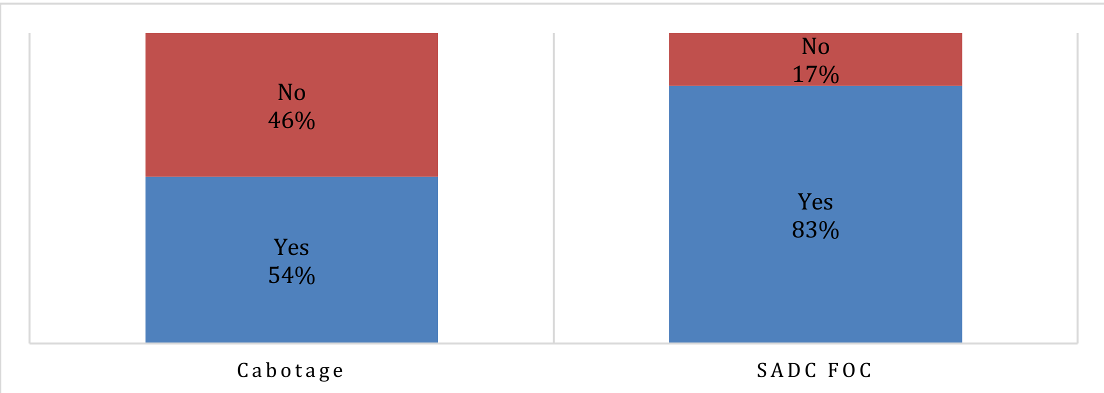

Figure 8-2: Opinion polls on introducing maritime cabotage and FOC status to SADC

The responses to the two-opinion poll question as shown in *figure 8-2* indicates that there are diverse views when it comes to the introduction of maritime cabotage, with 54% of respondents indicating 'Yes' while 46% indicated 'No'. When it however came to ship registration policies, most respondents indicate SADC should introduce FOC provisions. Even though it is clear that carriers want SADC to relax the ship registration provision, it was not as clear for 'cabotage'. To see the actual impact of these polls on the preference SSS, these variables were incorporated as specified in equation 54.

To model the effect of these opinion polls on the preference of SSS, the modified utility function was modified as follow:

$$\begin{aligned} \mathrm{U}_{ns} = \; & \tau_1 + \tau_2 + \beta_{Volumes}\, Volumes_{ns} + \beta_{charge} Charge_{\,ns} \\ & + \beta_{THC}\, THC_{ns} + \beta_{PDues}\, Port\ Dues_{ns} \\ & + \beta_{flag\_SADC}\ Flag_{SADC} + \beta_{flag_{closed}}\ Flag_{closed} \\ & + \beta_{flag_{open}}\ Flag_{open} + \beta_{DM}\ Shipowner_{SO,ns} \\ & + \beta_{DM}\ charterer_{Ag,ns} + \beta_{cabotage\_no}\ cabotage\_no_{ns} \\ & + \beta_{cabotage\_yes}\ cabotage\_yes_{ns} + \beta_{SADC\_FOC}\ FOC\_no_{ns} \\ & + \beta_{SADC\_FOC}\ FOC\_Yes_{ns} \\ & + \varepsilon_{nsj} \end{aligned} \tag{49}$$

where: for the cabotage attribute, the level for 'no' was fixed, and for the SADC variable, the level for 'no' was fixed at the start value.

Table 8-3 shows the maximum likelihood estimate results for the different OL models estimated. The base model is depicted as *Model 1*, the model with the covariates is depicted as *Model 2*, and the model with opinion polls as *Model 3*. *Model 1* reveals the extent to which the choices are determined by the base attributes. *Model 2* reveals the degree of preference heterogeneity within the sample based on decision maker characteristics; and, *Model 3,* is the more advanced model which reveals the effect of the potential impact of introducing FOC status and maritime cabotage to SADC.

The table is structured as follow: the upper part shows the base variables, followed by the decision-maker (DM) characteristics, policy opinion polls and last, the model statistics in the lower part of the table. The shipper characteristics captured the type of carrier (shipowner or charterer); and the opinions polls captured the opinions: 'SADC should introduce maritime cabotage' and 'SADC countries should adopt FOC provisions'.

Table 8-2: Results of OL models for carrier behavior

	Model 1 (base)			*Model 2 (heterogeneity)*			*Model 3 (opinion polls)*		
	Coeff.	r.s.e	rt-r	Coeff.	r.s.e	rt-r	Coeff.	r.s.e	rt-r
Tau1 (τ_1)	3.0897	0.7108	4.35	3.2437	0.7701	4.21	4.4983	1.0616	4.24
Tau2 (τ_2)	4.0625	0.758	5.36	4.2376	0.8338	5.08	5.5681	1.1084	5.02
Freight Volume ($\beta_{Volumes}$)	0.586	0.1176	4.98	0.5759	0.1309	4.4	0.5849	0.1565	3.74
Transport Charge (β_{charge})	0.0711	0.0371	1.91	0.0673	0.0381	1.76	0.0597	0.0464	1.29*
Discount % THC (β_{THC})	1.4477	0.6693	2.16	1.4954	0.7177	2.08	1.4864	0.7799	1.91
Discount % Port Dues (β_{PDues})	0.8887	0.5539	1.6	0.8371	0.5558	1.51	0.7124	0.5376	1.33*
Flag Closed (β_{flag_closed})	0	NA	NA	0	NA	NA	0	NA	NA
Flag SADC (β_{flag_SADC})	0.6	0.3712	1.62	0.6667	0.3731	1.79	0.8031	0.4171	1.93
Flag Open (β_{flag_open})	1.4697	0.329	4.47	1.5832	0.3141	5.04	1.818	0.3429	5.3
DM characteristics									
DM_Shipowner (Δ_{DM_SO})	-	-	-	0	NA	NA	0	NA	NA
DM_Operator (Δ_{DM_O})	-	-	-	0.7171	0.4099	1.75	0.6261	0.5037	1.24
Opinion polls									
Cabotage_No (Δ_{CAB_NO})	-	-	-	-	-	-	0	NA	NA
Cabotage_Yes (Δ_{CAB_Yes})	-	-	-	-	-	-	0.9779	0.3911	2.5
SADC_FOC_No (Δ_{FOC_NO})	-	-	-	-	-	-	0	NA	NA
SADC_FOC_Yes (Δ_{FOC_Yes})	-	-	-	-	-	-	1.0077	0.3103	3.25
Model statistics									
Decision makers	30			30			30		
Observations	360			360			360		
Parameters	8			9			11		
LL(start)	-1207.643			-1207.643			-1207.643		
LL(0)	-395.5004			-395.5004			-395.5004		
LL(final)	-296.4918			-292.5446			-280.4239		
Rho-square (0)	0.2503			0.2603			0.291		
Adj.Rho-square (0)	0.2301			0.2376			0.2632		
AIC	608.98			603.09			582.85		
BIC	640.07			638.06			625.6		

***Notes:* coeff = coefficient, rob.s.e = robust standard error, rob.t-r = robust t-ratio, *insignificant

8.2.3 Modeling results interpretation

The modelling results show that SADC carriers are positively influenced to freight income, discounted port and terminal charges and ship registration policies. The respective weights of these parameter estimates don't vary much across the estimated models, despite the addition of the covariates. Ship registration provisions had the most impact on preference for SSS, with respondents having strong preference for flags of convenience, over SADC and closed registration. This was only natural given FOC flags offer more incentives to register ships. Terminal candling charge discount (β_{THC}) also had significant contribution towards utility for SSS and this we found, coincided with literature that cargo handling in SADC to be most expensive in the world (Ensor, 2013).

The results further show that with regard to decision-maker characteristics, ship owners had lesser preference to participate in SSS then ship agents (operators, agents and charterers). Therefore, ship agents (who don't own ships of their own) are *ceteris paribus*, more likely than ship owning carriers to choose to participate in SSS. This may be attributable to the higher perceived risk by shipowners, who have taken out a mortgage on their vessel, to commit to a system that is new with no surety of success.

With regard to the opinion polls, respondents who said they were in favor of maritime cabotage were also in favor of developing SSS, and similarly, respondents who said they wanted SADC to adopt FOC status marginally favored the development of SSS in SADC. This might be attributable to the fact that small carriers in SADC feel that big global carriers often muscle them out of business. Similarly, carriers who indicated that SADC countries need to adopt FOC status, were more likely to participate in the SSS system; and this perhaps is because these carriers already face management constraints on their ships and were thus inclined to prefer provisions that relax ship registration provisions and associated fiscal policies.

Lastly, the results indicate model improvement in terms of *goodness of fit* from *model 1* to *model 3*. Model comparison is done more in detail in the next section.

8.3 Comparisons of models

The log likelihood (LL) ratio test was employed to test difference in the number of parameters between restricted and unrestricted versions of the model. The model fit for the more sophisticated models were compared to the lesser sophisticated models after every subsequent iteration and using the likelihood ratio test, a chi-square statistic was produced. Starting from the constants only mode, all estimated models were compared.

The results show that *Model 1* recorded the greatest improvement in terms of measures loglikelihood. From a start loglikelihood of -1207.643, *model 1* yielded a final log likelihood of -296.4918. From then on, model goodness of fit measure was marginal, albeit being positive. Notwithstanding these marginal improvements, *Model 3* recorded the best model fit in terms of rho-square, AIC and BIC measures of goodness of fit. From these results, it is further evident that adding covariates and opinion polls provide better fit to the data then just employing generic variables.

Table 8-3: Comparing goodness of fit

	Model 1	*Model 2*	*Model 3*
Parameters	8	9	11
LL(start)	-1207.643	-1207.643	-1207.643
LL(0)	-395.5004	-395.5004	-395.5004
LL(final)	-296.4918	-292.5446	-280.4239
Rho-square (0)	0.2503	0.2603	0.291
Adj.Rho-square (0)	0.2301	0.2376	0.2632
AIC	608.98	603.09	582.85
Likelihood ratio test			
OL model 1	-	*X^2 = 7.89, df = 1, P-v = 0.005*	*X^2 = 32.14 df = 3, P-v = 0.000*
OL model 2	-	-	*X^2 = 24.24 df = 2, P-v = 0.000*

8.4 Chapter Conclusion

This chapter analyzed the results of the carrier study by using the OL model. The results show that competitive pricing for SSS is the first concern from the side of the carrier. Subsequently, from the point of view of policy makers and authorities, the big weights given to flag registration provisions ('cabotage', 'FOC status' and 'Flag') and *THC* for SSS should be the first concern in terms of developing SSS. It is difficult to compare these results with previous work on the development of SSS because no choice study of this nature was developed. We explore in detail the impacts of these models in Chapter 9.

"On the roads which are in the city of Rome or will be within the area where will be lived joined tightly, no one is allowed after next year January 1st to drive or lead a carriage during the day after sunrise and before the tenth hour of the day, except it something to be supplied or transported for building temples of the immortal gods or for the implementation of a work for the authorities, or as from those areas something of those things of which demolition will be put out to tender by the authorities, will have to be removed on behalf of the authorities, except for those cases in which it will be according to this law permitted to certain persons for certain reasons to drive or lead a carriage."

~ *Julius Ceasar,* (Lex Iulia Municilais, BC 45)

9 MODELING IMPLICATIONS

This Chapter considers the implication of the modeling results in Chapter 7 and 8. In particular measures of willingness to pay (WTP) for the shipper behavior component and attribute elasticities for the carrier preference component are estimated, and then these are considered in terms of policies to support the development of SSS in SADC. The reason for the two different approaches is primarily because the cost variable (transport charge) in the carrier preference study was insignificant. Moreover, the carrier preference study unlike the shipper behavior study was a stated intention study which is prone to a lot of bias as it considers the respondents' intentions under extremely hypothetical settings. Therefor any measure of WTP estimates under such circumstances are bound to be too unrealistic to even consider for policy implications. Discussion focus is also on the base attributes of the two study segments, and not on the covariates and latent factors.

9.1 Modeling outcomes for the shipper behavior study: Measures of WTP

The analysis of the economic value of freight transport quality attributes in freight transport research has become one of the most relevant research topics among transport economists (de Jong, 2013). Traditionally, the attention of researchers was devoted to the value of travel time savings, however additional measures of service levels have become increasingly important (Zamparini et al., 2011). For example, Value of Reliability (VoR) has become an important factor in freight mode choice as shippers are increasingly demanding shorter lead times and little variability in service standards. In addition when it comes to developing SSS, Value of service Frequency (VoF) has been cited as a decisive shift factor (Bendall and Brooks, 2011; Brooks et al., 2012b).

The WTP estimate is obtained by substituting a specific attributes of interest (X_{nsj}) with that of a monetary variable ($Cost_{nsj}$), and accordingly it is calculated as the ratio of X_{nsj} over $Cost_{nsj}$ (Hess, 2016).

$$WTP_{X_{nsj}}^{C_{jn}} = \frac{\beta Cost_{nsj}}{\beta X_{nsj}} \times \frac{X_{nsj}}{Cost_{nsj}} \tag{50}$$

This ratio assumes that the utility function is linear in both the estimated attribute and the cost attribute and neither value is interacted with any other variables. Given WTP is given by a ratio of coefficients, when we report the mean of a WTP measure, we do so with a measure of standard error and confidence interval (Hensher et al., 2015, p. 543). There are four general methods to build confidence intervals (Delta method, Fieller method, Krinsky-Robb method, and bootstrapping), but the method of preference in this study is the Delta method as it is the method which is most straightforward to calculate the variance of random parameters and to derive the confidence interval (ibid).

The following WTP measures are estimated for both the unimodal and intermodal SSS study components: Value of Time for Transit time (VOT_{tt}), Value of Time for Expected Delay (VOT_{ed}), Value of Reliability (VoR) and Value of Service Frequency (VoF). These values of WTP are cited as the amount of money an individual is willing to incur per unit of the respective attribute, ceteris paribus. Table 9-1 presents the results, with the calculated mean values for these measures in WTP in US dollar amounts, with the 95% confidence intervals derived for the two study components.

Table 9-1: Measures of WTP for fully laden TEU unit: unimodal SSS component

	BL model			*ML model*			*ICLV model*		
Measure of WTP	coeff.	r.s.e.	r.t-r	coeff.	r.s.e.	r.t-r	coeff.	r.s.e.	r.t-r
VOT_{tt} (US$/day)	261.06	39.951	6.53	261.233	40.977	6.38	261.35	40.912	6.39
VOT_{tt} (US$/hr)	10.89	1.666	6.53	10.89	1.7087	6.38	10.88	1.7087	6.39
VOT_{ed} (US$/hr)	12.42	3.1981	3.88	9.70	2.4821	3.91	10.01	2.4720	3.94
VoR (US$/%)	1.91	1.0405	1.83	2.14	1.0416	2.06	2.18	1.0416	2.26
VoF (US$/DpW)	119.96	19.221	6.24	120.651	19.661	6.14	123.671	19.651	6.34

Table 9-2: WTP measures for fully laden TEU: intermodal SSS component

	MNL_final			*NL_SSS_2*			*CNL_ SSS*		
Measure of WTP	coeff.	r. s.e.	r.t-r	coeff.	r s.e.	r.t-r	coeff.	r.s.e.	r.t-r
VOT_{tt} (US$/day)	303.34	37.892	8.01	259.98	34.3877	7.56	221.86	29.110	7.62
VOT_{tt} (US$/hr)	12.65	1.580	8.01	10.84	1.434	7.56	9.25	1.214	7.62
VOT_{ed} (US$/hr)	22.12	18.536	1.19	-39.18	13.2086	-2.97	-37.66	13.291	-2.83
VoR (US$/33%)	2.87	1.333	2.15	3.86	1.2143	3.18	2.37	0.509	4.66
VoF (US$/DpW)	80.45	26.996	2.98	84.06	22.4785	3.74	82.18	16.697	4.92

The results show that VOT_{tt} in the unimodal SSS dataset is $261 per day (or $11per hour), and in the intermodal data set, $222 per day (or $9 per hour). Noting that the average weight of a fully laden TEU unit in the study was said to be 9340 kg (9.34 tons) in the survey, then the WTP amounts of VOT is equivalent to $1.2 – $1 per ton per hour. This amount is slightly lower than the average transport cost obtained from the RP data of $501.2 per day and the average transport rate of to $1.68 per ton per hour in some parts of SADC (Vilakazi et al., 2014). The average transport rate is US$0.12 per ton per km (Vilakazi et al., 2014). This figure was multiplied by the regional average speed of land transport of 14 km/hour (Lowitt, 2014) to get an equivalent rate for the study.

To compare transit time which was captured per day in the SCE and delay which was captured per hour in the SCE, VOT_{tt} is obtained both per unit day and hour. It is noted that the VOT_{ed} for delay in the unimodal dataset was lower then VOT_{tt}. In the intermodal dataset, it was the other way around, VOT_{ed} for delay was marginally higher than VOT_{tt} for transit time, and it also varied too much across models and was at some point even counter intuitive in the CNL model. This perhaps is because delay was presented as expected delay in the choice game, which made it more probable than actual or fixed. Also, during the focus group discussion of the shipper survey it became apparent that not all shippers are affected by delays at border posts. Some shippers have agents on the ground who often make alternative arrangements to accommodate delayed shipments (see Konstantinus & Zuidgeest, (2018).

The results further show that shippers in SADC have a significant WTP per reliability unit percentage increment at US$2.14 in the unimodal SSS data set and $2.37 in the intermodal SSS data set. This is very low compared to Europe where shippers are reported to have US$4.27 per unit percentage increment (Bergantino & Bolis, 2003), Australasia at US$ 13.83 per percentage increment. The possible justification for the large discrepancy is most probably because of more just-in-time logistics services in more advanced economies which does not seem to be the case in SADC. Nonetheless shippers in SADC indicate that reliability is the most highly considered attribute, to the extent that shippers often pay extra (in the form of bribes and fees) to ensure high service reliability (Konstantinus and Zuidgeest, 2018).

Furthermore, the results show that transport modes with higher service frequency offer critical value in SADC, and SSS if properly developed, must offer more frequent service. SADC shippers have a strong WTP for increased service frequencies, at US$121 in the unimodal SSS and US$82 in the intermodal SSS dataset. This figure is lower than VoF values for SSS obtained in the US at US$1100 per weekly departure (Puckett et al., 2011), but is higher than figures reported for Europe at US$27 per additional departure per week (Feo et al., 2011). The figure is however similar to the VoF for Australasia at US$82 (Kim et al., 2014). The large disparity between the values might be correct for the respective regions, however we must be cognizant of the sample size, type of shipments and transport units employed in the study. That said however, we can have confidence that gains in frequency of service results in more utility of the freight transport alternative.

When the WTP estimates from the different estimated models per respective dataset are compared, it is apparent that the mean values for WTP gradually decreases as more complex models are estimated. There are also substantial differences in the mean values for the base model VoF and for the final MNL model. The mean WTPs and confidence intervals vary significantly among the estimated models, especially between the base models and the more advanced models, and much of this variation can be put down to the treatment of heterogeneity, suggesting that there might be different values of WTP for different subsets of the data.

Furthermore, when the WTP estimates between unimodal and intermodal settings are compared, the WTP values for the unimodal SSS component are marginally larger then the intermodal SSS study component (see Figure 9-1). These marginal differences are also uniform between the two datasets. The exception however is VoT_{ed} which is positive in the unimodal data set but negative in the intermodal SSS dataset. This goes to show that SADC shippers in the hinterland are first of all more receptive to long delays then shippers in port cities. This is also understandable as the intermodal corridors often transit through more border posts, meaning more paperwork, then the unimodal corridors which use only two border crossings. Some border posts in SADC, as earlier identified have long delays due to congestion which at times can span as long as 60 km long (Swarts et al., 2012).

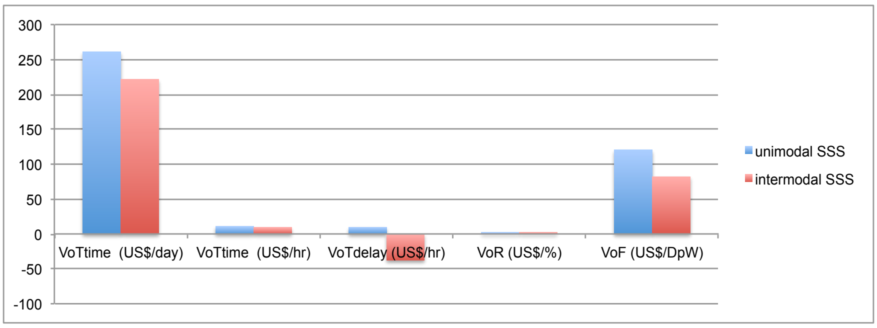

Figure 9-1: Obtained values of WTP

The marginally high WTP values in the unimodal dataset can also be put down to service levels of SSS, which are currently reported to be poor. Port cities in SADC are prone to congestion, and often the ineffectiveness of port make transport to and from them costly and unattractive (Pirie, 2013). Moreover, the intra-regional freight traffic between port cities is low; as opposed to traffic between ports and the hinterland (Konstantinus et al., 2019). This has driven down the cost of freight transport port-inland as opposed to port-port.

9.2 Modeling outcomes for the carrier preference study

The stated intentions study for the carrier preference component was analysed with the OL model as discussed in Chapter 8. From the modeling results, a key take away is that the development of SSS is largely impacted by regulatory policies that concern ship registration, maritime cabotage, terminal handling charges and freight volumes for SSS operations. The extent to which each of these attributes are impactful can be studied by estimated the extent to which changes in these attributes will affect the probability of the carrier participating in SSS.

Analysis is started by exploring segments of the ship registration provision (the *flag* attribute), which showed the biggest utility for SSS as reported earlier in Chapter 8, Table 8-2. The *flag* attribute employed a non-linear coding scheme, and accordingly to assess the individual impacts of the change in utility between different levels of this attribute, change scenarios were simulated. In Figure 9-2 below, the impacts on probability between the different types of ship registration options presented to the respondents in the survey are compared. These impacts were calculated for the three different flag options as follow: closed registry, FOC registry and a SADC registry. The results below were obtained by simulating a change to each level, of the *flag* attribute.

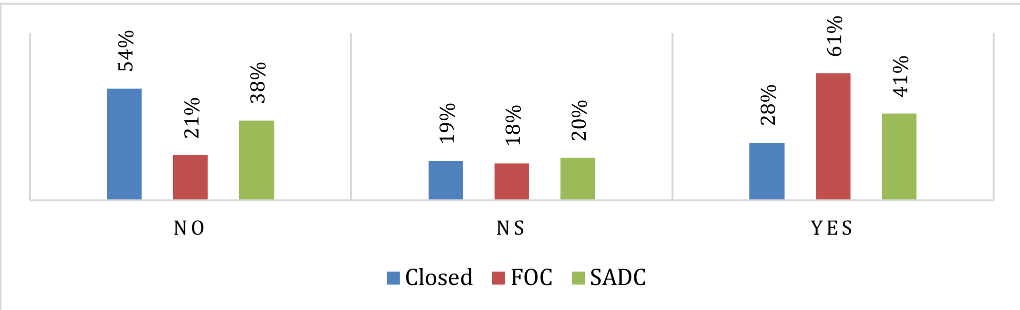

Figure 9-2: Impact of ship registration provisions on carrier preference

The simulation results show that the 'closed' flag option will result in a lower participation with 54% on the 'No' option, 19% Not sure, and a meager 28% on the 'Yes' option. Specifying the 'SADC' flag option will result in a more improved participation in SSS with the results showing 38% No, 20% Not sure and 41% on the Yes option. Lastly, the 'FOC' flag option will result in the most improvements with 21% on the No option, 18% Not sure and 61% on the Yes option. The results further show that the *Closed flag* and *FOC flag* flags options have higher certainty, which is visible in the big differences between Yes and No in these respective options, as compared to the *SADC flag* which has a low range between Yes and No, and a higher percentage in the 'Not sure' option. These results clearly offer some validation in terms of the extent to which each of these flag options will contribute to the development of SSS in SADC.

Subsequently, the attribute elasticities for the economic variables are estimated: *freight volumes, THC discount* and *PD discount*. The measure of attribute elasticity in freight mode choice refers the measure of change in mode share due to a 1% change in attribute. According to Hensher et al. (2015) elasticity is formally defined as 'a unitless measure that describes the relationship between the percentage change for some variable and the percentage change in the quantity demanded, *ceteris paribus.*' Elasticity is further classed into two types; *direct elasticity* which is the percentage change in probability of choosing an alternative given a percentage change in the attribute of that alternative; and *cross elasticity* which is the percentage change in probability of choosing an alternative given a percentage change in the attribute of a competing alternative (Hensher et al., 2015).

On this backdrop, the elasticity *(E)* of the probability of alternative *j* for respondent *n* with respect to a marginal change in *k*th attribute of in the OL model was calculated as follow:

$$E_{X_{ikn}}^{P_{in}} = \frac{\partial P_{jn}}{\partial X_{jnk}} \times \frac{X_{jkn}}{P_{jn}} \tag{51}$$

Seeing this equation makes reference to percentage changes, the elasticities were only derived for the continuous base variables(excluding the dummy variables). These estimated elasticities allow for the determination of the responsiveness in the probability of carriers participating in SSS in response to unit changes in the base attributes. Table 9-4 presents the results which were obtained by simulating 1% changes in the dataset.

Table 9-3: Estimated measures of elasticity

Attribute	No	NS	Yes
Freight Volumes	-0.3885928	-0.1522578	0.3882877
THC discount	-0.1309032	-0.0628748	0.1382521
PD discount	-0.061713	-0.032341	0.066627

***Notes:* DE= Direct elasticity; XE=Cross elasticity; NS=Not Sure

The estimated elasticities in Table 9-3 indicate that the base attributes are relatively inelastic, with PD discounts being close to being unit elastic (almost zero). That said however, among the three attributes, the probability of a carrier operating their vessel is affected most by changes in freight volumes then changes in *THC* and *PD discounts*.

