Assessing Inter-Urban Freight Mode Choice Preference for Short-sea Shipping in the Southern African Development Community Region

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Abstract

The Southern African Development Community (SADC) has identified the need to develop its regional freight transport system as a major activator to its development objectives. It has been suggested that the introduction of short-sea shipping (SSS) can help achieve this objective. To assess the take up of SSS in SADC, a stated choice (SC) experiment was conducted along 3 major intra-urban freight corridors in SADC running between: Walvis Bay (Namibia) ~ Cape Town (South Africa), Walvis Bay ~ Luanda (Angola) and Durban (South Africa) ~ Beira (Mozambique). Scenarios were defined using frequency of service, reliability in terms of arriving on time, expected delay, transport cost and transport time as attributes. A mixed multinomial logit model and a latent class choice model were accordingly estimated on the SC data to assess the role of random heterogeneity in freight mode choice. The results reveal that freight mode choice in SADC is majorly influenced by transit time and frequency of service, suggesting that if SSS were to develop, these are the two biggest factors to address. Moreover, the results imply that freight mode choice is further influenced by a combination of modal attributes and situational variables, and these decisions are subject to variation depending on product type, urgency of shipment and shipment direction (head-haul or back-haul). The results can now inform opportunities to develop SSS in SADC and to provide suggestions for policy-making and interventions that can lead to sustainable inter-urban freight transport.

Keywords: *Short Sea Shipping, Discrete Choice Modelling, SADC, Inter-Urban freight mode choice, maritime transport, Africa*

1. Introduction

The Southern African Development Community (SADC) is an inter-governmental organisation wherein the 16 Southern African countries work together on issues of socio-economic cooperation and integration, as well as political and security cooperation. The SADC has identified the need to develop its freight transport system as a key component for meeting its development objectives (SADC, 2013). In line with this objective, it has been suggested that the introduction of short-sea shipping (SSS), as both a supplement and alternative to road, can address transport problems currently faced and thereby meet development needs (Konstantinus, 2019). Notably, the need to develop SSS in SADC is motivated by a deficient inter-urban freight transport system that is characterised by a spatially challenged economy (Naudé, 2009), poor and declining transport infrastructure (Konstantinus et al., 2019), and extreme polarization in favour of road (Mutambara, 2009). Developing SSS in SADC can further impart socio-economic benefits including reduced road crashes, energy efficiency and the connection of remote and peripheral regions without the need for high infrastructure investments (Rennie, 2002; NDoT, 2011; Ombo, 2012, Konstantinus et al., 2019).

The political framework in SADC supports the development of SSS. The SADC Protocol on Transport, Communication and Meteorology (SADC, 1996) requires member states to promote a clean maritime and inland waterway system, complete with viable landside infrastructure. At the continental level, the Africa Maritime Transport Charter calls for African countries to "promote [maritime] cabotage and effective participation of private sector operators at national, regional and continental levels" (African Union, 2010). Proposed political actions include recognising and developing African regional coastal shipping as part of the planned 'domestic' transport network, complete with cargo consolidation hubs and intermodal maritime corridors linked to inland regions. In line with this, South Africa in 2017 approved the Comprehensive Maritime Transport Policy, which supports the introduction of maritime cabotage to the SADC region (NDoT, 2017). Such a move aims to limits the carriage of goods between SADC ports to SADC registered ships in line with article 1 of the Africa Maritime Transport Charter.

A survey of the maritime transport setting in SADC region reveals little activity of SSS. A report compiled by the South Africa Department of Transport (NDoT, 2011), which details the role of coastal shipping in the supply of transport services between SADC ports reveals that, less than 10 percent of freight tonnage between SADC ports is carried by sea, and majorly by a single coastal carrier, Ocean Africa Container Lines (OACL), which is co-owned by MAERSK and Grindrod Shipping. Of the 10 percent, about 80 percent is said to be feeder cargo and transhipments, which is not intended for the SADC region. The report also highlights that coastal shipping in SADC is characterized by: high transport cost mainly as a result of high port charges, long ship turnaround times in port as a result of weather and port delays, lack of port infrastructure and a political landscape where road enjoys unfair advantage over coastal shipping.

On this backdrop, taking the case of three inter-urban corridors in SADC: Cape Town (South Africa) ~ Walvis Bay (Namibia), Walvis Bay ~ Luanda (Angola) and Durban (South Africa) ~ Beira (Mozambique), this paper aims to assess the conditions under which SSS will be taken up by freight shippers, under varying levels of service offerings of road and SSS. The study corridors were selected based on volume of freight flows (current and projected) (Konstantinus et al., 2019); the plausibility of SSS along the corridor (i.e. availability of ports and a long maritime leg - enough for SSS to compete with road); and the existence of fair levels of road congestion and/or road accidents. The ports employed in the origin-destination pairings are also some of the region's most prominent ports, through which much of the region's imports are landed. Apart from these, SADC has many other corridors were SSS can be investigated (cf. SADC, 2015), but for this study, special consideration was given to corridors where data collection was possible with considerable ease.

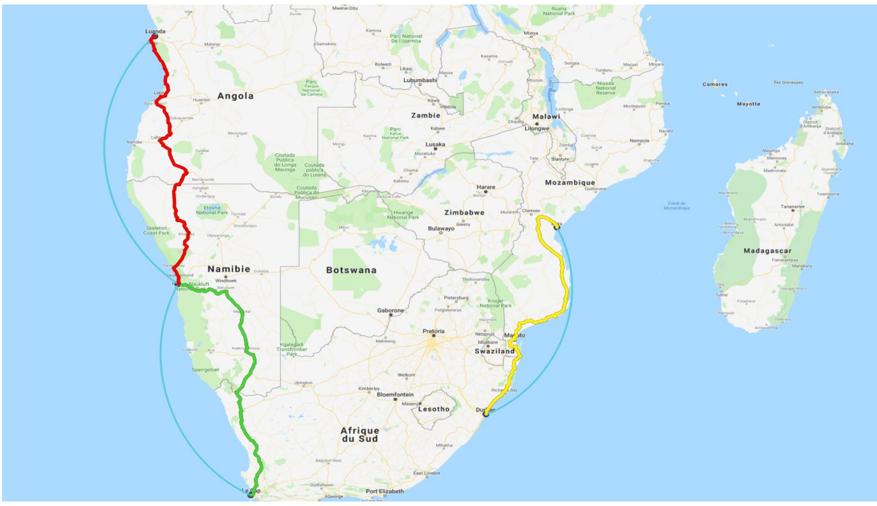

Figure 1: The three unimodal land and sea corridors

The research objectives of this paper are threefold: a) to determine the conditions under which shippers will prefer SSS over road, b) to determine the preference of SSS