In line with these results, Figure 9-2 further shows the change in probability of carriers participating in SSS with a 1% increase along three scenarios: 1% increase in freight volumes, 1% increase in terminal handling charges (*THC discount*) and 1% increase in port dues (*PD discount*).

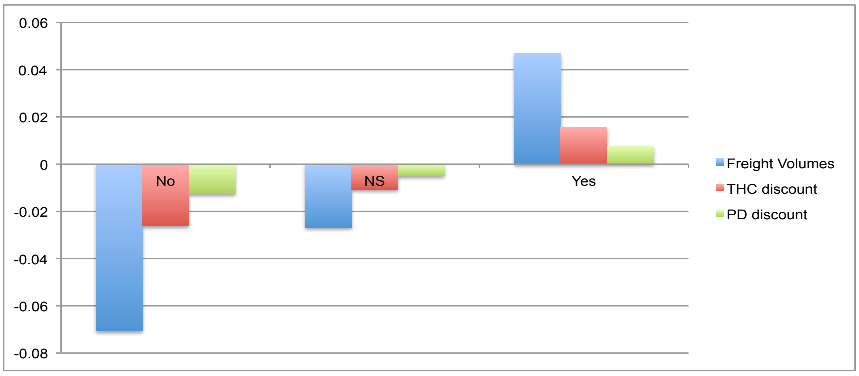

Figure 9-3: Estimated mode shift change due to 1% change

The results show that if freight volumes are increased by 1%, the probability of carriers participating in SSS goes up by 0.5%, and 'No' and 'Not sure' goes down by 0.3% and 0.7% respectively. If terminal handling charges are increased by 1%, the probability of carriers participating in SSS goes up by 0.2%, and 'No' and 'Not sure' goes down by 0.1% and 0.3% respectively. For port dues discount, the changes are even more marginal. The results show that if port dues are discounted by 1%, the probability of carriers participating in SSS goes up by a meager 0.08%, and 'No' and 'Not sure' goes down by 0.05% and 0.1%.

These findings suggest that the most effective economic variables in convincing carriers to participate in SSS is the freight volumes. In this regard, the low level of intra-regional trade in SADC might be an impediment to the development of SSS (Chidede, 2017). As a result, assigning more intra-regional freight volumes to maritime transport might be a policy consideration. Coercing shippers to use SSS might not be as easy as thought, the alternative option under could be the assignment of internationalized freight to maritime transport by introducing maritime cabotage.

Finally, the marginally high effect of terminal handling charges also implies that SSS operations should be incentivized, either by relaxing charges accorded to them or by offering direct incentives to SSS carriers that can offset the high terminal handling charges. This conclusion is not new; worldwide those interested in the promotion of SSS have often argued that incentivizing SSS operations is one way of developing the system (Strandenes and Marlow, 2000; Trujillo and Medda, 2009).

9.3 Policy implications and interventions

The implications of the modeling outputs demonstrated the extent which key SSS demand (shipper) and supply (carrier) attributes can affect the development of SSS in SADC, and by implication, how they could be adjusted to develop SSS in SADC.

9.3.1 Reducing transit time for SSS

The obvious intervention to grow SSS in SADC is first to reduce the ship turnaround time in port by improving port and terminal efficiency. To that effect, there are various techniques and interventions discussed in literature (See for instance Mokhtar & Zaly Shah, 2006; Tongzon, 1995; UNCTAD, 1985), and these were touched on during the study development stage (see Chapter 2). Examples of actions to improve port and terminal efficiency for SSS include:

- Reducing the turnaround time for SSS ships by: docking them and tending to them on arrival,[62] by providing 24 hours cargo operations to SSS, and by speedy administrative procedures for preparing to load and unload ships; and pilotage (Merk and Dang, 2012).
- Improving terminal efficiency by developing dedicated berths and cargo operations for SSS, and by introducing port operational concepts such as 'lean port' and 'cross docking' which allow maximizing of resources and removing waste from operations (Talley, 2014).
- Improving the connectivity of SSS berths to land based modes of transport (Musso et al., 2010).
- Combining land-sea transportation modes by promoting mutual co-operation between modes and carriers to guarantee delivery times (Steyhre et al., 2014).
- By employing various information technology applications to make port operations efficient, such as Electronic Data Interchange (EDI) for the commodity flows or Intelligent Transportation Systems (ITS) for port traffic management (Ng et al., 2013).

In addition, a critical issue in the modelling results of Chapter 7 was the customs provisions, which emerged critical, particularly in the intermodal transport component.

[62] For this to happen easily, the ship specification for SSS was characterized as a container ship with capacity of 400 TEUS, with a maximum loaded draft of 5m, propelled by controllable pitch propeller with bow and stern thrusters to allow self-docking. The specification might also be extended to ro-ro ships of similar features. The idea we want to sell is standardization.

This was purported in Chapter 7 to be the reason why in the intermodal SSS data set, respondents indicated less preference for intermodal SSS on the *Dur ~ Har corridor* as that would mean transiting an additional border compared to the *CT ~ WHK corridor* which only had one border to cross. A customs challenge identified in Europe during the early years of SSS was the delay in the commencement of cargo operations in SSS until all clearances have been received, and the non-availability of customs services in ports on a 24-hour basis furthermore inhibited the development of SSS in Europe (Zielinski, 2011). Europe addressed these problems by electronic authorisation, registration in operator systems (EOS) and electronic notification and customs (cargo does not need to be presented) (ibid). The conception of the 'Blue belt', which refers to the seas and oceans surrounding the EU, where intra-EU maritime transport can operate with low administrative burden; has allowed the use of surveillance, to help provide guarantees to customs and simplification of the goods clearance processes (ibid).

9.3.2 Making SSS cost competitive

In both the shipper and carrier studies, transport cost had a comparatively low marginal effect then the other attributes, and moreover in the carrier study, the freight charge was statistical insignificant. That said however, the effect of port dues and terminal handling charges on the likelihood of carriers participating in SSS was significant, and to that extend, port pricing has an influence on the viability of SSS in SADC.

Port pricing can be influenced by policymakers and to that effect should be adjusted to make SSS attractive. In Europe, Ng (2009) found that effective port pricing was pivotal to the competitiveness of SSS, particularly on routes connecting West Europe and the Baltic States. This was then sustained by enhancing port efficiency across the board, by enacting fair competition between ports, and by harmonizing charging principles across European ports. The European council also recommended a pricing system based on short term marginal social costs (including external costs) where users pay for the costs they incur for using the infrastructure (ibid). The whole idea was to make sure ports recover the actual costs incurred, including costs for new investments, operating costs and external costs, that insure fair port competition and more strategic pricing (Strandenes and Marlow, 2000).

Notwithstanding the low marginal effect of changes in freight transport costs in the shipper behavior models, road transport prices cannot be ignored, as the estimated elasticities show. Governments in SADC could subsequently consider fair market pricing options in freight transport. According to studies done, road freight in Africa is underpriced, meaning that the current costs do not cover the significant externalities emanating from it (Makamo et al., 2015). An efficient mobility model for Africa for the future must thus consider the true costs of transport and its regulatory framework will need to create incentives for people to make sustainable transport choices. If the concept of fair market pricing is applied,[63] the cost associated with the negative externality can be internalized in the transport price that is incurred by the transport user so that the total transport price is based on the full marginal cost for the mode. By so doing the system will correct the market failures caused by negative externalities. Fair pricing is based on the international law principle of "polluter pays", which requires the pollution causing party to bear the costs of rectifying (Schwartz, 2005).

9.3.3 Policies to induce freight for SSS

It furthermore became apparent from the carrier study that SADC needs to induce freight for SSS to make it viable. This is important seeing the competitive advantage of SSS is derived from economies of scale and density, which allows SSS to offer very low freight rates compared to road and rail. A key approach in many regions is through political action.

A good example is found in Europe, with the EU Integrated Maritime Policy (EC, 2011a). It addresses the issue of unfair competition that is enjoyed by road in Europe, it aims to even the platform so SSS can compete fairly, and it also emphasizes the need to keep supporting SSS because of better energy efficiency achievable compared to road transport. Policies such as these can be used as a first step to motivate a mode switch towards SSS in SADC.

Another lesson from Europe is the action to boost the competitiveness of SSS. In Europe this entailed a number of research-based-actions: including the preparation of guidelines for custom procedures, the identification and elimination of obstacles, research and technological development (such as the application of electronic data interchange for customs procedures) and Short-Sea Focal Points (SSFP) (ECSA, 2016). The SSFP's have

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[63] Fair Market Pricing is a method often employed to mitigate the effects of externalities *in eodem tempore* improve sustainability in freight transport. Three general approaches exist which governments can take to internalize externalities: Command-and-Control regulation whereby governments use regulations to set a quota of externality, Pricing methods whereby taxes or fees are charged for polluting and, Cap-and-Trade where polluters are assigned credits and they can trade these below a certain threshold. For further reading, see (Schwartz, 2005).

been setup in major European cities to improve the image of maritime transport, by providing concrete information on SSS to EU Member States, and by promoting SSS as a valid alternative to road haulage and by collecting useful statistical information. There were also actions to create 'one-stop' offices for administrative and customs formalities to enhance interoperability and intermodality in Europe.

9.3.4 Additional considerations for intermodal intra-regional transport

With regard to intermodality, the ease of accessibility to ports and port infrastructures is the first priority to make SSS more accessible to the intermodal carrier. In this study, the SADC freight study uncovered that maritime transport is not well integrated with complementary modes of land-based transport (see Annex II).

The earlier proposed actions may be supplemented by designating or incepting a trans-SADC network for freight carriage, on which SSS will be incorporated; similar to the motorway of the seas in Europe and the marine highways in the USA. Additionally, SSS could be incorporated into the regional transport infrastructure planning and the integration of certain maritime ports as multi-modal interfaces into the larger SSS system, to ensure that SSS receives as much attention as road and rail currently receives. The system components for this network might include the national port authorities, shipping lines, hinterland connections, designated sea routes between key ports in the region and a comprehensive use of information systems for data capturing.

A final consideration might include a move towards standardization across modes. For instance, adopting containerization across the freight transport industry might allow for small items of goods to be stowed in a reusable container, which can easily be transferred from one mode of transport to another.[64] The growing significance of containerization is a reflection of changes that have occurred over time in the international organization arrangement of manufacturing and production. These changes have created opportunity for SSS to flourish on other regions scale because where the demand and supply ratio persist to put pressure on transport costs, the capability for large economies of scale for unitized cargo increases the attractiveness of SSS.[65] Containerization has potential to

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[64] The quality of transferability has led to the container to be widely adopted in freight transport (Vigarié, 1999). Today it is estimated that 90 percent of non-bulk commodities are carried in container. There is also an evident trend of bulk cargo and other industries adapting and changing to containerization (Tomlinson, 2009).

[65] To meet transport demand, SSS employ ships that are fairly smaller, with a range in size between 400dwt to 6000dwt (roughly 700teu) (Stopford, 2009). Small bulk carriers, tankers, containerships, and ro-ro ships

address an important deterrent to the development of SSS; particularly its inability to provide door-to-door transport services. For SSS to complete a door-to door service, collaboration must be had with rail and road for the pre and end carriage sections of the trip. Therefore, the use of the container as a common unit of carriage across all the modes involved in the transport chain improves the transferability of the container. The use of the container also improves the interconnectivity, interoperability or compatibility of information technology as the same equipment of is required to handle the container regardless of mode used.

9.3.5 Maritime specific policies

The very last consideration is accorded to maritime policies to develop SSS. The carrier study revealed that carriers in SADC are more likely to participate in SSS if maritime cabotage was introduced and if ship registration laws were relaxed.

Principally, a key finding from the carrier study was that carriers were more likely to participate in SSS if maritime cabotage was introduced to SADC. In retrospection, it was mentioned that an important step in the development of SSS in Europe came in 1985 with the liberalization of European coastal shipping services (Pallis, 2002). However, the cabotage policy changes in Europe were done gradually, which ensured that European shippers-maintained control of the market share, and so by the time maritime cabotage was entirely liberalized, it was very difficult for non-European carriers to enter the market. Therefore, one could argue that a similar approach be taken in SADC. Maritime cabotage may thus be introduced in SADC, and then later removed when the SSS markets have matured at a level that allow local carriers to compete with non-SADC carriers.

Finally, the process to own and register a ship is a tedious one in many SADC countries, and hence could affect the take up of SSS. According to Hare (2012) ship registration provisions can affect the profitability of shipowners and consequently, this can affect the viability of SSS in SADC. Therefore, without addressing the fiscal environment of shipping, there is little chance for developing SSS effectively. On this, Chasomeris (2006), talking about the South African maritime policy, argues that "*A comprehensive package of*

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are employed to fit shipment requirements. Many of these are traditionally slow moving (averaging speed of 13 knots) however, the need to improve service times have seen the introduction of faster ships such as wave pierce catamarans and other high speed water crafts where demand is high. The designs of these ships place much emphasis on cargo flexibility, and maneuverability to be able to enter and depart ports quickly, and with little pilot assistance as possible (EC, 2006).

policy measures needs to be put in place with a tonnage tax as a key policy…. With an improved fiscal environment, a more cohesive set of partnerships between traders, carriers, the financial sector and the state should result, and these in turn are likely to confer significant benefits on the wider South African economy." (Chasomeris, 2006). The above extract can also be said for the entire SADC region. That is, SADC member states should, revise their ship registration policies to induce the growth of maritime transport in the region.

9.4 Chapter Conclusion

This chapter employed the modeling results of the shipper behavior and carrier preference components to draw further inference from the modeling results by considering possible implications in terms of policy action and initiatives to develop SSS. From the shipper behavior component, measures of willingness to pay (WTP) were obtained and interpreted. High WTP values were obtained for Value of Time (transit time) and Value of Frequency, thus indicating that SSS could be developed if policy actions are targeted towards improving transit time for SSS and frequency of service.

The modeling result from the carrier preference study were employed to estimate attribute elasticities from which learn the potential impact of taking certain actions. The results show policy action for ship registration and to dedicate freight volumes to SSS are the two biggest actions to develop SSS in SADC.

As a final contribution, the chapter discusses how the above modeling outcomes may be actuated through policy and actions, taking lessons from international practice.

con•clu•sion

[kuh n-**kloo**-zhu*h* n], *noun*

'the place where you grow tired of thinking'

10 CONCLUSION

This chapter summarizes the results of the thesis. In so doing, it revisits the motivation of the research, the objectives of the research, key findings of the research and it provide a direction as to the futures areas of research.

10.1 Research motivation and objectives

10.1.1 Motivation

The motivation of this research is rooted in the need to develop SSS to realise a seamless and sustainable freight transport system for the SADC region. SSS is both an environmentally friendly mode of transport and can accommodate large volumes of freight compared to road and rail. This, we found, is needed in SADC, seeing many of the SADC countries use a national net of roads to move freight, despite road being the most expensive, most polluting transport mode; and moreover, whilst maintaining the highest rate of fuel consumption per distance traveled and cargo unit carried.

The strengths of SSS versus rail and road are discussed in Chapter 2 and they include: low environmental costs, fewer accidents in terms of human safety, low energy consumption, and low transport costs. The introduction of SSS as an additional mode of freight transport to the SADC region has good potential to cause a reduction in road congestion, transport related accidents, air pollution, and a reduction in capital investments in freight transport infrastructure and systems.

In this study, SSS was first theoretically assessed, and subsequently conceptualized as an intra-regional freight transport system that offers door-door transport solutions. The conceptual framework was developed in a discrete choice setting that was used to gauge the preference of shippers and carriers in order to determine the conditions under which they would use the system. Against this backdrop, the idea of the research was to analytically characterize the needs of SSS in the SADC region and to determine what needs to be done to achieve such a system.

10.1.2 Objectives and thesis structure

In line with the study aim, discrete choice models were developed to determine the favorable conditions under which SSS would be employed by shippers and at the same time, maritime carriers would participate in the envisioned SSS system. Building on this aim, the thesis addressed four main research questions:

i. What are the general determinants of SSS, and how does SADC fare in terms of these?
ii. Which choice factors influence freight mode choice decisions in SADC and what importance do shippers associate with their definitive attribute levels, both in a unimodal SSS setting and an intermodal SSS setting?
iii. What importance do maritime carriers associate with definitive attributes and attribute levels of the regional maritime transport industries?
iv. What is the impact of these findings on policy interventions, and SSS infrastructure development with regard to the attractiveness of SSS?

These research questions were pegged to six specific research objectives.

The first objective was to assess the determinants of SSS and the transport conditions in SADC and this was done in Chapter 2. It was a necessary base, to describe SSS and to assess weather opportunities are available for SSS to develop in SADC. Determining the enablers and inhibitors of SSS in SADC was also necessary to assess the theoretical viability of SSS in SADC.

The second and third objective were majorly addressed in Chapter 6 and included: determining the decision maker in terms of freight mode choice and determining the choice factors that are most important to a shipper. These objectives were linked to the shipper behavior study reported in Chapter 7 and developed in Chapter 5.

The fourth objective was wider and included determining specific freight transport corridors, optimal sample sizes that is representative of the SADC region, subsequently developing the stated choice experiments, associate survey instruments, and discrete choice models (DCM) to assess shipper behavior in SADC. Moreover, effort was made to assess the preference for both unimodal and intermodal SSS. This objective was addressed in Chapters 5, 6 and 7. In Chapter 5 the corridors were developed, the experiments were developed, and the sample size was set to a minimum of 50 respondents per corridor. The corridors determined ran more or less parallel to the ocean, with distances long enough to justify the inception of SSS, which included: Cape Town ~ Windhoek, Durban ~ Harare, representing the intermodal SSS component; and Cape Town ~ Walvis Bay, Walvis Bay ~ Luanda, Durban ~ Beira, representing the unimodal SSS component. Subsequently, the modal attributes developed in Chapter 6 were employed to seed the choice experiments, the results of which were employed to develop the choice models in Chapter 7. Accordingly, different types of discrete choice models were developed to analyse the data. Namely, for the unimodal SSS dataset, the binary logit was employed as the base model and then the mixed logit and ICLV models were employed to account for random heterogeneity and to assess the impact of latent perceptions on the preference of SSS. The data revealed much random heterogeneity which is indicative of variability in the mode choice preference of shippers. In the intermodal SSS dataset, the multinomial logit formed the base model, and the nested logit and cross nested logit models were employed to account for correlation and cross-correlations amongst the intermodal alternatives.

The fifth objective was addressed in Chapters 5 and 8 and included the evaluation of the supply side of SSS. In Chapter 5, the choice experiments and associate survey instruments were developed, and the sample size required at least 24 respondents. The data collected was analysed in Chapter 8 with the ordered logit model. In particular, the preference of carriers to participate in SSS was assessed under certain maritime conditions defined by: freight charge, freight volumes, port dues discounted, terminal handling charges discount and flag requirements of ships. Moreover, the impact of covariates and opinion polls on the participation of carriers in SSS was also assessed to indicate the extend to which they contributed to the preference of SSS.

Finally, the sixth and final objective was to evaluate the impact of policy interventions, and SSS infrastructure development on the attractiveness of SSS. This was done in chapter 9 by estimating willingness to pay measures for shipper behavior results and estimating elasticities and change scenarios for the carrier preference results. The scenarios presented in Chapter 9 serves to illustrate the wide issues and interventions which can be explored with the developed models. Subsequently, the impacts of these results on SSS related policy was discussed, in particular the impact on port efficiency, and road transport pricing.

10.2 Key findings and contributions to existing literature

The key findings were developed in the thesis which makes a number of contributions to existing literature. Firstly, the literature review presented in Chapters 2 makes contributions to freight transport in SADC by describing the freight flows and the overall freight transport setting in SADC. Chapter 2 also makes key contributions to maritime transport in SADC by extending the knowledge developed by the South African National department of Transport on SSS on the determinants of coastal shipping in SADC (NDoT, 2011). The conclusion of Chapter 2 is that the opportunities for SSS are theoretically available given the large geographic region, the projected freight volumes and the customs and trade policies that the SADC region is pursuing. However, there are a number of shortfalls that needs to be addressed. Of note, port competitiveness, customs provisions and policies for intra-regional trade require impetus. Additional work is also required in terms of policy to support SSS. Moreover, Chapter 2 makes key contribution to the global body of maritime literature when it considers the development of SSS in a developing region, in particular to Africa. The idea of SSS in SADC brings with itself certain cultural anomalies, under a different composition of geography, law and level of maturity of the industry.

Chapter 4 extends existing work in freight behavior research when it considers the literature for the discrete choice modeling framework from a freight perspective and more so from an SSS perceptive, by tracing the evolution of intra-urban freight behavior research and associate discrete choice modeling techniques. The approach taken considers the different study approaches in the literature review cannon, namely the choice models employed, the data types employed, and the study units employed to study the development of SSS. The key findings that emerge from Chapter 4 include:

- The concentration of freight behavior research is centered mostly in Europe, North America and Australasia with Africa and South America receiving very little attention.
- Most behavioral studies to develop SSS have been from the shipper perspective and almost none from the carrier perspective.
- Shipper behavior studies to develop SSS have been studied both in the unimodal and intermodal SSS settings, however explicit delineation (as we have done) has often not been made.
- The experiment design approaches in most stated preference studies have been orthogonal, however recent freight behavior research is employing efficient designs, in particular d-efficient experiment designs.
- The attributes employed in most freight mode studies literature was mostly arbitral and taken from existing European literature.
- And last, it is not quite clear who the decision maker is. Most studies have employed either shipper or freight forwarder depending on whom they believed was the decision maker.

Moving on, Chapters 6- 8 employed different types of discrete choice models, in line with the second part of the thesis title: "Evidence based on discrete choice modeling" to address the respective research objectives. These models were developed from the data collected as detailed in Chapter 5 (i.e. the methods chapter), from surveys designed in line with the requirements of these models.

Chapter 6 makes key contributions to the existing body of freight behavior research when it addressed the question 'who is the decision-maker in freight mode choice?' and 'what are the most important modal attributes in SADC?' Key findings from Chapter 6 is thus, the shipper is the dominant decision-maker in SADC and the freight forwarder is the advisor; and with regards to the ranking of mode choice attributes, the results of the exploded logit model reveal the following order of modal attributes in order of importance: reliability, transport cost, risk of damage, frequency of service, transit time, customer service, service flexibility, monitoring and environmental friendliness.

In Chapter 7, different types of discrete choice models were developed to analyse the SP data collected from shippers on O-D paired routes where SSS could possibly be developed. The result firstly show that intra-urban freight mode is influenced by transit time, transport cost, reliability, expected delay time and frequency of service. Moreover, the result show that, shippers with an urgent shipment and those transporting on the head leg of a transport journey would derive negative utility from employing SSS. With regard to the latent factors, the results of the ICLV model reveal that latent perceptions will influence the take of SSS in SADC, of note, road captive shippers are less likely to use SSS, however deteriorating road conditions and concerns for road safety might coerce shippers to use SSS.

Chapter 7 makes key further contributions with regard to intermodal SSS. Firstly, the intermodal dataset also reveal that shippers are sensitive to transit time, transport cost, reliability, frequency of service and extend of delay. That said however, there are differences in the preference for SSS along the routes. On the intermodal SSS routes, shippers who employ own transport, and who ship more frequently prefer road then intermodal SSS alternatives. Furthermore, shippers on the Cape Town ~ Windhoek route reveal more preference for intermodal SSS compared to shippers on the Durban ~ Harare route. Furthermore, the use of the nested logit and cross nested logit models in the intermodal SSS dataset was to account for correlation and cross-correlations amongst the intermodal alternatives. The superiority of the CNL model, is an indication of the high correlation between intermodal alternatives and the individual modes that make up the intermodal alternatives.

Furthermore, the carrier preference study reported in Chapter 8 revealed the stated intentions of maritime carriers to participate in SSS for SADC. The study revealed that the intentions of carriers is influenced by the intra-urban (intra-regional) volumes of freight available for maritime transport, the port dues charged, the terminal handling charges and the flag requirements in terms of ship registration. Furthermore, the study revealed that shipowners are less receptive of SSS then ship operators and charterers. Moreover, carriers who were in favor of maritime cabotage and those who would like to see SADC introduce flags of convenience were more receptive of SSS.

Over and above the key findings discussed above, the conceptual framework described in Chapter 8 contributes to literature in two important respects. Firstly, by modeling the use of SSS in a virtual transport environment contributes to the global body of maritime research in transport. This is important, seeing that previous freight mode choice studies on SSS have not studied SSS from a carrier behavior perspective. Secondly, the use of a stated intentions study and the developed of an ordered logit model presents a novel approach to understand carrier preference. Most studies conducted from the carrier perspective are mostly theoretical with more focus on policy and technical aspects of ships and ports. Thus, this approach extends existing literature by enabling explicit representation of carrier preference.

The final analytical Chapter of the thesis (Chapter 9), which considered the willingness to pay (WTP) measures of the shipper behavior study and attribute elasticities of the carrier study to assess the impact of policies to develop SSS, also makes two key contributions. Notably, the results from the shipper behavior study reveal the greatest impacts on mode shift towards SSS is by reducing the transit time and increasing frequency of service for SSS. With regard to carrier preference, the attribute elasticities from the carrier study reveal that FOC ship registration and dedicating freight volumes to SSS has the greatest impact on developing SSS in SADC.

In summary, the study investigated opportunities for SSS in SADC by studying the preference of shippers and carriers. The research findings indicate that the potential for SSS can be developed, on routes were unimodal and intermodal SSS alternatives can be employed. However, for this to happen, authorities need to consider a myriad of factors including the shipper characteristics, carrier characteristics, situational variables, shipment characteristics and transport polices that can influence the modal shift from road to SSS.

10.3 Future direction of research

Although the research makes a number of contributions, there are future areas of research that can be explored in line with the findings and the research area.

First of all, the shipper behavior component collected both RP and SP data, however only SP data in line with the research objectives was employed for the study. The RP data was mostly employed for the SP diagnostics (attached in Annex VI) and to compare the WTP measures obtained from the modeling results in Chapter 9 (Section 9.1). Future research could employ both the RP and SP data to get more robust modeling results which can even be used to forecast.

Secondly, in the diagnostic questions for the SP components, respondents indicated that reliability is the most important attribute that they considered yet this did not come out strongly in the models developed. It is suspected q this was due to a simplification of the reliability attribute. Indeed, this has been reported in numerous studies as an issue in freight behavior research (Brookes et al., 2010). Future areas of research could explore alternative ways to effectively capture reliability and compare to these results.

Thirdly, since this research both in subject and approach is the first for the SADC region, there are no previous results with which they can be compared. Indeed, the results for the shipper behavior component was delineated along unimodal and intermodal SSS and subsequently compared; however similar studies could be appropriate in order to enhance the understanding which can provide a solid base for policy decisions.

Finally, seeing the study was constrained by a low budget, and a language barrier that restricted data collection to freight transport routes were English was at least spoken. Further research could translate the questionnaire into French, Portuguese and Swahili to extend the study on other routes in SADC.

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ANNEX I: SADC FREIGHT STUDY QUESTIONAIRE

Start

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SURVEY ON FREIGHT TRANSPORT IN SADC

Thank you for participating in this survey.

The survey is meant for any entity (company or individual) who dispatches freight along the major corridors in Mainland SADC. This includes shippers (i.e. importers, exporters), freight forwarders and company managers in charge of logistics.

The aim of the survey is to improve the understanding of freight mode choice decisions , and to identify the factors that influence these decisions.

The survey is being conducted by Abisai Konstantinus, as part of his PhD studies, supervised by Ass.Prof. Mark Zuidgeest at the Centre for Transport Studies in the University of Cape Town. It will involve answering general questions regarding mode choice decisions. We expect it to take 15 - 20 minutes to complete. The data gathered will be stored after the project, and could be used in academic publications, conference papers, and advisory commentories to governments.

If you have any questions or comments regarding the survey, please contact Abisai at email: knsabi001@myuct.ac.za or cell: +27719385915.

ParticipantConsent

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PARTICIPANT CONSENT FORM

CONFIDENTIALITY: Participant names and contact details are optional, and were provided, they will only be used for purposes of sending a study report,and for the samsung tablet draw competition were one lucky respondent will win a samsung tablet; otherwise these details will be kept confidential. Any data provided by you will also be treated with the admost confidence, and any results will only be published in summary form, so that individual responses are not devulged.

VOLUNTARY PARTICIPATION: Participation in this survey is voluntary. You may also stop the survey at any time, and at any point you dont feel like continuing. When we complete this study, we would like to send you a summary report of our findings. If you would like to receive this report, please provide your details below and answer yes to the very last question in the survey. Survey reports will only be forwarded to respondeds who complete the survey in full.

Name

CONTACT DETAILS:

Name (optional)	Name_r1_c1	
Company	Name_r2_c1	
Position/Designation	Name_r3_c1	
Email	Name_r4_c1	
Country	Name_r5_c1	

0% 100%

DMID

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PART 1: GENERAL INFORMATION

1. Please select the role that describes your company's role in the logistics supply chain:

DMID=1 ◯ Cargo Shipper

DMID=2 ◯ Cargo Receiver

DMID=3 ◯ Freight Forwarder

DMID=4 ◯ DMID_4_other Other: Please specify [ ]

Location

2. Please select the city in which your business is located: (If your city is not listed, please select the nearest city)

-select location-

Topcity

3. Please select one city in SADC to where you mostly ship to or from. (i.e. your biggest trade destination from your current business location):

-select city-

BranchLocation

4. Please select the locations in SADC where the processing sites/branches of your business are located:

BranchLocation_20 Johannesburg
BranchLocation_4 Kinshasa
BranchLocation_12 Dares Salam
BranchLocation_17 Harare
BranchLocation_19 Lusaka
BranchLocation_15 Beira
BranchLocation_16 Mbabane
BranchLocation_18 Bulawayo
BranchLocation_13 Blantyre
BranchLocation_5 Lumumbashi
BranchLocation_14 Maputo
BranchLocation_9 Cape Town
BranchLocation_7 Walvis Bay
BranchLocation_3 Matadi
BranchLocation_8 Windhoek
BranchLocation_10 Port Elizabeth
BranchLocation_1 Luanda
BranchLocation_6 Maseru
BranchLocation_2 Gabarone
BranchLocation_11 Durban

Size

5. Please indicate the approximate number of employees in your company

Size=1 1 ~ 20
Size=2 20 ~ 49
Size=3 50 ~ 99
Size=4 100 ~ 500
Size=5 Over 500

0% 100%

Industry

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PART 2: PRODUCT INFORMATION

6. Please choose the industry under which your business falls:

-select industry-

producttype

7. Please select the typical product type that your business trades in:

-select product type-

shelflife

8. Please indicate the average shelf life of your products:

-select shelf life-

carriageunit

9. Select the typical unit of carriage that is used for your long distance shipments within SADC?

-select measuring unit-

0% 100%

DM2

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PART 3: MODAL SPLIT

10. Please tell us; who makes the decision regarding selecting which mode of transport to use for your long distance transport needs?

DM2=1 ◯ Collective decision by Senior Management

DM2=2 ◯ Manager in charge of logistics

DM2=3 ◯ Freight Forwarder

DM2=4 ◯ DM2_4_other Other ______

Modechoice

11. Which of the following modes do you use for your long distance freight transport needs?

Modechoice_1 ☐ Road transport

Modechoice_2 ☐ Rail transport

Modechoice_3 ☐ Air transport

Modechoice_4 ☐ Sea transport

Modalsplit

12. Please indicate the percentage (%) freight volume that you assign to each of the following modes (The total should add up to 100).

	Modal split

Air transport	Modalsplit_r1_c1	
Sea transport	Modalsplit_r2_c1	
Rail transport	Modalsplit_r3_c1	
Road transport	Modalsplit_r4_c1	
Total	Modalsplit_r_total_c1	

FFownTransport

13. Do you often use own transport for long distance tranport?

FFownTransport=1 Yes

FFownTransport=2 No

0% 100%

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Reliability

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PART 4: TRANSPORT RELIABILITY IN SADC

Offering reliable transport services in terms of on-time arrival (as stipulated on the shipping document) is often considered one of the most important attributes that shippers appreciate in carriers (Eisele et al, 2011). A reliable transport service may be defined as a transport service that delivers consignements on time, without too much variation in delivery times over an extended period, and without deminishing in quality of service. According to studies done in SADC, unreliability and inefficiency in transport networks form a major obstacle to doing business within SADC (Ragoobur, 2008). Unreliability causes delays in the logistics supply chain, and these delays in turn lead to additional costs in the form of excess holding costs, additional labour costs, losses due to stock-out, and the risk of losing customers (Weisbrod et al, 2001).

14. How reliable would you say are the following modes? (select a % score from the list)

	Reliability_score %
Road	Reliability_r1_c1 -select%-
Coastal Shipping	Reliability_r2_c1 -select%-
Rail	Reliability_r3_c1 -select%-
Air	Reliability_r4_c1 -select%-

ReliabilityMitigation

15. Considering that unreliable transport can inconvenince business, which of the following do you do to mitigate the effects of unreliable transport services?

	All the time	Sometimes	Never

Use different modes of transport	ReliabilityMitigation_r7=1 ◯	ReliabilityMitigation_r7=2 ◯	ReliabilityMitigation_r7=3 ◯
Use different transport companies	ReliabilityMitigation_r3=1 ◯	ReliabilityMitigation_r3=2 ◯	ReliabilityMitigation_r3=3 ◯
Use own transport where high reliability is required	ReliabilityMitigation_r4=1 ◯	ReliabilityMitigation_r4=2 ◯	ReliabilityMitigation_r4=3 ◯
Monitor & Track shipments on transit	ReliabilityMitigation_r6=1 ◯	ReliabilityMitigation_r6=2 ◯	ReliabilityMitigation_r6=3 ◯
Charge carrier for late delivery	ReliabilityMitigation_r5=1 ◯	ReliabilityMitigation_r5=2 ◯	ReliabilityMitigation_r5=3 ◯
Pay more to avoid unessesary delays	ReliabilityMitigation_r1=1 ◯	ReliabilityMitigation_r1=2 ◯	ReliabilityMitigation_r1=3 ◯
Keep more stock in local warehouse	ReliabilityMitigation_r2=1 ◯	ReliabilityMitigation_r2=2 ◯	ReliabilityMitigation_r2=3 ◯

0% 100%

ModalAttributes

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PART 5: MODE CHOICE ATTRIBUTES

In freight mode choice, alternative modes of transport are described by their characteristics, and how these characteristics compare to each other in competing modes. These characteristics are called attributes, and shippers often prefer some attributes above others. For instance some shippers prefer speed and so they choose road, whereas some prefer low transport cost above other attributes and so they choose coastal shipping or rail.

16. Which of the following attributes do you consider most important when choosing a transport mode?

Please drag each item from the left column to the right column and rank them in order of preference.

Items to Rank	Most Preferred
ModalAttributes_8 Ability to Monitor & Track shipments during transit	
ModalAttributes_6 Quality of customer service	
ModalAttributes_4 Frequency of transport service per week/month	
ModalAttributes_7 Flexibility of transport mode to adapt to shipper requirements	
ModalAttributes_5 Door-to-door transport cost	

ModalAttributes_1

Reliability in terms of arriving on time

ModalAttributes_9

Environmental friendliness of mode

ModalAttributes_3

Rate of cargo loss/damage

ModalAttributes_2

Transit time (door-door)

Least Preferred

CSuse

17. Have you ever used coastal shipping before?

CSuse=1 Yes

CSuse=2 No

0% 100%

endofsurvey

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Thank you for taking part in the survey for freigh transport in SADC!

We wish you a wonderful day!

Powered by Sawtooth Software, Inc.

0% 100%

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ANNEX II: SADC FREIGHT STUDY ADDITIONAL MATERIAL

II.i Urban Freight Presentation

Freight Transport Decisions and their considerations in the Southern African Development Community (SADC)

Abisai Konstantinus[1], Mark Zuidgeest[1]
Centre for Transport Studies, University of Cape Town, South Africa;[2]

INTRODUCTION

Freight transport decisions in the SADC region, are generally not well understood. This study served two purposes: first it aimed to describe the freight procurement landscape in SADC and it sets the stage for discrete choice models to study shipper behavior and the potential of short sea shipping in SADC.

METHODS

Online survey were conducted with shippers and freight forwarders across SADC between 1 March 2017 and 1 January 2018. In total, over 3000 emails were promulgated. In the end, only 203 respondents attempted the survey, and only 86 completed the survey in full.

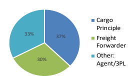

Figure 1-1: Responses by decision-maker

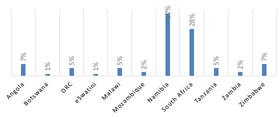

Figure 1-2: Responses by SADC nationality

RESULTS

FREIGHT PROCUREMENT IN SADC

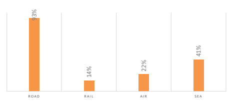

Figure 1-3: Mode usage

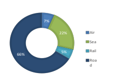

Figure 1-4: Modal assignment of freight

The setting recognizes the market realities, that mode choices are seldom all one or another, but rather, many shippers split their business among options. The results indicated in Figure 1-3 and 1-4 show a strong reliance on road with 93% of respondents using road. The results furthermore show that SADC shippers split their freight business as follow: 66% of freight business is assigned to road, 22% to sea, 7% to air, and 5% to rail.

RESULTS

RELIABILITY OF FREIGHT TRANSPORT MODES

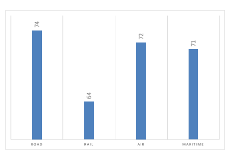

Figure 1-5: Perceived levels of reliability for transport modes

It emerged from the study that road is perceived the most reliable mode of transport with 74% perceived reliability, followed by air with 72%, then maritime with 71% and last, rail with 62%. These findings corroborates to the mode share where modes considered highly reliable enjoy a higher mode share

RESULTS

STRATEGIES TO MINIMISE EFFECTS OF UNRELIABLE TRANSPORT

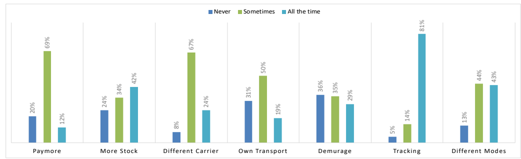

Figure 1-6: Strategies to mitigate effects of unreliable transport

The combined results above indicate that shippers incur numerous expenses to mitigate the effects of unreliable transport in SADC. This implies that most shippers in SADC have to incur additional logistics costs and 'paymore' in the form of miscellaneous costs paid as bribes, additional freight charges and hiring agents on the ground.

RESULTS

RANKING OF MODE CHOICE ATTRIBUTES

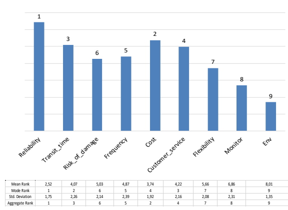

Figure 1-7: Ranking of modal attributes

Shippers were asked to rank different modal attributes. Reliability was ranked most important, followed by cost and transit time ahead of customer service and frequency of service, while environmental friendliness was ranked least important.

A low standard deviation for environmental friendliness confirms that most shippers in SADC do not think highly of sustainability, but rather shippers are only driven by time and cost attributes

SUMMARY

In summary, the freight transport landscape in SADC is characterized by extreme polarization in favor of road. Road, albeit not entirely reliable, is considered more reliable then other modes of freight transport. To mitigate the effects of unreliable transport, shippers in SADC, majorly use different carriers, employ own transport, often have to 'paymore' and they track their shipments.

Lastly, the ranking of modal attributes factors reveal that in SADC reliability in terms of transit time is the most important attributes and the least important is environmental friendliness.

ACKNOWLEDGEMENTS

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II.ii **Attribute description**

1. Reliability

Reliability is defined as the unexpected change in the expected transit time of a freight transport voyage due to some foreseen or unforeseen circumstances, such as road congestion, bad weather, labor strikes etc (Zamparini and Reggiani, 2007), the percentage of deliveries at the scheduled time (Brookes et al., 2012b).[66] Shippers usually develop the mental basis for the expected transit time of a transport voyage through past experiences of using a certain mode and accordingly make their business plans. When a delivery does not come on time, or when delivery times vary highly, that mode is said to be unreliable. Similarly, a transport mode that has low variation in transit time is said to have high reliability.

2. Transit time

Transit time refers to the time it takes for a shipment to move from origin to destination in a door-to-door transport chain. Transit time is also related to distance, such that the relative value of time will decreases as the distance of transport increases, and vice versa. Transport modes with long transit times tend to be unattractive, as shippers are continuously reducing their lead times to reduce carrying costs and streamline operations to improve productivity (McKinnon, 1995). A reduction in travel time might also open up avenues for shippers to concentrate production and distribution processes in a few locations while exploiting gains from economy of scale, and subsequently extending their geographical dimension of their markets (ibid).

3. Frequency

Frequency is related to the number of shipments offered by the carrier in a determined period of time. Literature shows that Frequency is particularly important to study the development of SSS. Brooks and Trifts, (2008) found that shippers were willing to accept service frequencies of every 2 weeks on some corridors in north America. Puckett et al (2011) revisited the Brooks and Trifts data and estimated the willingness-to- pay (WTP) for gains in service frequency for the routes examined. They also found significant

[66] Reliability differ across different cargo types; for instance cargoes that are time sensitive such as Just-in-time cargoes, reliability is extremely important; and subsequently small buffer times are specified for these cargoes (Eisele et al, 2011). The advent of globalization and integrated logistics services is driving demand for "time conscious customer oriented" transported services and so attributes such as reliability, responsiveness and flexibility are increasingly providing the means to support the ever more customer-tailored and adaptive supply chains (Haralambides and Gujar, 2011).

preference heterogeneity in the sample. Similarly, in Europe, Feo et al (2011) revealed a WTP for SSS service for an increase frequency of 24 hours.

4. Transport Cost

This refers to out of pocket expenses for door-door transport including loading and unloading. Transport cost to the carrier (i.e. transport service provider) is an indication of what an investor needs to incur to provide the transport service and to the shipper, they relate to the cost incurred to procure the transport service; which includes the freight rate, customs and clearance charges, port charges, wharfage, cargo handling and other costs relating to transporting the goods from origin to destination (Rodrigue, 2017).

Transport cost also include the monetary value of time, the time cost component, in the sense that a reduction of transport time can have benefit to the profitability of the carrier as they can save on labour and capital costs; and to the shipper this can mean increased value of goods and service as consumers enjoy fast delivery of their purchases (ibid).

5. Flexibility

Flexibility refers to the number of unplanned shipments that are executed without excessive delay or the ability to adapt to external incidents or changes in customer requirements. Flexibility is generally an implicit attribute considered by shippers, such that it doesn't always come out strong in quantitative studies; and previous literature that has included flexibility has generally incorporated it as a quality criterion (Bergantino & Bolis, 2003).

6. Cargo Loss and Damage

Cargo loss and damage may be defined as the percentage of commercial value of shipped goods that is lost, damaged or stolen; or the risk thereto. Loss and damage causes a disruption in the transport chain, which affects the cargo consignee. In maritime transport, wet damage often forms the largest portion of cargo claims, with damage to reefer cargoes particularly forming the largest percentage of cargo claims (Safety for Sea, 2018).

In SADC particularly, the incorporation of loss and damage (or cargo safety) is done as instances of cargo theft have increase in some parts of the region (TIPS, 2017). In South Africa for instance, there has been a 30 per cent increase in cargo truck hijackings over the last year, with thieves using high levels of violence and switching from targeting only high value goods to also targeting lower value items (C-track, 2017; News24, 2018).

7. Monitoring and Traceability

Monitoring and traceability refer to the ability of the transport mode to provide up to date information on the whereabouts of the shipment during any time of the journey. Generally this is an attribute employed in carrier selection (Solakivi and Ojala, 2017), however considering that mode choice and carrier choice is closely related, Monitoring and Traceability was considered essential to include in a study on freight mode choice in SADC. This is particularly so in the wake of rising cargo theft and freight trucks hijacking.

8. Environmental friendliness

Environmental friendliness refers to the sustainability aspect of the transport mode employed. A sustainable mode of transport has little strain on the economy in the sense that it produces low environmental impact and causes minimal tension on society (UNAGST, 2015). Environmental impact may be measured by the major negative externalities including: traffic congestion, air pollution, global warming (GHG), transport related accidents, noise, infrastructure wear-and-tear and other environmental damages and pollution (Rodrigue, 2017).

The inclusion of environmental friendliness was justified after the pilot survey revealed that numerous social and environmental advantages that SSS has compared to road and rail can lead to different transportation patterns and a change in the attitude of the shippers, particularly under corporate social responsibility. It is common for businesses these days to make decisions based on the environment and society, and even customers tend to prefer to support companies that are sustainable. Several studies have found a positive correlation between sustainability and financial performance (Bernhut, 2003).

9. Customer service

Customer service refers to the perceived responsiveness of the mode to the needs of the shipper (Naidu, 2011). The sixth annual American transportation procurement benchmark report indicates that service levels are often cited as the most important aspect of a bid to select a carrier (Johnson, 2014). Customer service, they said, speaks to the ability of systems to provide shippers a focus on parameters outside of transport cost, which is driven more by the value of their partnerships with carriers. The inclusion of customer service was especially justified after the pilot survey revealed that shippers wanted an aspect of service measured.

ANNEXES III: CORRIDOR SELECTION

For the envisioned study that forms the core of this thesis, three freight corridors where a modal shift to unimodal SSS could be realized and two corridors where a modal shift to intermodal SSS could be achieved (in line with the study objectives). These corridors span Walvis Bay–Luanda, Cape Town–Walvis Bay and Durban-Beira for the unimodal SSS setting, and Durban – Harare, and Cape Town – Windhoek for the intermodal SSS setting. The reader will note that three corridors are in the west of the SADC region, and two corridors are on the east of SADC region. The western corridors were connected by Cape Town in South Africa, Windhoek and Walvis Bay in Namibia and Luanda in Angola, and the eastern corridors were connected by Durban in South Africa, Beira in Mozambique and Harare in Zimbabwe. These five corridors represent distinct origin–destination pairing from potential areas of production and supply to high demand-pull areas, with long enough distances between them to develop SSS.

These corridors are particularly important for SSS analysis because of a number of reasons. The port of Walvis Bay has become a preferred importation port for shippers from neighboring countries, namely shippers from DRC, Angola, Zambia and Zimbabwe. The port of Walvis Bay is furthermore undergoing a number of big projects, which will make it more appealing to shippers from other parts of the region. Projects of note include the expansion of the container terminal, port automation to improve efficiency; and the development of an entirely new port "The SADC gateway port" which is 4 times the size of the existing port. Furthermore, Cape Town is a hub for manufacturing and distribution, and has the regional distribution centers for large supermarket franchises such as Shoprite, Checkers and Pick n Pay. Cape Town is also a regional hub for food produce, and other finished products. Lastly, Luanda on the other end is both the capital city and the main seaport of Angola, one of Africa's fastest growing economies. Luanda accommodates about 45 per cent of Angola's population; and according to the RFDM 2014, it has the most intense freight demand in terms of GDP per ton. With a population of 8 million and the highest population growth rate in Africa, Luanda has also been deemed the most expensive city in the world.

On the east coast of the SADC region, Durban is both the biggest port in SADC and in the Southern Hemisphere. To that effect, a steady flow of containers has been observed over corridors linking Durban to Harare, and Durban to Beira. Accordingly, there are plans to develop a cross border train linking Harare to Durban, which will run three times a week to accommodate the anticipated freight flows, and similarly there is coastal shipping service that runs between Durban and Beira.

The actual trajection of each of these five corridors were as follow:

- The Cape Town–Walvis Bay Corridor span a distance 1710 km by road, or 1300 km by sea. The land-based portion of the corridor spans a portion of the Trans-oranje corridor from Cape Town with border crossing at Vioolsdrift/Noordoewer and then joins onto Trans-Kalahari corridor, from Windhoek to Walvis Bay.
- The Cape Town – Windhoek route span 1300 km on the trans-oranje highway by road from Cape Town to Windhoek with border crossing at Vioolsdrift/Noordoewer. The sea-based route spans 1300 km from Cape Town to Walvis Bay by sea, is adjoined onward by rail or road for the remaining 400 km.
- The Walvis Bay – Luanda corridor spans a short distance on the trans-kalahari highway and then joins onto the trans-African[67] highway with border crossing at Oshikango. The sea based route span 1300 km from the port of Walvis Bay to the port of Luanda.
- The Durban – Harare corridor spans a distance of 2000 km by either road or rail with border crossing at Beightbridge. The intermodal SSS route span 1800 km from Durban, transiting via the port of Beira, and from Beira via road or rail -to Harare with border crossing at Forbes (Mutare).
- Lastly, the Durban Beira corridor spans a distance of 1300 km by sea from the port of Durban to the port of Beira, or 1810 km by road via the Giriyondo border post.

These corridors are not the only corridors were SSS could be studied. Table I shows a number of corridors in SADC where opportunities for SSS can be studied. Table III also indicates the regional highways on which these corridors are located, the freight volumes, distances, state of port efficiency, state of rail transport services, road congestion and any additional justification for developing SSS on these corridors.

[67] The Trans-African highway is a transcontinental road project that is being developed by UNECA, AFDB and the AU to promote trade and alleviate poverty in Africa through high infrastructure development.

Table I: Possible OD pairings where opportunities for SSS can be studied

Set	Origin	Destination	Port of transit	SADC Regional Highway	Freight Volumes	Mode	Distance (km)	State of port efficiency	State of rail	Road congestion	Criteria for selection
1	Walvis Bay	Luanda*	-	Trans Cunene	Stagnant	SSS	1695	Lua=30%	NA	High	Transhipment volumes from port of Walvis Bay. Walvis Bay is set to become hub port in region.
	Walvis Bay	Luanda*	-			*Road*	2030	WB=75%			
	Walvis Bay	Luanda*	-			Rail	-				
2	Walvis Bay	Kinshasa*	Matadi	Trans Cunene, Bas Congo	Growing	SSS	2830	Mat=30%	*NA*	Extremely high	Potential for transhipment volumes. Trade between Namibia and DRC growing. Port of Matadi cannot accommodate big ships.
	Walvis Bay	*Kinshasa**	-			*Road*	2750	WB=75%			
	Walvis Bay	Kinshasa*	-			Rail	-				
3	Cape Town	Walvis Bay		Trans Orange, Trans Kalahari	Potential	SSS	1300	CT=75%	SA = Good	Fair	Cape Town is a centre of production for many Namibian imports. Additional potential growth in freight volumes due to transhipment cargo.
	Cape Town	Walvis Bay				*Road*	1710	WB=75%	Nam = Good		
	Cape Town	Walvis Bay				Rail	-		*but long		
4	Cape Town	Windhoek	Walvis	Trans Orange	Potential	SSS	1710	CT=75%	SA = Good	Fair	Cape Town is a centre of production for Namibian imports and potential growth in freight volumes due to transhipment cargo.
	Cape Town	Windhoek	-			*Road*	1480	WB=75%	Nam = Good		
	Cape Town	Windhoek	-			Rail	-		*but long		
5	Cape Town	Jo-burg*	Durban	-	Potential	SSS	2202	CT=75%	Good	Fair	Projected growth in freight volumes between Cape Town and Johanesburg. Rising rate of road accidents.
	Cape Town	Jo-burg*	-			*Road*	1400	Dur=50%			
	Cape Town	Jo-burg*	-			Rail	1530				
6	Durban	Cape Town	-	-	Potential	SSS	1482	CT=75%	Good	Fair	Projected growth in freight volumes between Durban and Johanesburg. Rising rate of road accidents.
	Durban	Cape Town	-			*Road*	1635	Dur=50%			
	Durban	Cape Town	-			Rail	1232				
7	Durban	Harare	Beira	North-South	Growing	SSS	1857	Dur = 50%	SA = Good	Extremely high	Projected growth in freight volumes between Durban and Harare. Rising rate of road accidents, theft and hijackings.
	Durban	Harare				*Road*	1680	Bei = 50%	Zim = Poor		
	Durban	Harare				Rail	1710				
8	Durban	Beira*		North-South	Growing	SSS	1300	Dur = 50%	SA = Good	High	Projected growth in freight volumes and transhipments between Durban and Dar es Salam. Rising rate of road accidents.
	Durban	Beira*				*Road*	1807	Bei = 50%	Moz =		
	Durban	Beira*				Rail	-				
9	Durban	Dar es Salam*		North-South	Potential	SSS	2926	Dur = 50%	SA = Good	Extremely high	Projected growth in freight volumes and transhipments between Durban and Dar es Salam. Rising rate of road accidents.
	Durban	Dar es Salam*				*Road*	3940	Dar = 75%	Tanz =		
	Durban	Dar es Salam*				Rail	3940		*but long		
10	Dar es Salam*	Beira*		Darasalam	Potential	SSS	1874	Dar = 75%	NA	High	Projected growth in freight volumes and transhipments between Beira and Dar es Salam. Hub port construction in Tanzania.
	Dar es Salam*	Beira*				*Road*	2274	Bei = 50%			
	Dar es Salam*	Beira*				Rail	-				
11	Dar es Salam*	Harare	Beira	Darasalam, North-South, Beira	Potential	SSS	2847	Dar= 75%	Zim= Good	Extremely high	Projected growth in freight volumes and transhipments between Harare and Dar es Salam. Dar es Salam seen as alternative to Durban were its growinly becoming unsafe.
	Dar es Salam*	Harare	-			*Road*	2394	Bei = 50%	Tanz =		
	Dar es Salam*	Harare	-			Rail	2394		*but long		

Notes: *Poor data collection potential due to language barrier and/or difficulty of contacting respondents (shippers)

ANNEXES IV: SHIPPER BEHAVIOR STUDY QUESTIONAIRE

FREIGHT MODE CHOICE IN SADC

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Interview starts ~ interviewer selects corridor

Cape Town ~ Walvis Bay (1)

Walvis Bay ~ Luanda (2)

Durban ~ Beira (3)

Durban ~ Harare (4)

Cape Town ~ Windhoek (5)

PARTICIPANT CONSENT FORM (PAGE 1)

Thank you for agreeing to participate in this survey. The survey is meant for shippers and freight forwarders that dispatches freight on the corridor linking [script]. It involves answering questions regarding the selection process of a transport mode for transporting freight and a choice game. The survey is expected to take about 15 to 20 minutes to complete.

The study is being conducted by Abisai Konstantinus, as part of his PhD studies, supervised by Prof. Mark Zuidgeest at the Centre for Transport Studies in the University of Cape Town. It will involve answering general questions regarding mode choice decisions. We expect it to take 15 – 20 minutes to complete. The data gathered will be stored after the project, and could be used in academic publications, conference papers, and advisory commentories to governments. If you have any questions or comments regarding the survey, please contact Abisai at email: knsabi001@myuct.ac.za or cell: +27719385915.

CONFIDENTIALITY: Participant names are optional; and will be kept confidential. Any data supplied by you will also be treated with confidentiality, and the results will be published only in summary form, so that individual responses are not divulged.

VOLUNTARY PARTICIPATION: Participation in this survey is entirely voluntary. The survey may be stopped or terminated at any time.

RESPONDENT INFORMATION (OPTIONAL):

Contact: ____________________

Title: ____________________

Company: ____________________

Location: ____________________

Email: ____________________

NOTES ON SURVEY NAVIGATION:

To move between survey questions, please click the 'NEXT' or 'BACK' buttons at the bottom of each page. If you do not know the answer to a question, please leave it blank. You may also have to move down each screen to see all the questions.

PART 1: GENERAL COMPANY INFORMATION (PAGE 2)

Q1. Please choose the role that best describes your company's role in freight transport?

Shipper (1)

Freight Forwarder (2)

Q2. Please indicate the location of your main business centre: _______________

Q3. Please indicate the approximate number of employees in your company: _________

(Question 4 and 5 will help us to see whether big or small firms make decisions differently).

Q4. Please choose your industry. If you're a freight forwarder, choose the industry that you mostly service.

PART 2: TRANSPORT INFORMATION (PAGE 3)

ALL SUBSEQUENT QUESTIONS ARE BASED ON THE O-D PAIRING [SCRIPT].

Q5. Please tell us, how often per week do you ship on this corridor?

Q6. Please indicate the typical direction of shipping between {script}:

(if Cape Town ~ Walvis Bay was selected)

Cape Town ← Walvis Bay (1)

Cape Town → Walvis Bay (2)

Cape Town ⇔ Walvis Bay (3)

Q7. Please select the INCOTERM that best describes how you ship.________

Q8. Do you often use own transport on this corridor:

Yes (1)

No (2)

Q9. Do you have a long term contract with a road carrier to transport on this corridor:

Yes (1)

No (2)

Q10. How would you classify the product type you selected in Q7 above:

Raw (1)

Semi-Finished (2)

Finished (3)

Q11. Please indicate the primary product that you ship along this corridor:________

PART 3: PRODUCT INFORMATION (PAGE 4)

Q12. Please indicate the perishability of {script~ selected in Q11}

Perishable deteriorate quickly if not stored properly (1)

Semi-perishable: does not require refrigeration but have limited shelf life (2)

Perishable: does not expire (3)

Q13. Please indicate your frequency of shipping per week between [insert selection Q6}:

Once or less (1)

2- 4 times (2)

4 – 10 times (3)

More than 10 times (4)

Q14. How urgent was the shipment of {script}?

Urgent: require emergency dispatch (1)

Normal operating stock: shipped frequently, set lead time (2)

Once in a while shipment (3)

Q15. Please indicate the lead time in days that you allow for the door-door shipment of {script~product} on this corridor: __________ days

Q16. What is the typical shipping unit for {script ~product} on this corridor?

Bags (1)

Full Container Load (FCL) (2)

Full truck Load (FTL) (3)

Boxes (4)

Bulk loose (5)

Other (6)

Q17. Please indicate the unit value per shipment of {script} ________________

PART 4: REVEALED PREFERENCE (PAGE 5)

Now think of the last time you shipped a fully laden twenty foot container of " [Script] " on this corridor, and answer the following questions to the best of your knowledge. To avoid any ambiquity or if you find any of the information sensitive, you may provide approximate values.

Q18. What was the direction of shipment?

Cape Town ← Walvis Bay (1)

Cape Town → Walvis Bay (2)

Q19. Which of the following modes did you use?

Road (1)

Rail (2)

Coastal Shipping (3)

*if you used intermodal transport, please cite the main mode

Q20. How long in days was the door-door transport journey? ____.

Q21. How much in US$ was the door-door transport journey cost? ____.

Q22. How much in US$ was the total estimated value of {script-product} was in the TEU container?

____

Q23. Please indicate the extend of any damage or loss that occurred.

0% (1)

1~5% (2)

5~10% (3)

10~20% (4)

20%~more (5)

Q24. Now think to the last 3 shipments of {script} that you shipped along this corridor, using the the mode specified in Q15, tell us how many of these shipments were late? ______

PART 5: SP GAME (PAGE 6-20)

We are considering introducing a new mode of freight transport: Short Sea Shipping (SSS) on the corridor linking Cape Town and Luanda. SSS is a modified form of coastal shipping that offers a seamless door-to-door transport service. In this new mode, containerised shipments will be transported by sea for the longer leg of the transport journey, and by road or rail for the remainder of any journey which might be left. A simplified depiction of SSS is shown below. Figure 3: SSS operation (source: LKW, 2016)

25. Now, we will present you with a number of scenarios, wherein we would like to know the mode of transport you would choose given a number of conditions. The conditions may be different to what you're used to, this is expected. You can view the reasons behind the variability of these conditions as a result of the following:

*Variable transit times for road as a result of policies to restrict driving during certain hours.
*Variable transit times for SSS as a result of interventions to improve port efficiency levels.
*Varying reliability levels as a result of road, rail and port congestions.
* Varying transport costs as a result of road tolling, reduced port charges, and policies for environmental protection.

1. Transport Costs is the total cost incured for the door to door transport journey from consignor to consignee.
2. Transit time is the total time taken for the door to door transport journey from consignor to consignee.
3. Reliability refers to the number of times the shipment arrives on time.
4. Delay refers to the extent of time the current shipment is late by.
5. Frequency of service refers to the number of days per week the transport service is available.

When you submit your answer, please keep in mind your decisions could inform future policies in transport.

Note: The questions in this part relate to long haul distance(<1500km) transport within SADC.

{script if Cape Town ~ Walvis Bay: show the following 13 choice tasks}

SP_Fixed1

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If these were your only options, which would you choose to transport [Script] between Walvis Bay and Cape Town?

(1 of 13)

	Road	**SSS**
Frequency of Service	This service is avaialble everyday, except on weekends	This service is avaialble twice a week
Service Reliability	2 out of 3 shipments are on time	3 out of 3 shipments are on time
Potential extend of delay	Potential delay of 6 hours	Shipment should be on time
Transport Cost (door-to-door)	US$3,500	US$2,000
Typical door-to-door transit time	6 days	6 days
	Road	**SSS**
	SP_Fixed1 Select	SP_Fixed1 Select

Back Next

0% 100%

SP_Random1

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If these were your only options, which would you choose to transport [Script] between Walvis Bay and Cape Town?

(2 of 13)

	Road	**SSS**
Frequency of Service	This service is avaialble everyday, except on weekends	This service is avaialble twice a week
Service Reliability	1 out of 3 shipments are on time	3 out of 3 shipments are on time
Potential extend of delay	Potential delay of 12 hours	Shipment should be on time
Transport Cost (door-to-door)	US$3,000	US$2,500
Typical door-to-door transit time	6 days	6 days
	Road	**SSS**
	SP_Random1 Select	SP_Random1 Select

Back Next

0% 100%

SP_Random2

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If these were your only options, which would you choose to transport [Script] between Walvis Bay and Cape Town?

(3 of 13)

	Road	SSS
Frequency of Service	This service is avaialble everyday except on on sundays	This service is avaialble once a week
Service Reliability	2 out of 3 shipments are on time	2 out of 3 shipments are on time
Potential extend of delay	Potential delay of 12 hours	Potential delay of 6 hours
Transport Cost (door-to-door)	US$3,500	US$2,000
Typical door-to-door transit time	5 days	7 days
	Road	**SSS**
	SP_Random2 Select	SP_Random2 Select

Back Next

0% 100%

SP_Random3

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If these were your only options, which would you choose to transport [Script] between Walvis Bay and Cape Town?

(4 of 13)

	Road	SSS
Frequency of Service	This service is avaialble everyday except on on sundays	This service is avaialble once a week
Service Reliability	2 out of 3 shipments are on time	2 out of 3 shipments are on time
Potential extend of delay	Potential delay of 24 hours	Shipment should be on time
Transport Cost (door-to-door)	US$3,500	US$2,000
Typical door-to-door transit time	5 days	7 days
	Road	**SSS**
	SP_Random3 Select	SP_Random3 Select

Back Next

0% 100%

SP_Random4

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If these were your only options, which would you choose to transport [Script] between Walvis Bay and Cape Town?

(5 of 13)

	Road	SSS
Frequency of Service	This service is avaialble everyday except on on sundays	This service is avaialble once a week
Service Reliability	1 out of 3 shipments are on time	3 out of 3 shipments are on time
Potential extend of delay	Potential delay of 24 hours	Shipment should be on time
Transport Cost (door-to-door)	US$4,000	US$1,500
Typical door-to-door transit time	6 days	6 days
	Road	**SSS**
	SP_Random4 Select	SP_Random4 Select

Back Next

0% 100%

SP_Random5

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If these were your only options, which would you choose to transport [Script] between Walvis Bay and Cape Town?

(6 of 13)

	Road	SSS
Frequency of Service	This service is avaialble everyday of the week	This service is avaialble once a fortnight
Service Reliability	2 out of 3 shipments are on time	1 out of 3 shipments are on time
Potential extend of delay	Potential delay of 12 hours	Potential delay of 6 hours
Transport Cost (door-to-door)	US$3,500	US$2,000
Typical door-to-door transit time	5 days	7 days
	Road	**SSS**
	SP_Random5 Select	SP_Random5 Select

Back Next

0% 100%

SP_Random6

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If these were your only options, which would you choose to transport [Script] between Walvis Bay and Cape Town?

(7 of 13)

	Road	SSS
Frequency of Service	This service is avaialble everyday of the week	This service is avaialble once a fortnight
Service Reliability	3 out of 3 shipments are on time	1 out of 3 shipments are on time
Potential extend of delay	Shipment should be on time	Potential delay of 12 hours
Transport Cost (door-to-door)	US$3,000	US$2,500
Typical door-to-door transit time	4 days	8 days
	Road	**SSS**
	SP_Random6 Select	SP_Random6 Select

Back Next

0% 100%

SP_Random7

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If these were your only options, which would you choose to transport [Script] between Walvis Bay and Cape Town?

(8 of 13)

	Road	SSS
Frequency of Service	This service is avaialble everyday, except on weekends	This service is avaialble twice a week
Service Reliability	1 out of 3 shipments are on time	2 out of 3 shipments are on time
Potential extend of delay	Potential delay of 24 hours	Shipment should be on time
Transport Cost (door-to-door)	US$4,000	US$1,500
Typical door-to-door transit time	4 days	8 days
	Road	**SSS**
	SP_Random7 Select	SP_Random7 Select

Back Next

0% 100%

SP_Random8

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If these were your only options, which would you choose to transport [Script] between Walvis Bay and Cape Town?

(9 of 13)

	Road	SSS
Frequency of Service	This service is avaialble everyday, except on weekends	This service is avaialble twice a week
Service Reliability	1 out of 3 shipments are on time	2 out of 3 shipments are on time
Potential extend of delay	Shipment should be on time	Potential delay of 12 hours
Transport Cost (door-to-door)	US$4,000	US$1,500
Typical door-to-door transit time	6 days	6 days
	Road	**SSS**
	SP_Random8 Select	SP_Random8 Select

Back Next

0% 100%

SP_Random9

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If these were your only options, which would you choose to transport [Script] between Walvis Bay and Cape Town?

(10 of 13)

	Road	SSS
Frequency of Service	This service is avaialble everyday, except on weekends	This service is avaialble twice a week
Service Reliability	2 out of 3 shipments are on time	1 out of 3 shipments are on time
Potential extend of delay	Potential delay of 24 hours	Shipment should be on time
Transport Cost (door-to-door)	US$4,000	US$1,500
Typical door-to-door transit time	6 days	6 days
	Road	**SSS**
	SP_Random9 Select	SP_Random9 Select

Back Next

0% 100%

SP_Random10

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If these were your only options, which would you choose to transport [Script] between Walvis Bay and Cape Town?
(11 of 13)

	Road	SSS
Frequency of Service	This service is avaialble everyday of the week	This service is avaialble once a fortnight
Service Reliability	2 out of 3 shipments are on time	1 out of 3 shipments are on time
Potential extend of delay	Shipment should be on time	Potential delay of 12 hours
Transport Cost (door-to-door)	US$3,000	US$2,500
Typical door-to-door transit time	4 days	8 days
	Road	**SSS**
	SP_Random10 Select	SP_Random10 Select

Back Next

0% 100%

SP_Random11

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If these were your only options, which would you choose to transport [Script] between Walvis Bay and Cape Town?
(12 of 13)

	Road	SSS
Frequency of Service	This service is avaialble everyday of the week	This service is avaialble once a fortnight
Service Reliability	3 out of 3 shipments are on time	1 out of 3 shipments are on time
Potential extend of delay	Shipment should be on time	Potential delay of 6 hours
Transport Cost (door-to-door)	US$3,000	US$2,500
Typical door-to-door transit time	4 days	8 days
	Road	**SSS**
	SP_Random11 Select	SP_Random11 Select

Back Next

0% 100%

SP_Random12

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If these were your only options, which would you choose to transport [Script] between Walvis Bay and Cape Town?

(13 of 13)

	Road	SSS
Frequency of Service	This service is avaialble everyday except on on sundays	This service is avaialble once a week
Service Reliability	1 out of 3 shipments are on time	2 out of 3 shipments are on time
Potential extend of delay	Potential delay of 12 hours	Potential delay of 6 hours
Transport Cost (door-to-door)	US$3,500	US$2,000
Typical door-to-door transit time	5 days	7 days
	Road	**SSS**
	SP_Random12 Select	SP_Random12 Select

Back Next

0% 100%

Note: The questions in this part relate to long haul distance(<1500km) transport within SADC.

{script if Walvis Bay ~ Luanda: show the following 13 choice tasks}

SP_Fixed1

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

Knowing what you know, if these were your only options, which mode would you choose to transport [Script] between Walvis Bay and Luanda?

(1 of 13)

	Road	SSS
Frequency of Service	5 departures per week (no service on weekends)	2 departures per week
Service Reliability	0 out of 3 shipments are on time	3 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 96 hours	Current shipment could be on time
Transport Cost (door-to-door)	US$5,000	US$2,200
Transit time (door-to-door)	7 days	7 days
	Road	**SSS**
	SP_Fixed1 Select	SP_Fixed1 Select

Back Next

0% 100%

SP_Random1

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

Knowing what you know, if these were your only options, which mode would you choose to transport [Script] between Walvis Bay and Luanda?

(2 of 13)

	Road	SSS
Frequency of Service	6 departures per week (no service on sundays)	1 departure per week
Service Reliability	0 out of 3 shipments are on time	3 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 96 hours	Current shipment could be on time
Transport Cost (door-to-door)	US$5,000	US$2,200
Transit time (door-to-door)	5 days	11 days
	Road	**SSS**
	SP_Random1 Select	SP_Random1 Select

Back Next

0% 100%

SP_Random2

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

Knowing what you know, if these were your only options, which mode would you choose to transport [Script] between Walvis Bay and Luanda?

(3 of 13)

	Road	SSS
Frequency of Service	Departs everyday of the week	1 departure per fortnight
Service Reliability	1 out of 3 shipments are on time	1 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 48 hours	Shippment could be delayed by 48 hours
Transport Cost (door-to-door)	US$4,500	US$2,700
Transit time (door-to-door)	5 days	9 days
	Road	**SSS**
	SP_Random2 Select	SP_Random2 Select

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0% 100%

SP_Random3

UNIVERSITY OF CAPE TOWN
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Knowing what you know, if these were your only options, which mode would you choose to transport [Script] between Walvis Bay and Luanda?

(4 of 13)

	Road	SSS
Frequency of Service	Departs everyday of the week	1 departure per fortnight
Service Reliability	0 out of 3 shipments are on time	3 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 144 hours	Current shipment could be on time
Transport Cost (door-to-door)	US$4,000	US$3,200
Transit time (door-to-door)	7 days	7 days
	Road	**SSS**
	SP_Random3 Select	SP_Random3 Select

Back Next

0% 100%

SP_Random4

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

Knowing what you know, if these were your only options, which mode would you choose to transport [Script] between Walvis Bay and Luanda?

(5 of 13)

	Road	SSS
Frequency of Service	6 departures per week (no service on sundays)	1 departure per week
Service Reliability	1 out of 3 shipments are on time	2 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 96 hours	Shippment could be delayed by 48 hours
Transport Cost (door-to-door)	US$4,500	US$2,700
Transit time (door-to-door)	6 days	9 days
	Road	**SSS**
	SP_Random4 Select	SP_Random4 Select

Back Next

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SP_Random5

UNIVERSITY OF CAPE TOWN

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Knowing what you know, if these were your only options, which mode would you choose to transport [Script] between Walvis Bay and Luanda?

(6 of 13)

	Road	SSS
Frequency of Service	5 departures per week (no service on weekends)	2 departures per week
Service Reliability	0 out of 3 shipments are on time	2 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 48 hours	Shippment could be delayed by 72 hours
Transport Cost (door-to-door)	US$5,000	US$2,200
Transit time (door-to-door)	7 days	7 days
	Road	SSS
	SP_Random5 Select	SP_Random5 Select

Back Next

0% 100%

SP_Random6

UNIVERSITY OF CAPE TOWN

IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

Knowing what you know, if these were your only options, which mode would you choose to transport [Script] between Walvis Bay and Luanda?

(7 of 13)

	Road	SSS
Frequency of Service	5 departures per week (no service on weekends)	2 departures per week
Service Reliability	2 out of 3 shipments are on time	1 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 144 hours	Current shipment could be on time
Transport Cost (door-to-door)	US$5,000	US$2,200
Transit time (door-to-door)	5 days	11 days
	Road	SSS
	SP_Random6 Select	SP_Random6 Select

Back Next

0% 100%

SP_Random7

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

Knowing what you know, if these were your only options, which mode would you choose to transport [Script] between Walvis Bay and Luanda?

(8 of 13)

	Road	SSS
Frequency of Service	5 departures per week (no service on weekends)	2 departures per week
Service Reliability	2 out of 3 shipments are on time	1 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 144 hours	Shippment could be delayed by 24 hours
Transport Cost (door-to-door)	US$4,000	US$3,200
Transit time (door-to-door)	7 days	7 days
	Road	**SSS**
	SP_Random7 Select	SP_Random7 Select

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0% 100%

SP_Random8

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

Knowing what you know, if these were your only options, which mode would you choose to transport [Script] between Walvis Bay and Luanda?

(9 of 13)

	Road	SSS
Frequency of Service	Departs everyday of the week	1 departure per fortnight
Service Reliability	2 out of 3 shipments are on time	2 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 144 hours	Current shipment could be on time
Transport Cost (door-to-door)	US$5,000	US$2,200
Transit time (door-to-door)	7 days	7 days
	Road	**SSS**
	SP_Random8 Select	SP_Random8 Select

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0% 100%

SP_Random9

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

Knowing what you know, if these were your only options, which mode would you choose to transport [Script] between Walvis Bay and Luanda?

(10 of 13)

	Road	SSS
Frequency of Service	Departs everyday of the week	1 departure per fortnight
Service Reliability	2 out of 3 shipments are on time	1 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 48 hours	Shippment could be delayed by 72 hours
Transport Cost (door-to-door)	US$4,000	US$3,200
Transit time (door-to-door)	5 days	11 days
	Road	**SSS**
	SP_Random9 Select	SP_Random9 Select

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0% 100%

SP_Random10

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

Knowing what you know, if these were your only options, which mode would you choose to transport [Script] between Walvis Bay and Luanda?

(11 of 13)

	Road	SSS
Frequency of Service	5 departures per week (no service on weekends)	2 departures per week
Service Reliability	0 out of 3 shipments are on time	2 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 96 hours	Shippment could be delayed by 48 hours
Transport Cost (door-to-door)	US$4,000	US$3,200
Transit time (door-to-door)	6 days	11 days
	Road	**SSS**
	SP_Random10 Select	SP_Random10 Select

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0% 100%

SP_Random11

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

Knowing what you know, if these were your only options, which mode would you choose to transport [Script] between Walvis Bay and Luanda?

(12 of 13)

	Road	SSS
Frequency of Service	6 departures per week (no service on sundays)	1 departure per week
Service Reliability	1 out of 3 shipments are on time	2 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 48 hours	Shippment could be delayed by 24 hours
Transport Cost (door-to-door)	US$4,500	US$2,700
Transit time (door-to-door)	6 days	9 days
	Road	**SSS**
	SP_Random11 Select	SP_Random11 Select

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0% 100%

SP_Random12

UNIVERSITY OF CAPE TOWN
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Knowing what you know, if these were your only options, which mode would you choose to transport [Script] between Walvis Bay and Luanda?

(13 of 13)

	Road	SSS
Frequency of Service	6 departures per week (no service on sundays)	1 departure per week
Service Reliability	1 out of 3 shipments are on time	1 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 96 hours	Shippment could be delayed by 24 hours
Transport Cost (door-to-door)	US$4,500	US$2,700
Transit time (door-to-door)	6 days	9 days
	Road	**SSS**
	SP_Random12 Select	SP_Random12 Select

Back Next

0% 100%

Note: The questions in this part relate to long haul distance(<1500km) transport within SADC.

{script if Durban ~ Beira: show the following 13 choice tasks}

SP_Fixed1

UNIVERSITY OF CAPE TOWN
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knowing what you know, if these were your only options, which mode would you choose to transport [Script] between Durban and Beira?

(1 of 13)

	Road	SSS
Frequency of Service	6 departures per week (no service on sundays)	2 departures per week
Service Reliability	0 out of 3 shipments are on time	2 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 72 hours	Current shipment could be on time
Transport Cost (door-to-door)	US$4,000	US$1,750
Transit time (door-to-door)	8 days	5 days
	Road	**SSS**
	SP_Fixed1 Select	SP_Fixed1 Select

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0% 100%

SP_Random1

UNIVERSITY OF CAPE TOWN
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knowing what you know, if these were your only options, which mode would you choose to transport [Script] between Durban and Beira?

(2 of 13)

	Road	SSS
Frequency of Service	6 departures per week (no service on sundays)	1 departure per week
Service Reliability	2 out of 3 shipments are on time	2 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 48 hours	Current shipment could be on time
Transport Cost (door-to-door)	US$4,000	US$1,750
Transit time (door-to-door)	6 days	7 days
	Road	**SSS**
	SP_Random1 Select	SP_Random1 Select

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0% 100%

SP_Random2

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

knowing what you know, if these were your only options, which mode would you choose to transport [Script] between Durban and Beira?

(3 of 13)

	Road	SSS
Frequency of Service	Departs everyday of the week	1 departure per fortnight
Service Reliability	1 out of 3 shipments are on time	1 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 48 hours	Shippment could be delayed by 24 hours
Transport Cost (door-to-door)	US$3,500	US$2,600
Transit time (door-to-door)	6 days	7 days
	Road	**SSS**
	SP_Random2 Select	SP_Random2 Select

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0% 100%

SP_Random3

UNIVERSITY OF CAPE TOWN
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knowing what you know, if these were your only options, which mode would you choose to transport [Script] between Durban and Beira?

(4 of 13)

	Road	SSS
Frequency of Service	5 departures per week (no service on weekends)	2 departures per week
Service Reliability	1 out of 3 shipments are on time	1 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 72 hours	Current shipment could be on time
Transport Cost (door-to-door)	US$2,500	US$2,125
Transit time (door-to-door)	7 days	6 days
	Road	**SSS**
	SP_Random3 Select	SP_Random3 Select

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SP_Random4

UNIVERSITY OF CAPE TOWN

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knowing what you know, if these were your only options, which mode would you choose to transport [Script] between Durban and Beira?

(5 of 13)

	Road	SSS
Frequency of Service	Departs everyday of the week	1 departure per fortnight
Service Reliability	0 out of 3 shipments are on time	3 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 72 hours	Current shipment could be on time
Transport Cost (door-to-door)	US$4,000	US$1,750
Transit time (door-to-door)	7 days	6 days
	Road	**SSS**
	SP_Random4 Select	SP_Random4 Select

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SP_Random5

UNIVERSITY OF CAPE TOWN

IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

knowing what you know, if these were your only options, which mode would you choose to transport [Script] between Durban and Beira?

(6 of 13)

	Road	SSS
Frequency of Service	Departs everyday of the week	1 departure per fortnight
Service Reliability	2 out of 3 shipments are on time	1 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 24 hours	Shippment could be delayed by 48 hours
Transport Cost (door-to-door)	US$2,500	US$2,125
Transit time (door-to-door)	5 days	8 days
	Road	**SSS**
	SP_Random5 Select	SP_Random5 Select

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SP_Random6

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

knowing what you know, if these were your only options, which mode would you choose to transport [Script] between Durban and Beira?

(7 of 13)

	Road	SSS
Frequency of Service	Departs everyday of the week	1 departure per fortnight
Service Reliability	2 out of 3 shipments are on time	1 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 24 hours	Shippment could be delayed by 24 hours
Transport Cost (door-to-door)	US$3,500	US$2,600
Transit time (door-to-door)	5 days	8 days
	Road	**SSS**
	SP_Random6 Select	SP_Random6 Select

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0% 100%

SP_Random7

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

knowing what you know, if these were your only options, which mode would you choose to transport [Script] between Durban and Beira?

(8 of 13)

	Road	SSS
Frequency of Service	6 departures per week (no service on sundays)	1 departure per week
Service Reliability	1 out of 3 shipments are on time	2 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 48 hours	Shippment could be delayed by 48 hours
Transport Cost (door-to-door)	US$3,500	US$2,600
Transit time (door-to-door)	6 days	7 days
	Road	**SSS**
	SP_Random7 Select	SP_Random7 Select

Back Next

0% 100%

SP_Random8

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

knowing what you know, if these were your only options, which mode would you choose to transport [Script] between Durban and Beira?

(9 of 13)

	Road	SSS
Frequency of Service	5 departures per week (no service on weekends)	2 departures per week
Service Reliability	2 out of 3 shipments are on time	1 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 72 hours	Current shipment could be on time
Transport Cost (door-to-door)	US$4,000	US$1,750
Transit time (door-to-door)	5 days	8 days
	Road	**SSS**
	SP_Random8 Select	SP_Random8 Select

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0% 100%

SP_Random9

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

knowing what you know, if these were your only options, which mode would you choose to transport [Script] between Durban and Beira?

(10 of 13)

	Road	SSS
Frequency of Service	5 departures per week (no service on weekends)	1 departure per week
Service Reliability	0 out of 3 shipments are on time	3 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 72 hours	Current shipment could be on time
Transport Cost (door-to-door)	US$2,500	US$2,125
Transit time (door-to-door)	5 days	8 days
	Road	**SSS**
	SP_Random9 Select	SP_Random9 Select

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0% 100%

SP_Random10

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

knowing what you know, if these were your only options, which mode would you choose to transport [Script] between Durban and Beira?

(11 of 13)

	Road	SSS
Frequency of Service	6 departures per week (no service on sundays)	2 departures per week
Service Reliability	0 out of 3 shipments are on time	2 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 24 hours	Shippment could be delayed by 24 hours
Transport Cost (door-to-door)	US$2,500	US$2,125
Transit time (door-to-door)	7 days	6 days
	Road	**SSS**
	SP_Random10 Select	SP_Random10 Select

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0% 100%

SP_Random11

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

knowing what you know, if these were your only options, which mode would you choose to transport [Script] between Durban and Beira?

(12 of 13)

	Road	SSS
Frequency of Service	6 departures per week (no service on sundays)	1 departure per week
Service Reliability	1 out of 3 shipments are on time	2 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 48 hours	Shippment could be delayed by 24 hours
Transport Cost (door-to-door)	US$3,500	US$2,600
Transit time (door-to-door)	6 days	7 days
	Road	**SSS**
	SP_Random11 Select	SP_Random11 Select

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0% 100%

SP_Random12

UNIVERSITY OF CAPE TOWN

IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

knowing what you know, if these were your only options, which mode would you choose to transport [Script] between Durban and Beira?

(13 of 13)

	Road	SSS
Frequency of Service	5 departures per week (no service on weekends)	2 departures per week
Service Reliability	0 out of 3 shipments are on time	2 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 24 hours	Shippment could be delayed by 48 hours
Transport Cost (door-to-door)	US$4,000	US$1,750
Transit time (door-to-door)	7 days	6 days
	Road	**SSS**
	SP_Random12 Select	SP_Random12 Select

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0% 100%

Note: The questions in this part relate to long haul distance(<1500km) transport within SADC.

{script if Cape Town ~ Windhoek: show the following 13 choice tasks}

SP_Fixed1

UNIVERSITY OF CAPE TOWN

IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

If these were your only options, which would you choose to transport [Script] between Cape Town and Windhoek?

(1 of 13)

	Road	SSS+Road	SSS+Rail
Frequency of Service	5 departures per week (no service allowed on weekends)	2 departures per week	2 departures per week
Service Reliability	1 out of 3 shipments are on time	2 out of 3 shipments are on time	3 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 24 hours	Shippment could be delayed by 6 hours	Current shipment could be on time
Transport Cost (door-to-door)	US$ 4,000	US$ 3,000	US$ 2,200
Transit time (door-to-door)	5 days	7 days	8 days
	Road	**SSS+Road**	**SSS+Rail**
	SP_Fixed1 Select	SP_Fixed1 Select	SP_Fixed1 Select

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SP_Random1

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

If these were your only options, which would you choose to transport [Script] between Cape Town and Windhoek?

(2 of 13)

	Road	SSS+Road	SSS+Rail
Frequency of Service	Departs everyday of the week	1 departure per fortnight	1 departure per fortnight
Service Reliability	2 out of 3 shipments are on time	1 out of 3 shipments are on time	0 out of 3 shipments are on time
Extend of delay	Current shipment could be on time	Shippment could be delayed by 12 hours	Shippment could be delayed by 3 hours
Transport Cost (door-to-door)	US$ 3,000	US$ 3,000	US$ 2,800
Transit time (door-to-door)	3 days	9 day	12 days
	Road	**SSS+Road**	**SSS+Rail**
	SP_Random1 Select	SP_Random1 Select	SP_Random1 Select

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0% 100%

SP_Random2

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

If these were your only options, which would you choose to transport [Script] between Cape Town and Windhoek?

(3 of 13)

	Road	SSS+Road	SSS+Rail
Frequency of Service	Departs everyday of the week	1 departure per fortnight	1 departure per fortnight
Service Reliability	2 out of 3 shipments are on time	1 out of 3 shipments are on time	0 out of 3 shipments are on time
Extend of delay	Current shipment could be on time	Shippment could be delayed by 12 hours	Shippment could be delayed by 6 hours
Transport Cost (door-to-door)	US$ 3,000	US$ 3,000	US$ 2,800
Transit time (door-to-door)	3 days	9 day	12 days
	Road	**SSS+Road**	**SSS+Rail**
	SP_Random2 Select	SP_Random2 Select	SP_Random2 Select

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0% 100%

SP_Random3

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

If these were your only options, which would you choose to transport [Script] between Cape Town and Windhoek?

(4 of 13)

	Road	SSS+Road	SSS+Rail
Frequency of Service	6 departures per week (no service allowed on sundays)	1 departure per week	1 departure per week
Service Reliability	0 out of 3 shipments are on time	3 out of 3 shipments are on time	1 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 24 hours	Current shipment could be on time	Current shipment could be on time
Transport Cost (door-to-door)	US$ 4,000	US$2,400	US$ 2,200
Transit time (door-to-door)	5 days	5 days	10 days
	Road	**SSS+Road**	**SSS+Rail**
	SP_Random3 Select	SP_Random3 Select	SP_Random3 Select

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0% 100%

SP_Random4

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

If these were your only options, which would you choose to transport [Script] between Cape Town and Windhoek?

(5 of 13)

	Road	SSS+Road	SSS+Rail
Frequency of Service	Departs everyday of the week	1 departure per fortnight	1 departure per fortnight
Service Reliability	2 out of 3 shipments are on time	1 out of 3 shipments are on time	0 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 12 hours	Shippment could be delayed by 6 hours	Shippment could be delayed by 3 hours
Transport Cost (door-to-door)	US$ 3,500	US$ 2,700	US$ 2,500
Transit time (door-to-door)	4 days	7 days	12 days
	Road	**SSS+Road**	**SSS+Rail**
	SP_Random4 Select	SP_Random4 Select	SP_Random4 Select

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0% 100%

SP_Random5

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

If these were your only options, which would you choose to transport [Script] between Cape Town and Windhoek?

(6 of 13)

	Road	SSS+Road	SSS+Rail
Frequency of Service	Departs everyday of the week	1 departure per fortnight	1 departure per fortnight
Service Reliability	2 out of 3 shipments are on time	1 out of 3 shipments are on time	0 out of 3 shipments are on time
Extend of delay	Current shipment could be on time	Shippment could be delayed by 6 hours	Shippment could be delayed by 3 hours
Transport Cost (door-to-door)	US$ 3,000	US$ 3,000	US$ 2,800
Transit time (door-to-door)	3 days	9 day	12 days
	Road	**SSS+Road**	**SSS+Rail**
	SP_Random5 Select	SP_Random5 Select	SP_Random5 Select

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0% 100%

SP_Random6

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

If these were your only options, which would you choose to transport [Script] between Cape Town and Windhoek?

(7 of 13)

	Road	SSS+Road	SSS+Rail
Frequency of Service	5 departures per week (no service allowed on weekends)	2 departures per week	2 departures per week
Service Reliability	1 out of 3 shipments are on time	1 out of 3 shipments are on time	2 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 24 hours	Current shipment could be on time	Current shipment could be on time
Transport Cost (door-to-door)	US$ 4,000	US$2,400	US$ 2,200
Transit time (door-to-door)	5 days	5 days	8 days
	Road	**SSS+Road**	**SSS+Rail**
	SP_Random6 Select	SP_Random6 Select	SP_Random6 Select

Back Next

0% 100%

SP_Random7

UNIVERSITY OF CAPE TOWN

IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

If these were your only options, which would you choose to transport [Script] between Cape Town and Windhoek?

(8 of 13)

	Road	**SSS+Road**	**SSS+Rail**
Frequency of Service	6 departures per week (no service allowed on sundays)	1 departure per week	2 departures per week
Service Reliability	1 out of 3 shipments are on time	2 out of 3 shipments are on time	2 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 12 hours	Shippment could be delayed by 12 hours	Shippment could be delayed by 6 hours
Transport Cost (door-to-door)	US$ 3,500	US$ 2,700	US$ 2,500
Transit time (door-to-door)	4 days	7 days	8 days
	Road	**SSS+Road**	**SSS+Rail**
	SP_Random7 Select	SP_Random7 Select	SP_Random7 Select

Back Next

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SP_Random8

UNIVERSITY OF CAPE TOWN

IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

If these were your only options, which would you choose to transport [Script] between Cape Town and Windhoek?

(9 of 13)

	Road	**SSS+Road**	**SSS+Rail**
Frequency of Service	5 departures per week (no service allowed on weekends)	2 departures per week	1 departure per week
Service Reliability	0 out of 3 shipments are on time	2 out of 3 shipments are on time	2 out of 3 shipments are on time
Extend of delay	Current shipment could be on time	Shippment could be delayed by 12 hours	Shippment could be delayed by 6 hours
Transport Cost (door-to-door)	US$ 4,000	US$2,400	US$ 2,500
Transit time (door-to-door)	5 days	5 days	10 days
	Road	**SSS+Road**	**SSS+Rail**
	SP_Random8 Select	SP_Random8 Select	SP_Random8 Select

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SP_Random9

UNIVERSITY OF CAPE TOWN

IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

If these were your only options, which would you choose to transport [Script] between Cape Town and Windhoek?

(10 of 13)

	Road	SSS+Road	SSS+Rail
Frequency of Service	6 departures per week (no service allowed on sundays)	1 departure per week	2 departures per week
Service Reliability	1 out of 3 shipments are on time	2 out of 3 shipments are on time	1 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 12 hours	Shippment could be delayed by 6 hours	Current shipment could be on time
Transport Cost (door-to-door)	US$ 3,500	US$ 2,700	US$ 2,200
Transit time (door-to-door)	4 days	7 days	8 days
	Road	**SSS+Road**	**SSS+Rail**
	SP_Random9 Select	SP_Random9 Select	SP_Random9 Select

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SP_Random10

UNIVERSITY OF CAPE TOWN

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If these were your only options, which would you choose to transport [Script] between Cape Town and Windhoek?

(11 of 13)

	Road	SSS+Road	SSS+Rail
Frequency of Service	5 departures per week (no service allowed on weekends)	2 departures per week	2 departures per week
Service Reliability	0 out of 3 shipments are on time	2 out of 3 shipments are on time	2 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 24 hours	Current shipment could be on time	Shippment could be delayed by 6 hours
Transport Cost (door-to-door)	US$ 3,000	US$ 3,000	US$ 2,800
Transit time (door-to-door)	5 days	5 days	10 days
	Road	**SSS+Road**	**SSS+Rail**
	SP_Random10 Select	SP_Random10 Select	SP_Random10 Select

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SP_Random11

UNIVERSITY OF CAPE TOWN
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If these were your only options, which would you choose to transport [Script] between Cape Town and Windhoek?

(12 of 13)

	Road	SSS+Road	SSS+Rail
Frequency of Service	5 departures per week (no service allowed on weekends)	2 departures per week	1 departure per week
Service Reliability	0 out of 3 shipments are on time	3 out of 3 shipments are on time	1 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 24 hours	Current shipment could be on time	Shippment could be delayed by 3 hours
Transport Cost (door-to-door)	US$ 4,000	US$2,400	US$ 2,500
Transit time (door-to-door)	3 days	9 day	10 days
	Road	**SSS+Road**	**SSS+Rail**
	SP_Random11 Select	SP_Random11 Select	SP_Random11 Select

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SP_Random12

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

If these were your only options, which would you choose to transport [Script] between Cape Town and Windhoek?

(13 of 13)

	Road	SSS+Road	SSS+Rail
Frequency of Service	6 departures per week (no service allowed on sundays)	1 departure per week	1 departure per week
Service Reliability	1 out of 3 shipments are on time	2 out of 3 shipments are on time	1 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 12 hours	Shippment could be delayed by 6 hours	Current shipment could be on time
Transport Cost (door-to-door)	US$ 3,500	US$ 2,700	US$ 2,200
Transit time (door-to-door)	4 days	7 days	8 days
	Road	**SSS+Road**	**SSS+Rail**
	SP_Random12 Select	SP_Random12 Select	SP_Random12 Select

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0% 100%

Note: The questions in this part relate to long haul distance(<1500km) transport within SADC.

{script if Durban ~ Harare: show the following 13 choice tasks}

SP_Fixed1

UNIVERSITY OF CAPE TOWN

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If these were your only options, which would you choose to transport [Script] between Durban and Harare?

(1 of 13)

	Road	SSS+Road	SSS+Rail	Rail
Frequency of Service	4 departures per week	1 departure per week	1 departure per week	3 departures per week
Service Reliability	0 out of 3 shipments are on time	3 out of 3 shipments are on time	2 out of 3 shipments are on time	1 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 96 hours	Shippment could be delayed by 12 hours	Shipment could be on time	Shipment could be on time
Transport Cost (door-to-door)	US$ 4,500	US$ 2,700	US$ 2,400	US$ 1,000
Transit time (door-to-door)	10 days	11 days	11 days	11 days
	Road	**SSS+Road**	**SSS+Rail**	**Rail**
	SP_Fixed1 Select	SP_Fixed1 Select	SP_Fixed1 Select	SP_Fixed1 Select

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0% 100%

SP_Random1

UNIVERSITY OF CAPE TOWN

IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

If these were your only options, which would you choose to transport [Script] between Durban and Harare?

(2 of 13)

	Road	SSS+Road	SSS+Rail	Rail
Frequency of Service	5 departures per week (no service on weekends)	1 departure per fortnight	2 departures per week	4 departures per week
Service Reliability	0 out of 3 shipments are on time	1 out of 3 shipments are on time	2 out of 3 shipments are on time	2 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 24 hours	Shippment could be delayed by 12 hours	Shipment could be on time	Shippment could be delayed by 96 hours
Transport Cost (door-to-door)	US$ 4,500	US$ 3,200	US$ 2,400	US$ 1,000
Transit time (door-to-door)	8 days	11 days	16 days	12 days
	Road	**SSS+Road**	**SSS+Rail**	**Rail**
	SP_Random1 Select	SP_Random1 Select	SP_Random1 Select	SP_Random1 Select

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0% 100%

SP_Random2

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

If these were your only options, which would you choose to transport [Script] between Durban and Harare?

(3 of 13)

	Road	SSS+Road	SSS+Rail	Rail
Frequency of Service	6 departures per week (no service on sundays)	2 departures per week	2 departures per week	3 departures per week
Service Reliability	1 out of 3 shipments are on time	3 out of 3 shipments are on time	1 out of 3 shipments are on time	1 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 48 hours	Shipment could be on time	Shipment could be on time	Shipment could be on time
Transport Cost (door-to-door)	US$ 4,000	US$ 2,700	US$ 2,700	US$ 2,000
Transit time (door-to-door)	8 days	8 days	10 days	14 days
	Road	**SSS+Road**	**SSS+Rail**	**Rail**
	SP_Random2 Select	SP_Random2 Select	SP_Random2 Select	SP_Random2 Select

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SP_Random3

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

If these were your only options, which would you choose to transport [Script] between Durban and Harare?

(4 of 13)

	Road	SSS+Road	SSS+Rail	Rail
Frequency of Service	Departs everyday of the week	1 departure per fortnight	1 departure per fortnight	1 departure per week
Service Reliability	2 out of 3 shipments are on time	1 out of 3 shipments are on time	0 out of 3 shipments are on time	1 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 12 hours	Shippment could be delayed by 24 hours	Shippment could be delayed by 72 hours	Shippment could be delayed by 96 hours
Transport Cost (door-to-door)	US$ 3,500	US$ 3,700	US$ 3,000	US$ 3,000
Transit time (door-to-door)	6 days	14 days	16 days	16 days
	Road	**SSS+Road**	**SSS+Rail**	**Rail**
	SP_Random3 Select	SP_Random3 Select	SP_Random3 Select	SP_Random3 Select

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SP_Random4

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

If these were your only options, which would you choose to transport [Script] between Durban and Harare?

(5 of 13)

	Road	SSS+Road	SSS+Rail	Rail
Frequency of Service	Departs everyday of the week	1 departure per week	1 departure per week	1 departure per week
Service Reliability	0 out of 3 shipments are on time	2 out of 3 shipments are on time	1 out of 3 shipments are on time	3 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 48 hours	Shippment could be delayed by 12 hours	Shippment could be delayed by 24 hours	Shipment could be on time
Transport Cost (door-to-door)	US$ 4,500	US$ 3,200	US$ 2,700	US$ 1,000
Transit time (door-to-door)	8 days	11 days	13 days	12 days
	Road	**SSS+Road**	**SSS+Rail**	**Rail**
	SP_Random4 Select	SP_Random4 Select	SP_Random4 Select	SP_Random4 Select

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0% 100%

SP_Random5

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

If these were your only options, which would you choose to transport [Script] between Durban and Harare?

(6 of 13)

	Road	SSS+Road	SSS+Rail	Rail
Frequency of Service	5 departures per week (no service on weekends)	2 departures per week	2 departures per week	2 departures per week
Service Reliability	0 out of 3 shipments are on time	3 out of 3 shipments are on time	2 out of 3 shipments are on time	2 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 24 hours	Shipment could be on time	Shipment could be on time	Shippment could be delayed by 48 hours
Transport Cost (door-to-door)	US$ 4,500	US$ 2,700	US$ 2,400	US$ 2,000
Transit time (door-to-door)	7 days	14 days	10 days	14 days
	Road	**SSS+Road**	**SSS+Rail**	**Rail**
	SP_Random5 Select	SP_Random5 Select	SP_Random5 Select	SP_Random5 Select

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SP_Random6

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

If these were your only options, which would you choose to transport [Script] between Durban and Harare?

(7 of 13)

	Road	SSS+Road	SSS+Rail	Rail
Frequency of Service	Departs everyday of the week	1 departure per fortnight	1 departure per fortnight	1 departure per week
Service Reliability	2 out of 3 shipments are on time	1 out of 3 shipments are on time	0 out of 3 shipments are on time	0 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 12 hours	Shippment could be delayed by 24 hours	Shippment could be delayed by 72 hours	Shippment could be delayed by 96 hours
Transport Cost (door-to-door)	US$ 3,500	US$ 3,700	US$ 3,000	US$ 3,000
Transit time (door-to-door)	6 days	14 days	16 days	16 days
	Road	**SSS+Road**	**SSS+Rail**	**Rail**
	SP_Random6 Select	SP_Random6 Select	SP_Random6 Select	SP_Random6 Select

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SP_Random7

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

If these were your only options, which would you choose to transport [Script] between Durban and Harare?

(8 of 13)

	Road	SSS+Road	SSS+Rail	Rail
Frequency of Service	5 departures per week (no service on weekends)	1 departure per week	2 departures per week	3 departures per week
Service Reliability	0 out of 3 shipments are on time	2 out of 3 shipments are on time	2 out of 3 shipments are on time	3 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 24 hours	Shippment could be delayed by 12 hours	Shippment could be delayed by 24 hours	Shipment could be on time
Transport Cost (door-to-door)	US$ 3,500	US$ 3,200	US$ 2,400	US$ 3,000
Transit time (door-to-door)	6 days	11 days	13 days	14 days
	Road	**SSS+Road**	**SSS+Rail**	**Rail**
	SP_Random7 Select	SP_Random7 Select	SP_Random7 Select	SP_Random7 Select

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0% 100%

SP_Random8

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

If these were your only options, which would you choose to transport [Script] between Durban and Harare?

(9 of 13)

	Road	SSS+Road	SSS+Rail	Rail
Frequency of Service	5 departures per week (no service on weekends)	1 departure per week	1 departure per week	4 departures per week
Service Reliability	1 out of 3 shipments are on time	2 out of 3 shipments are on time	1 out of 3 shipments are on time	0 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 48 hours	Shippment could be delayed by 24 hours	Shippment could be delayed by 24 hours	Shipment could be on time
Transport Cost (door-to-door)	US$ 4,500	US$ 3,700	US$ 2,400	US$ 1,000
Transit time (door-to-door)	7 days	8 days	10 days	16 days
	Road	**SSS+Road**	**SSS+Rail**	**Rail**
	SP_Random8 Select	SP_Random8 Select	SP_Random8 Select	SP_Random8 Select

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0% 100%

SP_Random9

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

If these were your only options, which would you choose to transport [Script] between Durban and Harare?

(10 of 13)

	Road	SSS+Road	SSS+Rail	Rail
Frequency of Service	6 departures per week (no service on sundays)	1 departure per week	1 departure per week	4 departures per week
Service Reliability	1 out of 3 shipments are on time	2 out of 3 shipments are on time	2 out of 3 shipments are on time	2 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 48 hours	Shippment could be delayed by 24 hours	Shipment could be on time	Shipment could be on time
Transport Cost (door-to-door)	US$ 3,500	US$ 3,200	US$ 2,700	US$ 3,000
Transit time (door-to-door)	8 days	11 days	10 days	12 days
	Road	**SSS+Road**	**SSS+Rail**	**Rail**
	SP_Random9 Select	SP_Random9 Select	SP_Random9 Select	SP_Random9 Select

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0% 100%

SP_Random10

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

If these were your only options, which would you choose to transport [Script] between Durban and Harare?

(11 of 13)

	Road	SSS+Road	SSS+Rail	Rail
Frequency of Service	Departs everyday of the week	1 departure per fortnight	1 departure per fortnight	2 departures per week
Service Reliability	2 out of 3 shipments are on time	1 out of 3 shipments are on time	0 out of 3 shipments are on time	0 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 12 hours	Shippment could be delayed by 12 hours	Shippment could be delayed by 72 hours	Shippment could be delayed by 48 hours
Transport Cost (door-to-door)	US$ 4,000	US$ 3,700	US$ 3,000	US$ 2,000
Transit time (door-to-door)	6 days	14 days	16 days	16 days
	Road	**SSS+Road**	**SSS+Rail**	**Rail**
	SP_Random10 Select	SP_Random10 Select	SP_Random10 Select	SP_Random10 Select

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SP_Random11

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

If these were your only options, which would you choose to transport [Script] between Durban and Harare?

(12 of 13)

	Road	SSS+Road	SSS+Rail	Rail
Frequency of Service	6 departures per week (no service on sundays)	2 departures per week	1 departure per week	3 departures per week
Service Reliability	1 out of 3 shipments are on time	1 out of 3 shipments are on time	1 out of 3 shipments are on time	0 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 24 hours	Shipment could be on time	Shippment could be delayed by 24 hours	Shipment could be on time
Transport Cost (door-to-door)	US$ 4,000	US$ 2,700	US$ 2,700	US$ 1,000
Transit time (door-to-door)	7 days	8 days	13 days	12 days
	Road	**SSS+Road**	**SSS+Rail**	**Rail**
	SP_Random11 Select	SP_Random11 Select	SP_Random11 Select	SP_Random11 Select

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SP_Random12

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

If these were your only options, which would you choose to transport [Script] between Durban and Harare?

(13 of 13)

	Road	SSS+Road	SSS+Rail	Rail
Frequency of Service	6 departures per week (no service on sundays)	2 departures per week	1 departure per fortnight	2 departures per week
Service Reliability	2 out of 3 shipments are on time	2 out of 3 shipments are on time	0 out of 3 shipments are on time	1 out of 3 shipments are on time
Extend of delay	Shippment could be delayed by 12 hours	Shipment could be on time	Shippment could be delayed by 72 hours	Shippment could be delayed by 48 hours
Transport Cost (door-to-door)	US$ 4,000	US$ 2,700	US$ 3,000	US$ 2,000
Transit time (door-to-door)	7 days	8 days	13 days	14 days
	Road	SSS+Road	SSS+Rail	Rail
	SP_Random12 Select	SP_Random12 Select	SP_Random12 Select	SP_Random12 Select

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PART 5: DIAGNOSTIC QUESTIONS (PAGE 21)

Thank you for completing the choice tasks. Before we conclude the survey, please answer the following questions:

Q 29. Were you able to understand the choice scenarios that were presented?

Yes	(1)
Not Sure	(2)
No	(3)

Q 30. Were the choice scenarios offered realistic?

Yes	(1)
Not Sure	(2)
No	(3)

Q 31. Can you please indicate which of these attributes did you considered when you chose your preferred mode to transport [Script] ?

Transport cost	(1)
Transit time	(2)
Reliability	(3)
Frequency of service	(4)
Delay time	(5)

PART 7: ATTITUDES AND PERCEPTIONS (PAGE 22)

Q32.How would you rate the following service attributes on this corridor:?

Q32.1 RAIL

	Very Poor	Poor	Average	Good	Very Good
Quality of Service:	PerceptionsRail_r1=1	PerceptionsRail_r1=2	PerceptionsRail_r1=3	PerceptionsRail_r1=4	PerceptionsRail_r1=5
Cargo safety and security:	PerceptionsRail_r2=1	PerceptionsRail_r2=2	PerceptionsRail_r2=3	PerceptionsRail_r2=4	PerceptionsRail_r2=5
Flexibility to shipper needs:	PerceptionsRail_r3=1	PerceptionsRail_r3=2	PerceptionsRail_r3=3	PerceptionsRail_r3=4	PerceptionsRail_r3=5
Convinience:	PerceptionsRail_r4=1	PerceptionsRail_r4=2	PerceptionsRail_r4=3	PerceptionsRail_r4=4	PerceptionsRail_r4=5
Communication and Information flow:	PerceptionsRail_r5=1	PerceptionsRail_r5=2	PerceptionsRail_r5=3	PerceptionsRail_r5=4	PerceptionsRail_r5=5
Reliability in terms of arriving on-time:	PerceptionsRail_r6=1	PerceptionsRail_r6=2	PerceptionsRail_r6=3	PerceptionsRail_r6=4	PerceptionsRail_r6=5

Q32.2 COASTAL SHIPPING

	Very Poor	Poor	Average	Good	Very Good
Quality of Service:	PerceptionsSSS_r1=1	PerceptionsSSS_r1=2	PerceptionsSSS_r1=3	PerceptionsSSS_r1=4	PerceptionsSSS_r1=5
Cargo safety and security:	PerceptionsSSS_r2=1	PerceptionsSSS_r2=2	PerceptionsSSS_r2=3	PerceptionsSSS_r2=4	PerceptionsSSS_r2=5
Flexibility to shipper needs:	PerceptionsSSS_r3=1	PerceptionsSSS_r3=2	PerceptionsSSS_r3=3	PerceptionsSSS_r3=4	PerceptionsSSS_r3=5
Convinience:	PerceptionsSSS_r4=1	PerceptionsSSS_r4=2	PerceptionsSSS_r4=3	PerceptionsSSS_r4=4	PerceptionsSSS_r4=5
Communication and Information flow:	PerceptionsSSS_r5=1	PerceptionsSSS_r5=2	PerceptionsSSS_r5=3	PerceptionsSSS_r5=4	PerceptionsSSS_r5=5
Reliability in terms of arriving on-time:	PerceptionsSSS_r6=1	PerceptionsSSS_r6=2	PerceptionsSSS_r6=3	PerceptionsSSS_r6=4	PerceptionsSSS_r6=5

Q32.3 ROAD

	Very Poor	Poor	Average	Good	Very Good
Quality of Service:	PerceptionsRoad_r1=1	PerceptionsRoad_r1=2	PerceptionsRoad_r1=3	PerceptionsRoad_r1=4	PerceptionsRoad_
Cargo safety and security:	PerceptionsRoad_r2=1	PerceptionsRoad_r2=2	PerceptionsRoad_r2=3	PerceptionsRoad_r2=4	PerceptionsRoad_
Flexibility to shipper needs:	PerceptionsRoad_r3=1	PerceptionsRoad_r3=2	PerceptionsRoad_r3=3	PerceptionsRoad_r3=4	PerceptionsRoad_
Convinience:	PerceptionsRoad_r4=1	PerceptionsRoad_r4=2	PerceptionsRoad_r4=3	PerceptionsRoad_r4=4	PerceptionsRoad_
Communication and Information flow:	PerceptionsRoad_r5=1	PerceptionsRoad_r5=2	PerceptionsRoad_r5=3	PerceptionsRoad_r5=4	PerceptionsRoad_
Reliability in terms of arriving on-time:	PerceptionsRoad_r6=1	PerceptionsRoad_r6=2	PerceptionsRoad_r6=3	PerceptionsRoad_r6=4	PerceptionsRoad_
Conditions of the road:	PerceptionsRoad_r7=1	PerceptionsRoad_r7=2	PerceptionsRoad_r7=3	PerceptionsRoad_r7=4	PerceptionsRoad_

Q33. For the following questions please indicate the extend to which you agree or disagree with the following statements.

	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
I am fully aware of the transport modes and their service levels which are available on this corridor.	Attitudes_r1=1	Attitudes_r1=2	Attitudes_r1=3	Attitudes_r1=4	Attitudes_r1=5
Road offers me the flexibility I need to ship containerised [Script] , it will be difficult to change to another mode.	Attitudes_r2=1	Attitudes_r2=2	Attitudes_r2=3	Attitudes_r2=4	Attitudes_r2=5
As part of the company's social responsibility policy, we could consider using short sea shipping to transport [Script] in order to reduce the number of road accidents on our roads.	Attitudes_r3=1	Attitudes_r3=2	Attitudes_r3=3	Attitudes_r3=4	Attitudes_r3=5
My perception of maritime transport is that it is unreliable, complicated and unnatractive to use; and therefor we are unlikely to use short sea shipping to transport [Script] on this corridor:	Attitudes_r4=1	Attitudes_r4=2	Attitudes_r4=3	Attitudes_r4=4	Attitudes_r4=5
As part of the company's green supply chain management policy, we could consider using short sea shipping to transport [Script] in order to reduce air pollution, road congestion, and wear and tear of roads due which is in part caused by heavy freight trucks.	Attitudes_r5=1	Attitudes_r5=2	Attitudes_r5=3	Attitudes_r5=4	Attitudes_r5=5
High corruption and bribery at terminals, ports and customs points on this corridor is a concern.	Attitudes_r6=1	Attitudes_r6=2	Attitudes_r6=3	Attitudes_r6=4	Attitudes_r6=5

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We have concluded our survey. We thank you for your participation.

Table II: Current transport conditions to transport TEU (20' container) in SADC

Attribute		CT–WHK	CT–WB	CT - Lua	WB-Lua	Dur-Bei	Dur–Har
Integrated SSS (road)							
	Sea Freight	$1150	$1150	$950	$1250	$650	$650
	Port Costs	$300	$300	$550	$350	$550	$550
	Port Health	$300	$300	$400	$350	$400	$400
	Road	$500	$250	$400	$250	$400	$2500
ΣCost D2D		$2250	$2000	$2300	$4700	$2100	$4050
	Sea leg	3 day	3 day	4 days	3 days	2 days	2 days
	Port transit	3 days	3 days	5 days	4 days	4 days	4 days
	Road leg	1 days	-	-	2 days		2 days
ΣTransit time		7 days	6 days	9 days	9 days	6 days	8 days
	Sea leg (km)	1300 km	1300 km	2963 km	2060 km	1178 km	1178 km
	Road	400 km	-	-	551 km	-	557 km
ΣDistance (km)		1700 km	1300 km	3544 km	2611 km	1178 km	1735 km
Frequency		-	1 p/wk	1 times	1 p/wk	2 p/wk	-
Reliability		75%	75%	75%	50%	50%	75%
Damage/Loss		Low	Low	Med	High	Med	Low
Integrated SSS (Rail)							
	Sea Freight	$1150	-	-	$1595	-	$650
	Port Costs	$300	-	-	$500	-	$550
	Port Health	$300			$300	-	$300
	Rail Freight	$450	-	-	$800	-	$800
Σ Cost (D2D)		$1900	-		$3195	-	$2000
	Sea leg	3 day	-	-	3 days	-	3 days
	Port stay	2 days	-	-	3 days	-	3 days
	Rail Leg	3 days	-	-	4 days	-	4 days
Σ Transit time		8 days	-	-	10 days	-	10 days
	Sea leg (km)	1300 km	-	-	2060 km	-	1300
	Rail leg	400 km	-	-	557	-	557
Σ Distance		1700 km	-	-	2617 km	-	1857 km
Frequency		1 p/wk	-	-	1 p/wk	2 p/wk	1 p/wk
Delay		50%	-	-	25%	-	25%
Damage/Loss		Med	-	-	High	-	High
Rail							
Total Cost		-	-	-	-	-	*$3300*
Transit time		-	-	-	-	-	*14 days*
Distance		-	-	-	-	-	*2191*
Frequency		-	-	-	-	-	*1 p/wk*
Reliability		-	-	-	-	-	*65%*
Damage/Loss		-	-	-	-	-	*High*
Road							
Total Cost		$3000	$3500	$9000	$5250	$4500	$3700
Transit		2	4 days	8 days	4 days	4 days	6 days
Distance (km)		1500 km	1720 km	3544 km	2218 km	1792 km	1680 km
Frequency		Everyday	Everyday	Everyday	Everyday	Everyday	Everyday
Reliability (%)		100%	100%	75%	75%	75%	100%
Damage/Loss		Low	Low	Med	Med	Med	Low

ANNEXES V: CARRIER BEHAVIOR STUDY QUESTIONAIRE

CARRIER PREFERENCE FOR SHORT SEA SHIPPING IN SADC

CONTACT DETAILS (Optional):

Name: ______________________
Company: ______________________
Title: ______________________
Email: ______________________

INTRODUCTION: Thank you for participating in this study. The study is conducted as part of PhD research at the Centre for Transport Studies at the University of Cape Town. The target respondents for this survey are ship owners, operators and agents who own, operate or intent to operate ships in SADC. The purpose of the survey is to:

- To improve the understanding of hindrances towards the development of coastal shipping in SADC.
- To determine the willingness of carriers to participate in the envisioned Short Sea Shipping system given a number of conditions.

We expect the survey to take about 30 minutes to complete.

CONFIDENTIALITY: Participant names are optional. Any data supplied by you will also be treated with confidentiality, and the results will be published only in summary form, so that individual responses are not divulged. No negative consequences will result from your participation.

VOLUNTARY PARTICIPATION: Participation in this survey is entirely voluntary. The survey may also be stopped, or terminated at any time should you feel the need.

QUESTIONS: 1. Do you have any questions? (Please indicate yes/no) _________

2. Can we continue? (Please indicate yes/no) _________

NOTES ON SURVEY:

The survey is divided into 3 parts. Part A contains some primer questions, which allow us to get your perspective of certain issues of the industry. Part B is a choice game where you will be given specific information and asked to make choices. Part C is some diagnostic questions, which tells us how you made decisions in Part B. Part D is some questions about you.

A. **PRIMING QUESTIONS**

1. The following factors are known to influence the development of regional maritime transport around the world. On a scale of 1-5 (5 being highest); how would you rate each of these in SADC?[68]

Factors	1	2	3	4	5
Accessibility of maritime transport to road and rail transport.					
Sufficiency of equipment to support regional intermodal maritime transport.					
Information flow and communication:					
Collaboration between road, rail, ports and maritime carriers.					
Ship registration policies to promote growth of industry.					
Maritime Fiscal policies (ie. ship tax)					
Maritime administration & policies					
Customs services in ports					

2. The following factors have been cited to make maritime transport in SADC **costly** and therefore unattractive to use. On a scale of 1-5 (5 being highest), please indicate the extent to which you think these contribute to the high cost of intra-regional maritime transport in SADC.

Factors	1	2	3	4	5
Insufficient port infrastructure					
Low Port efficiency					
Low dedicated sea freight					
High Port Charges and Expenses					
High Terminal Handling fees					
High bunker prices					
High cost of manning ships					
High corruption and bribes					

3. The following factors have been cited to make maritime transport in SADC <u>slow</u> and <u>unreliable</u>. On a scale of 1-5 (5 being highest) please indicate the

[68] The Southern African Development Community (SADC) region is a regional economic community that comprise of all the 15 countries of Southern Africa namely: Angola, Namibia, South Africa, Botswana, Democratic Republic of the Congo, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Tanzania, Seychelles, Swaziland, Zambia and Zimbabwe.

extent to which you think these factors contribute to maritime transport to become slow and unreliable in SADC.

Factors	1	2	3	4	5
Insufficient port infrastructure.					
Port inefficiency.					
Port Congestion.					
Bad weather conditions.					
Delays due to strikes.					
High bunker prices.					
Poor information flow between ports, carrier and shipper.					
Delays due to customs & government officials.					

4. In this section, I will read a question. Answer yes or no.

	Yes	**No**
Maritime cabotage should be introduced for the entire SADC region to carry intra regional traded cargo.		
SADC countries should change ship registration policies to become flags of convenience (FOC).		
SADC countries should change shipping-tax policies from income to tonnage-based.		
Maritime administration (such as surveys and administration fees) should be made affordable by maritime authorities in the region.		
Wealth redistribution policies such as BEE should be implemented in the maritime industry.		
Regional maritime transport should get government subsidy to grow.		
Ships involved in coastal shipping must have a quota of local crew.		

5. Do you have any comments, contributions or suggestions regarding any of the questions above?

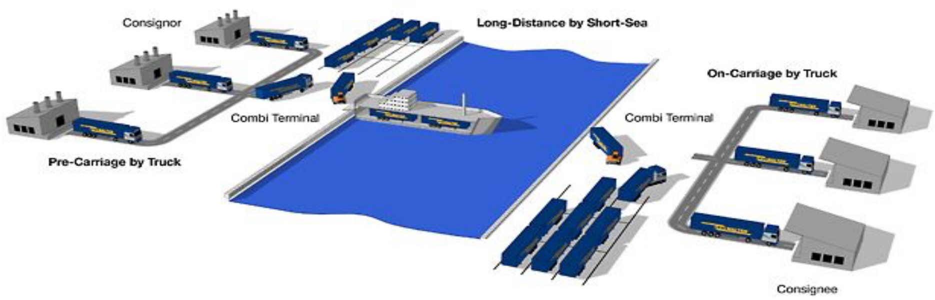
____

____

B. **SSS CHOICE GAME**

In this section, we are studying the introduction of a high frequency short sea shipping (SSS) service in SADC that is well integrated with other modes of transport. The envisioned SSS service, will offer a regular door-to-door service between the following port cities: **Luanda⇔Walvis Bay⇔Cape Town⇔Port Elizabeth ⇔ Durban ⇔ Beira ⇔ Dares Salam**

In this new mode, containerized (and general cargo) shipments would be transported by sea for the longer legs of the journey, and by road or rail for the remainder of the journey. A simplified operation of the system (SSS) is depicted below:



In this exercise, we are assessing the best way to make SSS efficient and seamless to a point that it can compete with road and rail. The carrier for the entire transport chain (SSS operator) is a single entity, which is furthermore responsible for all costs pertaining to the transportation of the container (except customs and import duties). We would now like to test, the extent to which you are comfortable with the envisioned environment. We will present you 12 scenarios, wherein the following attributes are varied:

Transport Charge: This refers to the amount you receive as income for every container transported door-door. It is meant to cover the freight rate, Port Dues, Terminal-handling charges, land transport costs, and other expenses related to the transportation of the container from the consignor's premises to the consignee's premises.

Dedicated TEU Volumes: This is the number of TEU containers (or equivalent) general cargo volumes that will be made available between every origin-destination pairing of ports. This amount may be there naturally, or may be induced by government due to new policies to promote the use of SSS. This does not include any feeder, or transshipment volumes.

Flag Requirements: This refers to the ship registration requirements that may be imposed on the SSS operator. To participate in the system, you could be required to register only in a SADC country (such as South Africa or Namibia), or you could be required to register in any country as long as it is not FOC, or you could be given an option to use any flag including FOC.

Port Dues Discount: Port Dues discount refers to the amount in % by which the respective original port dues will be discounted. You may consider your SADC experience when you answer.

Terminal Handling Charge Discount: Terminal handling charge discount refers to the amount in % by which the respective THC will be discounted.

The question you need to answer is always the same: Would you operate your vessel? You can answer: Yes, Unsure, or No. For every scenario, read through the conditions and decide if you would operate your vessel in the situation. When you answer, consider only the information in that set; don't compare it to the previous question.

Please note: ***When you submit your answer, please keep in mind, your decisions could inform future policies on regional maritime transport.***

***PERMANENT SETTING:** For all the scenarios, the permanent setting is as follow: This information applies to all 12 questions:

- **Frequency of service**: 1 weekly departure from every port in the loop.
- **Port Conditions (such to improve terminal efficiency and quick turnaround time)**:
    - Berth on arrival (within window of 3 hours).
    - Pilot exemption granted after 12 port visits.
    - Dedicated SSS port terminal to facilitate SSS service.
- **Ship Specifications**:
    - Ship type: Container (or general cargo) with TEU capacity of at least 400teu
    - Maximum loaded draft: 5m
    - Controllable pitch propulsion with bow and stern thrusters (to allow self docking)
- **Customs charges & taxes:** waivered for intra-regional trade.
- If you're a charterer, the shipowner will accept whatever you choose

I'll leave this paper here so you can look back at it.

1. Do you have any questions?

Choice Task 1

(Show the first choice. Read the information in each box, then the question. Give them time to think about their choice. Mark their choice on the sheet.)

Attribute	***Value***		
Transport Charge (door-door):	US$ 1,500		
Dedicated Container Volumes per week:	50 TEU units		
Port Dues discounted by:	45 %		
Terminal Handling Charge discounted by:	0 %		
Flag requirement:	Ship must register in any closed		
***Would you operate your vessel?**	**No**	**Unsure**	**Yes**

Choice Task 2

Attribute	***Value***		
Transport Charge (door-door):	US$ 1,500		
Dedicated Container Volumes per week:	250 TEU units		
Port Dues discounted by:	0 %		
Terminal Handling Charge discounted by:	0 %		
Flag requirement:	Ship must register in any closed		
Would you operate your vessel?	**No**	**Unsure**	**Yes**

Choice Task 3

Attribute	***Value***		
Transport Charge (door-door):	US$ 2,500		
Dedicated Container Volumes per week:	200 TEU units		
Port Dues discounted by:	30 %		
Terminal Handling Charge discounted by:	30 %		
Flag requirement:	Ship must register in SADC		
Would you operate your vessel?	**No**	**Unsure**	**Yes**

Choice Task 4

Attribute	***Value***		
Transport Charge (door-door):	US$ 2,500		
Dedicated Container Volumes per week:	250 TEU units		
Port Dues discounted by:	30%		
Terminal Handling Charge discounted by:	30 %		
Flag requirement:	Ship can register anywhere, including		
Would you operate your vessel?	**No**	**Unsure**	**Yes**

Choice Task 5

Attribute	***Value***		
Transport Charge (door-door):	US$ 2,500		
Dedicated Container Volumes per week:	200 TEU units		
Port Dues discounted by:	45 %		
Terminal Handling Charge discounted by:	45 %		
Flag requirement:	Ship can register anywhere, including		
Would you operate your vessel?	**No**	**Unsure**	**Yes**

Choice Task 6

Attribute	***Value***		
Transport Charge (door-door):	US$ 1,500		
Dedicated Container Volumes per week:	50 TEU units		
Port Dues discounted by:	0 %		
Terminal Handling Charge discounted by:	45 %		
Flag requirement:	Ship must register in any closed		
Would you operate your vessel?	**No**	**Unsure**	**Yes**

Choice Task 7

Attribute	***Value***		
Transport Charge (door-door):	US$ 2,500		
Dedicated Container Volumes per week:	250 TEU units		
Port Dues discounted by:	45 %		
Terminal Handling Charge discounted by:	45 %		
Flag requirement:	Ship can register anywhere, including		
Would you operate your vessel?	**No**	**Unsure**	**Yes**

Choice Task 8

Attribute	***Value***		
Transport Charge (door-door):	US$ 2,000		
Dedicated Container Volumes per week:	200 TEU units		
Port Dues discounted by:	15 %		
Terminal Handling Charge discounted by:	15 %		
Flag requirement:	Ship must register in SADC		
Would you operate your vessel?	**No**	**Unsure**	**Yes**

Choice Task 9

Attribute	***Value***		
Transport Charge (door-door):	US$ 1,500		
Dedicated Container Volumes per week:	150 TEU units		
Port Dues discounted by:	15 %		
Terminal Handling Charge discounted by:	15 %		
Flag requirement:	Ship can register anywhere, including		
Would you operate your vessel?	**No**	**Unsure**	**Yes**

Choice Task 10

Attribute	***Value***		
Transport Charge (door-door):	US$ 2,000		
Dedicated Container Volumes per week:	150 TEU units		
Port Dues discounted by:	15 %		
Terminal Handling Charge discounted by:	15 %		
Flag requirement:	Ship must register in SADC		
Would you operate your vessel?	**No**	**Unsure**	**Yes**

Choice Task 11

Attribute	***Value***		
Transport Charge (door-door):	US$ 2,000		
Dedicated Container Volumes per week:	150 TEU units		
Port Dues discounted by:	30 %		
Terminal Handling Charge discounted by:	30 %		
Flag requirement:	Ship must register in SADC		
Would you operate your vessel?	**No**	**Unsure**	**Yes**

Choice Task 12

Attribute	***Value***		
Transport Charge (door-door):	US$ 2,000		
Dedicated Container Volumes per week:	50 TEU units		
Port Dues discounted by:	0 %		
Terminal Handling Charge discounted by:	0 %		
Flag requirement:	Ship must register in any closed		
Would you operate your vessel?	**No**	**Unsure**	**Yes**

C. DIAGNOSTICS

6. Were you able to understand the choice scenarios?

a. Yes ☐

b. Not sure ☐

c. No ☐

7. Were the choice scenarios realistic:

a. Yes ☐

b. Not sure ☐

c. No ☐

8. Please indicate the attributes you considered when you made your choices:

a. Transport Charge ☐

b. Container Volumes ☐

c. Flag Requirements ☐

d. Port Dues Discount ☐

e. Terminal Handling Charge Discount ☐

D. GENERAL INFORMATION

This section has some questions about you. Please select the answer by ticking in the square.

9. Are you currently a shipowner or charterer?
   - a. Shipowner ☐
   - b. Charterer ☐
10. What type of maritime transport service do you offer in SADC?
    - a. Deep sea shipping ☐
    - b. Coastal shipping ☐
    - c. Both Deep sea & Coastal Shipping ☐
11. Please indicate the shipping sector that you operate in:
    - a. Container Market ☐
    - b. Tanker Market: Wet Bulk ☐
    - c. Dry Bulk Market ☐
    - d. General Cargo ☐
    - e. Ro-Ro ☐
    - f. Offshore supply & maintenance ☐
12. What is the nationality of your company? ______________________
13. How big is your fleet (number of ships)? ______________________
14. Please indicate the nationality of your ships (where your ships are registered):
    - a. South African registered ☐
    - b. SADC registered (but non-South African) ☐
    - c. Closed Registry (Foreign) ☐
    - d. Flag of Convenience or Open Registry ☐
15. What is the approximate number of employees in your company?
    - a. 1~20 ☐
    - b. 20~49 ☐
    - c. 50~99 ☐
    - d. 100~500 ☐
    - e. Over 500 ☐

ANNEX VI: SP DIAGNOSTICS

Subsequent the modeling exercises in Chapters 7 and 8, it was necessary to consider the effectiveness of the SP games in the surveys. Therefore, in the SP components of all surveys employed in the study, diagnostics questions were incorporated. These were necessary to verify the respondents' answers and to assess how serious they took the questions.

SP Diagnostics: Shipper behavior study

For the shipper behavior component, four types of diagnostic questions were employed: a fixed SP choice task; a question to indicate the attributes considered, a question to assess whether respondents understood the SP scenarios and a question to assess whether respondents found the SP scenarios realistic.

The fixed SP choice task was incorporated as a 13th SP task, wherein road was set very poorly and SSS (and intermodal SSS alternatives in the intermodal SSS options) was set extremely good. The SP fixed task was necessary to assess for political voting during interviewing. Table 7-3 presents the results for the unimodal SSS survey and Table 7-4 presents the results for the intermodal SSS survey.

The results show that in both the unimodal SSS and intermodal SSS surveys, responses were well considered and that respondent bias, if any, was very minimal. This is substantiated by clear differences between actual freight mode choices previously made (captured by the RP choice variable), the SP choice tasks and the Fixed tasks scenarios.

Table III: Overview of choices from SP game: unimodal SSS

	CT ~ WB		WB ~ Lua		Dur ~ Bei		Unimodal SSS	
Type of Scenario	RD	SSS	RD	SSS	RD	SSS	RD	SSS
RP Choice overall	88.89	11.11	93.55	6.45	61.11	38.89	64.13	35.87
SP choice overall	48.46	51.54	38.71	61.29	32.41	67.59	32.41	67.59
FT choice overall	9.26	90.74	9.68	90.32	38.89	61.11	20.86	79.14

Table IV: Overview of choices from SP game: intermodal SSS

	CT ~ Whk			Dur ~ Har				Combined Intermodal SSS			
Scenario type	RD	SRD	SRL	RD	SRD	SRL	RL	RD	SRD	SRL	RL
RP Choice %	98.08	1.92	0	95.08	0	0	4.92	96.46	0.88	0	2.65
SP choice %	44.55	41.67	13.78	15.42	25.83	32.5	32.41	28.94	33.18	23.81	14.06
FT choice %	11.54	71.15	17.31	10	16.67	23.33	50	10.71	41.96	20.54	26.79

With regard to attributes considered; respondents were asked to indicate the attributes they considered during the choice tasks after the SP choice tasks in the survey. They could select as many or as few attributes as they saw fit. Figure 7-6 presents the results for the unimodal SSS component, and Figure 7-7 present for the intermodal SSS component.

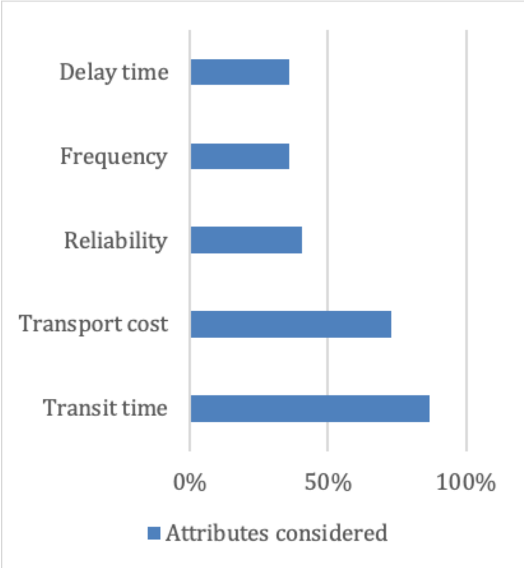


Figure I: Attributes considered unimodal SSS

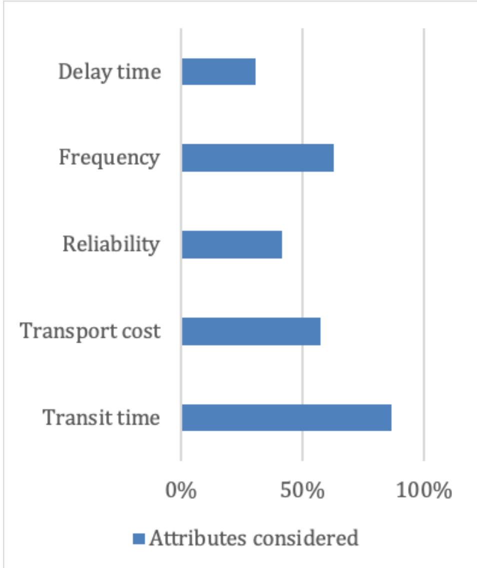


Figure II: Attributes considered intermodal SSS

In the unimodal SSS survey, the attributes mostly considered were transit time and transport costs. Reliability, service frequency were considered less then 50% of the time. In the intermodal SSS survey, figure 7-7 shows that transit time, service frequency and transport cost were the more popular with extend of delay the least popular. In both surveys, we notice the attribute most considered is transit time and the least considered is delay time.

The results show that respondents gave thought to the choice tasks, and even more so, they did so differently. Furthermore, the results are in no way contracting the results of the SADC freight study (Chapter 6), particularly because these attributes were considered based on specific attribute levels, which were corridor specific and product specific.

Subsequently, respondents were asked to indicate the extent to which they understood the choice scenarios, along a scale of 3 answers, yes, not sure and no. In the unimodal SSS survey, the majority (93 %) of the respondents said they understood the choice scenarios, 6% said they were not sure and only 1% said they did not understand the SP choice scenarios. In the intermodal SSS survey, similarly, the majority (87%) of respondents indicated they understood the choice scenarios, 13% said they were not sure and none said they did not understand the SP choice scenarios.

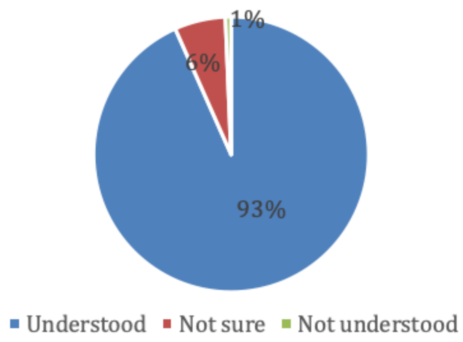


Figure III: Understandability unimodal SSS

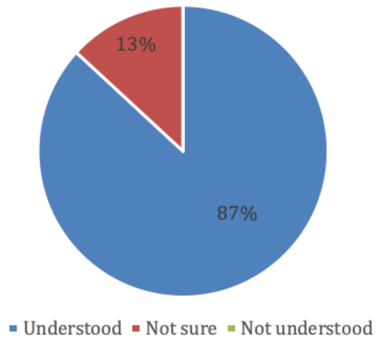


Figure IV: Understandability intermodal SSS

Lastly, respondents were asked whether they found the choice scenarios realistic, on a scale of 3 options: yes, not sure and no. In the unimodal SSS survey most of the respondents (63%) said they found the SP choice tasks realistic, 29% said they were not sure and 8% indicated they found them unrealistic. In the intermodal SSS survey, a slightly lower percentage of respondents (51%) said they found the SP choice tasks realistic, 35% said they were not sure, and 14% indicated they found them unrealistic. This was expected seeing the intermodal SSS options and transport routes proposed are not familiar to most shippers on these corridors. Also, this might be an indication that the respondents did not agree with most service levels presented, especially intermodal SSS.

Overall, the results show that respondents gave thought to the choice tasks, and even more so, they did so differently. Furthermore, the results are in no way contracting the results of the SADC freight study (Chapter 6), particularly because these attributes were considered based on specific attribute levels, which were corridor specific and product specific.

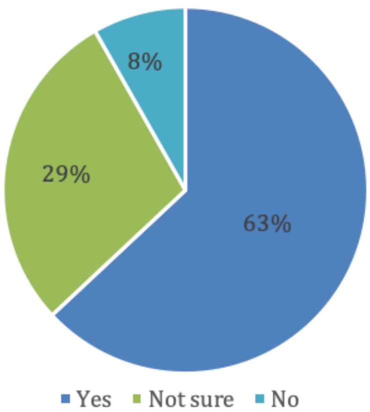


Figure V: Realistic SP scenarios

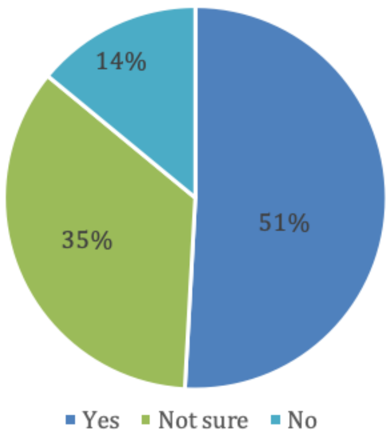


Figure VI: Realistic SP scenarios

SP Diagnostics: Carrier behavior

In the carrier survey, only three diagnostic questions were incorporated; and these were to gauge the attributes considered, to determine whether respondents understood the choice scenarios and to determine whether they found the SP scenarios realistic.

With regard to attributes considered in the carrier survey, the SP diagnostics indicated that most of the base attributes were considered most of the time, with flag requirements being least considered at times. This implies that respondents considered mostly the direct economic variables then the lesser service level variables such as flag requirements.

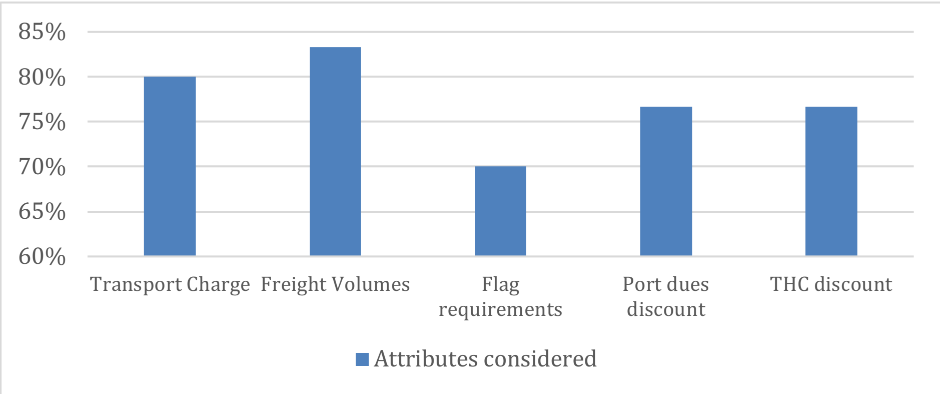


Figure VII: Attributes considered

With regard to the extent to which they understood the choice scenarios; all said they understood the choice scenarios. This is indicative that the respondents were well briefed, and the interviews were well conducted, despite the survey being translated into many languages. However, with regard to understanding the choice scenarios more than 50% of respondents said they found the scenarios unrealistic, with only 23% saying the scenarios were realistic. This was also understandable seeing the study had many assumptions; for example dedicated berths for the SSS vessels and pilot on arrival.

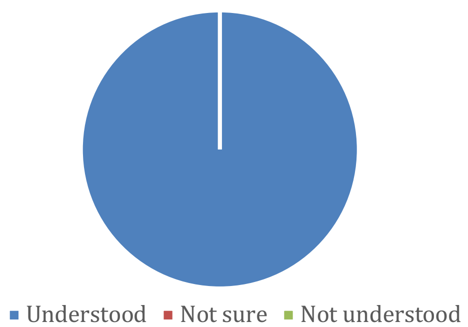


Figure VII: Understood SP tasks

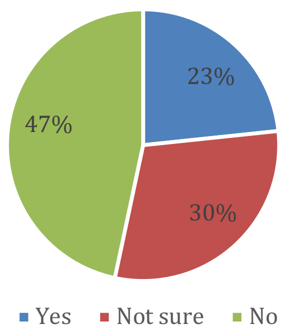


Figure IX: Realistic SP scenarios

ANNEX VII: ALTERNATIVE MODEL SPECIFICATIONS FOR INTERMODAL SSS

	NL_SSS			*NL_SSS1*			*NL_SSS_3*			*CNL_SSS_1*			*CNL_SSS_2*		
Attribute	coeff	r.s.e	r.t-r	coeff	r.s.e	r.t-r	coeff	r.s.e	rob.t-r	coeff	r.s.e	r.t-r	coeff	r.s.e	r.t-r
ASC RD (δ_{RD})	0	NA	NA	0.000	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
ASC SRD (δ_{SRD})	0.6927	0.1794	3.86	0.334	0.174	1.92	0.4037	0.1836	2.2	0.6336	0.1366	4.64	0.4039	0.1836	2.2
ASC SRL (δ_{SRL})	0.539	0.1978	2.72	-0.0947	0.3131	-0.3	-0.2029	0.3078	-0.66	0.1954	0.2073	0.94	-0.195	0.3069	-0.64
ASC RL (δ_{RL})	0.2389	0.3098	0.77	0.1902	0.3952	0.48	0.0401	0.738	0.05	0.0224	0.292	0.08	0.047	0.7314	0.06
Transit time (β_{time})	-0.1551	0.0219	-	-0.2206	0.0343	-6.43	-0.2849	0.0331	-8.61	-0.1331	0.0204	-6.52	-	0.0331	-8.6
Transport cost (β_{Cost})	-0.0008	0.0001	-	-0.0008	0.0001	-9.51	-0.0011	0.0001	-8.5	-0.0007	0.0001	-8.61	-	0.0001	-8.51
Delay extend (β_{Del})	-0.0067	0.0108	-	-0.0231	0.0109	-2.11	-0.0423	0.0141	-2.99	-0.0098	0.0077	-1.27	-	0.0141	-2.95
Frequency of service	0.0691	0.0173	3.99	0.0654	0.0166	3.93	0.089	0.0243	3.66	0.0567	0.0124	4.57	0.0893	0.0243	3.68
Reliability of service	0.0012	0.0006	1.98	0.0025	0.0009	2.73	0.0041	0.0013	3.14	0.0013	0.0005	2.43	0.0041	0.0013	3.14
ASC_{SRD} Dur_Har	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
ASC_{SRD} CT_Whk	0.2835	0.1261	2.25	0.5818	0.1574	3.7	1.3011	0.3383	3.85	0.2833	0.1031	2.75	1.2983	0.3374	3.85
Own trans RD (Δ_{OT_RD})	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
Own trans SRD (Δ_{OT_SRD})	0.1245	0.3234	0.38	-0.3294	0.2386	-1.38	-0.7463	0.3544	-2.11	0.0683	0.2061	0.33	-	0.3538	-2.1
Own trans SRL (Δ_{OT_SRL})	0.6384	0.326	1.96	1.0224	0.3226	3.17	0.8278	0.3774	2.19	0.5945	0.2521	2.36	0.8277	0.377	2.2
Own trans RL (Δ_{OT_RL})	-0.2733	0.397	-	-0.314	0.4106	-0.76	-1.9368	0.8071	-2.4	-0.2989	0.3526	-0.85	-	0.8036	-2.4
Ship freq RD	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
Ship freq SRD	-1.3386	0.4126	-	-0.6172	0.3102	-1.99	-0.8951	0.4437	-2.02	-0.9446	0.3363	-2.81	-	0.4433	-2.02
Ship freq SRL	-2.3415	0.4675	-	-2.9715	0.5733	-5.18	-3.459	0.7597	-4.55	-1.9375	0.4306	-4.5	-	0.7598	-4.54
Ship freq RL	-2.6413	0.704	-	-2.6001	0.7244	-3.59	-2.5562	1.1441	-2.23	-2.3545	0.6896	-3.41	-	1.1448	-2.24
λ RD_SRD	0.4041	0.0609	6.63							0.3782	0.0743	5.09			
λ _ SRD_SRL				0.6775	0.1313	5.16				0.3126	0.0617	5.07	3.1978	0.775	4.13
λ _SRL_RL							3.2059	0.7802	4.11				0.8027	0.0427	18.8
α_SRD_RD_BASE										-0.5295	0.3721	-1.42			
α_SRL_RL_BASE													4.1103	0.3845	10.69
Observations	1344			1344			1344			1344			1344		
Parameters	8			16			16			18			18		
LL (Start)	-1683.511			-1685.902			-1685.958			-1685.844			-1684.829		
LL(0)	-1683.666			-1683.666			-1683.666			-1683.666			-1683.666		
LL(final)	-1383.445			-1398.02			-1370.112			-1377.501			-1370.057		
Pseudo R2	0.1883			0.1697			0.1862			0.1818			0.1863		
Adjusted R2	0.1688			0.1602			0.1767			0.1712			0.1756		
AIC	2798.89			2828.04			2772.22			2791			2776.11		
BIC	2882.14			2911.29			2855.48			2884.66			2869.78		

Notes: coeff = coefficient, rob.s.e = robust standard error, rob.t-r = robust t-ratio, *insignificant

ANNEX VIII: ADDITIONAL MODELING OUTCOMES

B. SADC Freight study

Table V: Robust covariance matrix: EL model

	b_reliability	b_transit_time	b_damage_ris	b_frequency	b_customer_s	b_flexibility	b_monitor	b_enviro_frier	scale_2	scale_3	scale_4	scale_5	scale_6	scale_7	scale_8
b_reliability	0.2955704	0.01092005	0.00113189	0.06259479	-0.0402307	-0.114477	-0.26353	-0.5261961	-0.0634302	-0.1201642	-0.091343	-0.2238	-0.1450643	-0.1769279	-0.1761232
b_transit_time	0.01092005	0.35663753	0.16245253	0.02924945	0.08723285	0.0841223	0.15065852	0.1988906	0.18394937	0.12566577	0.01389974	0.01879323	0.05244245	-0.0088812	0.02741153
b_damage_ris	0.00113189	0.16245253	0.18630563	0.0335757	0.07035453	0.06766048	0.1193705	0.19200413	0.07179983	0.13944504	0.01733184	0.01574178	0.05391784	0.00881411	0.0369886
b_frequency	0.06259479	0.02924945	0.0335757	0.09322866	0.03112532	0.00599739	-0.0020411	-0.0179087	-0.0103229	-0.0034246	0.04873816	-0.0574798	0.00340214	-0.0137903	0.00111959
b_customer_s	-0.0402307	0.08723285	0.07035453	0.03112532	0.08418024	0.07202502	0.13267191	0.23263925	0.05075713	0.07357304	0.04884802	0.01475726	0.07521978	0.04999421	0.07082469
b_flexibility	-0.114477	0.0841223	0.06766048	0.00599739	0.07202502	0.12514252	0.2177417	0.38561584	0.07204103	0.10266226	0.07270142	0.09749655	0.08456762	0.11215315	0.12703935
b_monitor	-0.26353	0.15065852	0.1193705	-0.0020411	0.13267191	0.2177417	0.44569627	0.80767326	0.14080861	0.21182508	0.153759	0.21767305	0.19231925	0.2153335	0.26123042
b_enviro_frier	-0.5261961	0.1988906	0.19200413	-0.0179087	0.23263925	0.38561584	0.80767326	1.55925148	0.22759859	0.39198526	0.29913638	0.43842348	0.38911413	0.43525164	0.52866047
scale_2	-0.0634302	0.18394937	0.07179983	-0.0103229	0.05075713	0.07204103	0.14080861	0.22759859	0.11923257	0.08537122	0.02352918	0.06379249	0.0544363	0.04140977	0.05563945
scale_3	-0.1201642	0.12566577	0.13944504	-0.0034246	0.07357304	0.10266226	0.21182508	0.39198526	0.08537122	0.16731449	0.05500116	0.11036351	0.10880963	0.08791386	0.11629346
scale_4	-0.091343	0.01389974	0.01733184	0.04873816	0.04884802	0.07270142	0.153759	0.29913638	0.02352918	0.05500116	0.11431068	0.07205302	0.07943944	0.09828116	0.12474945
scale_5	-0.2238	0.01879323	0.01574178	-0.0574798	0.01475726	0.09749655	0.21767305	0.43842348	0.06379249	0.11036351	0.07205302	0.22292648	0.1084972	0.14683637	0.15455609
scale_6	-0.1450643	0.05244245	0.05391784	0.00340214	0.07521978	0.08456762	0.19231925	0.38911413	0.0544363	0.10880963	0.07943944	0.1084972	0.14191537	0.10700695	0.13434007
scale_7	-0.1769279	-0.0088812	0.00881411	-0.0137903	0.04999421	0.11215315	0.2153335	0.43525164	0.04140977	0.08791386	0.09828116	0.14683637	0.10700695	0.17401949	0.16389501
scale_8	-0.1761232	0.02741153	0.0369886	0.00111959	0.07082469	0.12703935	0.26123042	0.52866047	0.05563945	0.11629346	0.12474945	0.15455609	0.13434007	0.16389501	0.25296901

Table VI: Robust covariance matrix: EL model

	b_reliability	b_transit_time	b_damage_ris	b_frequency	b_customer_s	b_flexibility	b_monitor	b_enviro_frier	scale_2	scale_3	scale_4	scale_5	scale_6	scale_7	scale_8
b_reliability	1	0.03363418	0.0048235	0.37707959	-0.2550479	-0.5952308	-0.7260727	-0.7751025	-0.3378846	-0.5403534	-0.4969371	-0.871864	-0.7082971	-0.7801299	-0.6440988
b_transit_time	0.03363418	1	0.63023131	0.16040927	0.50345594	0.39819441	0.37788588	0.26671206	0.89204618	0.51444233	0.06884142	0.06665107	0.2331067	-0.0356498	0.0912612
b_damage_ris	0.0048235	0.63023131	1	0.25476363	0.56179002	0.44311823	0.41425192	0.35623738	0.48174028	0.78981119	0.11876498	0.07724315	0.33159258	0.04895155	0.17038104
b_frequency	0.37707959	0.16040927	0.25476363	1	0.35134524	0.05552452	-0.010013	-0.0469712	-0.0979108	-0.0274202	0.47211848	-0.3987121	0.0295776	-0.108268	0.00729037
b_customer_s	-0.2550479	0.50345594	0.56179002	0.35134524	1	0.70173944	0.68494298	0.64212538	0.50663424	0.61993595	0.49796459	0.10772585	0.6881962	0.41306244	0.48533987
b_flexibility	-0.5952308	0.39819441	0.44311823	0.05552452	0.70173944	1	0.92197606	0.87295996	0.58976637	0.70948231	0.60785083	0.58372185	0.63458084	0.75999384	0.71400647
b_monitor	-0.7260727	0.37788588	0.41425192	-0.010013	0.68494298	0.92197606	1	0.96885352	0.61081863	0.77569517	0.68120472	0.69056462	0.76469549	0.77320234	0.77798388
b_enviro_frier	-0.7751025	0.26671206	0.35623738	-0.0469712	0.64212538	0.87295996	0.96885352	1	0.52785427	0.76744077	0.70854551	0.74362656	0.82718795	0.83557107	0.84175382
scale_2	-0.3378846	0.89204618	0.48174028	-0.0979108	0.50663424	0.58976637	0.61081863	0.52785427	1	0.60443175	0.20154214	0.39128326	0.41848169	0.28747917	0.32036992
scale_3	-0.5403534	0.51444233	0.78981119	-0.0274202	0.61993595	0.70948231	0.77569517	0.76744077	0.60443175	1	0.39770557	0.57144957	0.70613191	0.51521874	0.5652686
scale_4	-0.4969371	0.06884142	0.11876498	0.47211848	0.49796459	0.60785083	0.68120472	0.70854551	0.20154214	0.39770557	1	0.45136507	0.6237033	0.69683173	0.73360383
scale_5	-0.871864	0.06665107	0.07724315	-0.3987121	0.10772585	0.58372185	0.69056462	0.74362656	0.39128326	0.57144957	0.45136507	1	0.60999036	0.74551069	0.6508361
scale_6	-0.7082971	0.2331067	0.33159258	0.0295776	0.6881962	0.63458084	0.76469549	0.82718795	0.41848169	0.70613191	0.6237033	0.60999036	1	0.68092353	0.7090179
scale_7	-0.7801299	-0.0356498	0.04895155	-0.108268	0.41306244	0.75999384	0.77320234	0.83557107	0.28747917	0.51521874	0.69683173	0.74551069	0.68092353	1	0.78114764
scale_8	-0.6440988	0.0912612	0.17038104	0.00729037	0.48533987	0.71400647	0.77798388	0.84175382	0.32036992	0.5652686	0.73360383	0.6508361	0.7090179	0.78114764	1

C. Unimodal SSS modelling

Table VIII: Robust covariance matrix: Final ML model

	ASC_SSS_mu	ASC_SSS_sigr	ASC_Corridor_	ASC_Corridor_	Direction_Hea	Urgent_Shipm	B_TIME	B_COST	B_EXPD	B_FREQ	B_REL
ASC_SSS_mu	1	0.09474361	-0.6623263	-0.825554	-0.6050351	0.28844783	-0.2879606	0.35046985	0.24518442	0.10677605	0.12300463
ASC_SSS_sigr	0.09474361	1	0.14981873	0.09783783	-0.2942971	-0.1901418	-0.1590606	-0.187012	0.17771184	0.18249853	-0.0211198
ASC_Corridor_	-0.6623263	0.14981873	1	0.72694478	0.31692062	-0.3438867	-0.020543	-0.0635545	-0.2965168	-0.0020694	-0.1527272
ASC_Corridor_	-0.825554	0.09783783	0.72694478	1	0.24382448	-0.2827029	0.09322238	-0.3235314	-0.2336474	0.09905042	-0.0781379
Direction_Hea	-0.6050351	-0.2942971	0.31692062	0.24382448	1	-0.2699577	0.20417944	0.14560867	-0.0057177	-0.0481116	-0.0519559
Urgent_Shipm	0.28844783	-0.1901418	-0.3438867	-0.2827029	-0.2699577	1	0.1539228	0.30576059	0.11197671	-0.1004095	0.06524688
B_TIME	-0.2879606	-0.1590606	-0.020543	0.09322238	0.20417944	0.1539228	1	0.15953133	0.18394998	-0.0119694	-0.1998965
B_COST	0.35046985	-0.187012	-0.0635545	-0.3235314	0.14560867	0.30576059	0.15953133	1	0.08769619	-0.1258574	-0.0161465
B_EXPD	0.24518442	0.17771184	-0.2965168	-0.2336474	-0.0057177	0.11197671	0.18394998	0.08769619	1	0.22395417	-0.1785304
B_FREQ	0.10677605	0.18249853	-0.0020694	0.09905042	-0.0481116	-0.1004095	-0.0119694	-0.1258574	0.22395417	1	-0.069627
B_REL	0.12300463	-0.0211198	-0.1527272	-0.0781379	-0.0519559	0.06524688	-0.1998965	-0.0161465	-0.1785304	-0.069627	1

Table IX: Robust covariance matrix: Final ML model

	ASC_SSS_mu	ASC_SSS_sigr	ASC_Corridor_	ASC_Corridor_	Direction_Hea	Urgent_Shipm	B_TIME	B_COST	B_EXPD	B_FREQ	B_REL
ASC_SSS_mu	0.26520314	0.00858801	-0.1580482	-0.1520061	-0.0996794	0.04941245	-0.0077166	3.09E-05	0.00045228	0.00136385	9.91E-05
ASC_SSS_sigr	0.00858801	0.03098177	0.01221934	0.00615724	-0.016572	-0.011133	-0.0014569	-5.63E-06	0.00011205	0.00079674	-5.81E-06
ASC_Corridor_	-0.1580482	0.01221934	0.21471217	0.12043593	0.04698013	-0.0530058	-0.0004953	-5.04E-06	-0.0004922	-2.38E-05	-0.0001107
ASC_Corridor_	-0.1520061	0.00615724	0.12043593	0.12783583	0.02788939	-0.033623	0.00173441	-1.98E-05	-0.0002992	0.00087839	-4.37E-05
Direction_Hea	-0.0996794	-0.016572	0.04698013	0.02788939	0.102346	-0.0287284	0.00339901	7.97E-06	-6.55E-06	-0.0003818	-2.60E-05
Urgent_Shipm	0.04941245	-0.011133	-0.0530058	-0.033623	-0.0287284	0.11065208	0.00266433	1.74E-05	0.00013342	-0.0008284	3.39E-05
B_TIME	-0.0077166	-0.0014569	-0.0004953	0.00173441	0.00339901	0.00266433	0.00270776	1.42E-06	3.43E-05	-1.54E-05	-1.63E-05
B_COST	3.09E-05	-5.63E-06	-5.04E-06	-1.98E-05	7.97E-06	1.74E-05	1.42E-06	2.93E-08	5.38E-08	-5.34E-07	-4.32E-09
B_EXPD	0.00045228	0.00011205	-0.0004922	-0.0002992	-6.55E-06	0.00013342	3.43E-05	5.38E-08	1.28E-05	1.99E-05	-1.00E-06
B_FREQ	0.00136385	0.00079674	-2.38E-05	0.00087839	-0.0003818	-0.0008284	-1.54E-05	-5.34E-07	1.99E-05	0.00061518	-2.70E-06
B_REL	9.91E-05	-5.81E-06	-0.0001107	-4.37E-05	-2.60E-05	3.39E-05	-1.63E-05	-4.32E-09	-1.00E-06	-2.70E-06	2.45E-06

D. Intermodal SSS modelling

Table X: Robust covariance matrix: CNL model

	ASC_SRD	ASC_SRL	ASC_RL	B_TIME	B_COST	B_EXPD	B_FREQ	B_REL	ASC_Corridor_	G_OWN_SRD	G_OWN_SRL	G_OWN_RL	G_SFREQ_SRD	G_SFREQ_SRL	G_SFREQ_RL	LAMBDA_RD_	LAMBDA_SRD	LAMBDA_SRL_	ALPHA_SRD_F	ALPHA_SRL_R
ASC_SRD	0.01976215	0.02611156	0.02147108	-0.0013604	-1.40E-06	8.10E-05	0.000683	-7.65E-06	-0.002828	-0.0054276	-0.0016737	0.00583944	-0.0114476	-0.0162658	-0.012224	0.00277153	0.00021175	-0.0091753	-0.0217299	-0.0112868
ASC_SRL	0.02611156	0.0652902	0.06500273	-0.0016248	-1.83E-06	0.00045812	0.00083417	1.40E-06	-0.0030123	-0.0032287	-0.0021466	0.03243276	-0.0210582	-0.0568026	-0.0169117	0.00729499	0.00096553	-0.07615	-0.0482293	0.02260235
ASC_RL	0.02147108	0.06500273	0.4869154	-0.0073831	-9.58E-06	0.00076878	0.00035478	2.03E-05	-0.007465	-0.0111953	0.01143985	-0.1112628	-0.0039891	-0.0129339	-0.1658697	0.02033554	0.00096838	-0.3055952	0.01116112	0.12858908
B_TIME	-0.0013604	-0.0016248	-0.0073831	0.00108271	2.23E-06	2.97E-05	-0.0001152	-6.28E-06	-0.0031636	0.0024505	-0.0026507	0.00558776	0.00044977	0.0019157	0.00696129	-0.0028125	2.13E-05	-0.0021676	-0.0007195	-0.005163
B_COST	-1.40E-06	-1.83E-06	-9.58E-06	2.23E-06	1.04E-08	8.08E-08	-4.71E-07	-2.39E-08	-8.40E-06	4.22E-06	-6.56E-06	1.75E-05	4.42E-06	3.61E-06	3.42E-05	-6.47E-06	-1.10E-07	-1.33E-05	1.03E-06	-1.09E-05
B_EXPD	8.10E-05	0.00045812	0.00076878	2.97E-05	8.08E-08	0.00011745	-1.11E-05	-9.72E-07	-8.98E-05	0.00026222	-0.0003909	0.00174806	0.0002898	0.00058373	-0.000318	-0.0005249	2.08E-05	-0.0015021	-0.0007386	-8.82E-05
B_FREQ	0.000683	0.00083417	0.00035478	-0.0001152	-4.71E-07	-1.11E-05	0.00020632	-1.63E-06	0.00047236	0.00069226	0.00122902	1.14E-05	-0.0016466	-0.0035518	-0.0026642	0.00032473	2.22E-05	0.00192331	-0.0006451	-0.0002821
B_REL	-7.65E-06	1.40E-06	2.03E-05	-6.28E-06	-2.39E-08	-9.72E-07	-1.63E-06	2.40E-07	2.10E-05	-4.63E-05	-7.91E-06	-7.65E-05	3.11E-05	-0.0001285	7.81E-05	2.57E-05	6.60E-07	1.16E-05	2.44E-05	6.34E-05
ASC_Corridor_	-0.002828	-0.0030123	-0.007465	-0.0031636	-8.40E-06	-8.98E-05	0.00047236	2.10E-05	0.04747343	-0.0206254	0.00072588	-0.047417	-0.0054481	-0.0123189	-0.0429837	0.01144306	-0.001178	0.08298716	-0.0065509	0.00294116
G_OWN_SRD	-0.0054276	-0.0032287	-0.0111953	0.0024505	4.22E-06	0.00026222	0.00069226	-4.63E-05	-0.0206254	0.0691427	0.05381608	0.0490033	-0.047539	-0.0130903	-0.0279722	-0.0134795	0.00050421	-0.023799	-0.0198401	-0.0252516
G_OWN_SRL	-0.0016737	-0.0021466	0.01143985	-0.0026507	-6.56E-06	-0.0003909	0.00122902	-7.91E-06	0.00072588	0.05381608	0.070106	0.00928187	-0.0471821	-0.0391674	-0.0452142	0.0022598	-0.0003452	0.0057399	-0.0087502	-0.0006738
G_OWN_RL	0.00583944	0.03243276	-0.1112628	0.00558776	1.75E-05	0.00174806	1.14E-05	-7.65E-05	-0.047417	0.0490033	0.00928187	0.4779929	-0.0186331	-0.0048367	-0.0242746	-0.0247758	0.0015542	-0.188937	-0.0238251	0.00595
G_SFREQ_SRD	-0.0114476	-0.0210582	-0.0039891	0.00044977	4.42E-06	0.0002898	-0.0016466	3.11E-05	-0.0054481	-0.047539	-0.0471821	-0.0186331	0.10784221	0.08059367	0.06231165	-0.0001615	-5.46E-05	-0.0171722	0.04317457	0.02985709
G_SFREQ_SRL	-0.0162658	-0.0568026	-0.0129339	0.0019157	3.61E-06	0.00058373	-0.0035518	-0.0001285	-0.0123189	-0.0130903	-0.0391674	-0.0048367	0.08059367	0.52918557	-0.2368032	-0.0090265	-0.0007792	0.01655659	-0.0095249	-0.0631171
G_SFREQ_RL	-0.012224	-0.0169117	-0.1658697	0.00696129	3.42E-05	-0.000318	-0.0026642	7.81E-05	-0.0429837	-0.0279722	-0.0452142	-0.0242746	0.06231165	-0.2368032	1.21576062	-0.0247009	0.00019882	-0.0409751	0.07574699	0.02507781
LAMBDA_RD_	0.00277153	0.00729499	0.02033554	-0.0028125	-6.47E-06	-0.0005249	0.00032473	2.57E-05	0.01144306	-0.0134795	0.0022598	-0.0247758	-0.0001615	-0.0090265	-0.0247009	0.01717865	-0.0002916	0.00899165	0.00314153	0.02198521
LAMBDA_SRD	0.00021175	0.00096553	0.00096838	2.13E-05	-1.10E-07	2.08E-05	2.22E-05	6.60E-07	-0.001178	0.00050421	-0.0003452	0.0015542	-5.46E-05	-0.0007792	0.00019882	-0.0002916	0.00023925	-0.0032458	-0.0003142	0.00118223
LAMBDA_SRL_	-0.0091753	-0.07615	-0.3055952	-0.0021676	-1.33E-05	-0.0015021	0.00192331	1.16E-05	0.08298716	-0.023799	0.0057399	-0.188937	-0.0171722	0.01655659	-0.0409751	0.00899165	-0.0032458	0.51351054	-0.0471673	-0.189573
ALPHA_SRD_F	-0.0217299	-0.0482293	0.01116112	-0.0007195	1.03E-06	-0.0007386	-0.0006451	2.44E-05	-0.0065509	-0.0198401	-0.0087502	-0.0238251	0.04317457	-0.0095249	0.07574699	0.00314153	-0.0003142	-0.0471673	0.14795067	0.12854094
ALPHA_SRL_R	-0.0112868	0.02260235	0.12858908	-0.005163	-1.09E-05	-8.82E-05	-0.0002821	6.34E-05	0.00294116	-0.0252516	-0.0006738	0.00595	0.02985709	-0.0631171	0.02507781	0.02198521	0.00118223	-0.189573	0.12854094	0.24706578

Table XI: Robust correlation matrix: CNL model

	ASC_SRD	ASC_SRL	ASC_RL	B_TIME	B_COST	B_EXPD	B_FREQ	B_REL	ASC_Corridor_	G_OWN_SRD	G_OWN_SRL	G_OWN_RL	G_SFREQ_SRD	G_SFREQ_SRL	G_SFREQ_RL	LAMBDA_RD_	LAMBDA_SRD	LAMBDA_SRL_	ALPHA_SRD_F	ALPHA_SRL_R
ASC_SRD	1	0.72692857	0.218882	-0.2940912	-0.0973751	0.05319512	0.33824662	-0.1111001	-0.0923297	-0.1468316	-0.0449647	0.06008181	-0.2479732	-0.1590572	-0.0788629	0.15042105	0.0973832	-0.0910815	-0.4018673	-0.1615279
ASC_SRL	0.72692857	1	0.36456992	-0.1932512	-0.0701358	0.16543841	0.22727947	0.0111928	-0.0541068	-0.0480534	-0.0317279	0.18359008	-0.2509587	-0.3055906	-0.0600261	0.21782424	0.24429746	-0.4158831	-0.4907138	0.17796039
ASC_RL	0.218882	0.36456992	1	-0.3215579	-0.1346199	0.10166021	0.03539644	0.05947449	-0.0490997	-0.0610147	0.06191786	-0.2306282	-0.017408	-0.0254799	-0.2155838	0.22234857	0.08972175	-0.6111462	0.04158366	0.37074136
B_TIME	-0.2940912	-0.1932512	-0.3215579	1	0.66468181	0.08326481	-0.2437313	-0.3900602	-0.4412633	0.2832213	-0.304245	0.24562436	0.04162396	0.08003297	0.19187149	-0.6521418	0.04180368	-0.0919293	-0.0568452	-0.315675
B_COST	-0.0973751	-0.0701358	-0.1346199	0.66468181	1	0.07310602	-0.3219608	-0.4791917	-0.3783818	0.15758082	-0.2428564	0.24886981	0.13192969	0.04863652	0.3046861	-0.4843941	-0.0696125	-0.181472	0.02637753	-0.2150057
B_EXPD	0.05319512	0.16543841	0.10166021	0.08326481	0.07310602	1	-0.0715881	-0.1831805	-0.0380166	0.09201932	-0.1362427	0.23330506	0.08142941	0.07404397	-0.0266143	-0.3695284	0.12378731	-0.1934227	-0.1771804	-0.0163676
B_FREQ	0.33824662	0.22727947	0.03539644	-0.2437313	-0.3219608	-0.0715881	1	-0.2314188	0.15093089	0.18328392	0.32315454	0.00114837	-0.3490762	-0.3399187	-0.168216	0.17248648	0.09990546	0.18685423	-0.1167624	-0.0395095
B_REL	-0.1111001	0.0111928	0.05947449	-0.3900602	-0.4791917	-0.1831805	-0.2314188	1	0.19638443	-0.3593573	-0.060979	-0.2259723	0.19360671	-0.3607404	0.14459485	0.40082947	0.08720372	0.03305894	0.1296025	0.26049901
ASC_Corridor_	-0.0923297	-0.0541068	-0.0490997	-0.4412633	-0.3783818	-0.0380166	0.15093089	0.19638443	1	-0.3600012	0.01258241	-0.3147737	-0.0761419	-0.077722	-0.1789183	0.40070282	-0.3495459	0.53150936	-0.0781664	0.0271573
G_OWN_SRD	-0.1468316	-0.0480534	-0.0610147	0.2832213	0.15758082	0.09201932	0.18328392	-0.3593573	-0.3600012	1	0.77296762	0.2695513	-0.5505315	-0.0684341	-0.0964782	-0.3911165	0.12397086	-0.1263023	-0.1961611	-0.1932013
G_OWN_SRL	-0.0449647	-0.0317279	0.06191786	-0.304245	-0.2428564	-0.1362427	0.32315454	-0.060979	0.01258241	0.77296762	1	0.05070456	-0.5426313	-0.2033497	-0.1548719	0.06511743	-0.0842902	0.03025185	-0.0859179	-0.0051195
G_OWN_RL	0.06008181	0.18359008	-0.2306282	0.24562436	0.24886981	0.23330506	0.00114837	-0.2259723	-0.3147737	0.2695513	0.05070456	1	-0.082069	-0.0096168	-0.0318433	-0.2734154	0.1453362	-0.381357	-0.0895912	0.01731411
G_SFREQ_SRD	-0.2479732	-0.2509587	-0.017408	0.04162396	0.13192969	0.08142941	-0.3490762	0.19360671	-0.0761419	-0.5505315	-0.5426313	-0.082069	1	0.33736698	0.17208809	-0.0037517	-0.010756	-0.0729722	0.34180243	0.18291395
G_SFREQ_SRL	-0.1590572	-0.3055906	-0.0254799	0.08003297	0.04863652	0.07404397	-0.3399187	-0.3607404	-0.077722	-0.0684341	-0.2033497	-0.0096168	0.33736698	1	-0.2952294	-0.0946716	-0.0692476	0.03176086	-0.0340407	-0.1745568
G_SFREQ_RL	-0.0788629	-0.0600261	-0.2155838	0.19187149	0.3046861	-0.0266143	-0.168216	0.14459485	-0.1789183	-0.0964782	-0.1548719	-0.0318433	0.17208809	-0.2952294	1	-0.1709207	0.01165766	-0.0518586	0.17860059	0.04575718
LAMBDA_RD_	0.15042105	0.21782424	0.22234857	-0.6521418	-0.4843941	-0.3695284	0.17248648	0.40082947	0.40070282	-0.3911165	0.06511743	-0.2734154	-0.0037517	-0.0946716	-0.1709207	1	-0.1438476	0.09573489	0.06231433	0.3374658
LAMBDA_SRD	0.0973832	0.24429746	0.08972175	0.04180368	-0.0696125	0.12378731	0.09990546	0.08720372	-0.3495459	0.12397086	-0.0842902	0.1453362	-0.010756	-0.0692476	0.01165766	-0.1438476	1	-0.2928324	-0.0528149	0.15377063
LAMBDA_SRL_	-0.0910815	-0.4158831	-0.6111462	-0.0919293	-0.181472	-0.1934227	0.18685423	0.03305894	0.53150936	-0.1263023	0.03025185	-0.381357	-0.0729722	0.03176086	-0.0518586	0.09573489	-0.2928324	1	-0.1711229	-0.5322252
ALPHA_SRD_F	-0.4018673	-0.4907138	0.04158366	-0.0568452	0.02637753	-0.1771804	-0.1167624	0.1296025	-0.0781664	-0.1961611	-0.0859179	-0.0895912	0.34180243	-0.0340407	0.17860059	0.06231433	-0.0528149	-0.1711229	1	0.67232104
ALPHA_SRL_R	-0.1615279	0.17796039	0.37074136	-0.315675	-0.2150057	-0.0163676	-0.0395095	0.26049901	0.0271573	-0.1932013	-0.0051195	0.01731411	0.18291395	-0.1745568	0.04575718	0.3374658	0.15377063	-0.5322252	0.67232104	1

E. Carrier Behavior modelling

Table XII Robust correlation matrix

	tau1	tau2	DM_Charterer	Cabotage_Yes	SADC_FOC_Ye	B_VOLUME	B_CHARGE	B_THC_DISC	P_DUES_DISC	FLAG_SADC	FLAG_FOC
tau1	1	0.98075931	0.24377952	0.54157232	0.37448731	0.53388743	0.77043986	0.20924511	-0.3899813	-0.1253099	-0.0631438
tau2	0.98075931	1	0.27917091	0.53336429	0.29268176	0.55562855	0.76342559	0.24951908	-0.3337261	-0.1160387	-0.0382924
DM_Charterer	0.24377952	0.27917091	1	-0.0759527	0.17315113	0.28194958	0.09933371	0.39823291	-0.1287661	-0.124178	-0.1220607
Cabotage_Yes	0.54157232	0.53336429	-0.0759527	1	0.25340274	0.3253949	0.17794703	0.25132272	-0.2023082	0.01872321	0.08083394
SADC_FOC_Ye	0.37448731	0.29268176	0.17315113	0.25340274	1	0.05062305	0.05116012	0.22548407	-0.4433578	0.21819998	0.2049084
B_VOLUME	0.53388743	0.55562855	0.28194958	0.3253949	0.05062305	1	0.19623107	0.58448493	-0.2181562	-0.0743173	-0.1272295
B_CHARGE	0.77043986	0.76342559	0.09933371	0.17794703	0.05116012	0.19623107	1	-0.3066103	-0.4496042	-0.4828951	-0.3975593
B_THC_DISC	0.20924511	0.24951908	0.39823291	0.25132272	0.22548407	0.58448493	-0.3066103	1	0.05324644	0.40539895	0.21526558
P_DUES_DISC	-0.3899813	-0.3337261	-0.1287661	-0.2023082	-0.4433578	-0.2181562	-0.4496042	0.05324644	1	0.16433237	0.40151293
FLAG_SADC	-0.1253099	-0.1160387	-0.124178	0.01872321	0.21819998	-0.0743173	-0.4828951	0.40539895	0.16433237	1	0.57823427
FLAG_FOC	-0.0631438	-0.0382924	-0.1220607	0.08083394	0.2049084	-0.1272295	-0.3975593	0.21526558	0.40151293	0.57823427	1

Table XIII: Robust covariance matrix

	tau1	tau2	DM_Charterer	Cabotage_Yes	SADC_FOC_Ye	B_VOLUME	B_CHARGE	B_THC_DISC	P_DUES_DISC	FLAG_SADC	FLAG_FOC
tau1	1.12703386	1.15402978	0.13035644	0.22483719	0.12338233	0.08869122	0.03791242	0.1732402	-0.2225621	-0.0554871	-0.0229832
tau2	1.15402978	1.22849159	0.15585583	0.23118159	0.10067674	0.09636806	0.03922176	0.21568242	-0.1988453	-0.0536448	-0.0145516
DM_Charterer	0.13035644	0.15585583	0.25370766	-0.0149607	0.02706696	0.0222229	0.0023192	0.15643316	-0.0348664	-0.0260886	-0.0210792
Cabotage_Yes	0.22483719	0.23118159	-0.0149607	0.1529278	0.03075402	0.01991207	0.00322558	0.07664783	-0.04253	0.00305395	0.010838
SADC_FOC_Ye	0.12338233	0.10067674	0.02706696	0.03075402	0.09631519	0.00245843	0.00073596	0.0545743	-0.0739675	0.02824493	0.02180315
B_VOLUME	0.08869122	0.09636806	0.0222229	0.01991207	0.00245843	0.0244864	0.00142333	0.0713281	-0.0183514	-0.0048505	-0.0068259
B_CHARGE	0.03791242	0.03922176	0.0023192	0.00322558	0.00073596	0.00142333	0.00214857	-0.0110837	-0.0112032	-0.0093361	-0.0063181
B_THC_DISC	0.1732402	0.21568242	0.15643316	0.07664783	0.0545743	0.0713281	-0.0110837	0.60820472	0.0223231	0.13187	0.05755879
P_DUES_DISC	-0.2225621	-0.1988453	-0.0348664	-0.04253	-0.0739675	-0.0183514	-0.0112032	0.0223231	0.2889868	0.03684687	0.07400323
FLAG_SADC	-0.0554871	-0.0536448	-0.0260886	0.00305395	0.02824493	-0.0048505	-0.0093361	0.13187	0.03684687	0.17397104	0.08269028
FLAG_FOC	-0.0229832	-0.0145516	-0.0210792	0.010838	0.02180315	-0.0068259	-0.0063181	0.05755879	0.07400323	0.08269028	0.11755045

**Notes:

F. *Attribute elasticities: Shipper Behaviour Study*

In the shipper behaviour study, the elasticities of the base attributes were estimated by simulating a 1 percent change in the respective attribute of the respective mode. The elasticities in Table XIV and XV are estimated in terms of the impact on the market shares of the freight transport alternatives and they show the responsiveness of mode share as a result of 1 percent change in these attributes. The attributes considered are: transport cost, transit time, frequency of service and extend of delay.

Table XIV: Estimated measures of elasticity unimodal SSS

Attribute	X	Road	SSS
Transport cost	DE	-2.158487	-0.9337321
	XE	1.228418	1.2587870
Transit time	DE	-0.8160333	-0.8062542
	XE	0.5117639	1.1018260
Expected Delay	DE	-0.2352672	-0.0856354
	XE	0.1542696	0.1269045
Frequency of Service	DE	0.3524408	0.0928481
	XE	-0.2422032	-0.1405483
Reliability	DE	0.05693424	0.03962612
	XE	-0.03820487	-0.0596017

***Notes:* X = Elasticity, DE= Direct elasticity; XE=Cross elasticity

Table XV: Estimated measures of elasticity intermodal SSS

Attribute	X	Mod	RD	Mode	SSS & Road	Mod	SSS & Rail	Mod	Rail
Transport cost	DE	RD	-2.589886	SRD	-2.22231	SRL	-1.570922	RL	-0.5320444
	XE	SRD	1.375049	RD	1.22349	RD	1.223493	RD	0.08666493
	XE	SRL	0.541803	SRL	0.859134	SRD	0.8591338	SRD	0.1610496
	XE	RL	0.3193623	RL	0.524157	RL	0.5241569	SRL	-0.02445444
Transit time	DE	RD	-0.7637	SRD	-1.524622	SRL	-1.334014	RL	-0.7793685
	XE	SRD	0.44154	RD	0.7970842	RD	0.6260372	RD	0.1217243
	XE	SRL	0.18709	SRL	0.703498	SRD	-0.01026193	SRD	0.2128892
	XE	RL	0.13427	RL	0.4036804	RL	-0.01026193	SRL	-0.003164211
Expected Delay	DE	RD	-0.02397	SRD	-0.03394401	SRL	-0.02849803	RL	-0.01020777
	XE	SRD	0.01514	RD	0.01727491	RD	0.004936082	RD	0.001653246
	XE	SRL	0.00604	SRL	0.022258	SRD	0.01598004	SRD	0.002850662
	XE	RL	0.00341	RL	0.00669395	RL	0.0001111724	SRL	6.705977e-05
Frequency of Service	DE	RD	0.28109	SRD	0.1625682	SRL	0.1065116	RL	0.07128869
	XE	SRD	-0.18319	RD	-0.07686599	RD	-0.02352274	RD	-0.01069846
	XE	SRL	-0.06973	SRL	-0.1188369	SRD	-0.05500423	SRD	-0.01998831
	XE	RL	-0.04135	RL	-0.02922101	RL	-0.002755694	SRL	-0.001595138
Reliability	DE	RD	0.05069	SRD	0.1212864	SRL	0.05681288	RL	0.03081191
	XE	SRD	-0.03313	RD	-0.06060329	RD	-0.01715668	RD	-0.005039388
	XE	SRL	-0.01125	SRL	-0.08197683	SRD	-0.02510042	SRD	-0.009497821
	XE	RL	-0.00770	RL	-0.02540511	RL	-0.001629549	SRL	0.00106095

***Notes:* X = Elasticity; DE= Direct elasticity; XE=Cross elasticity, Mode = mode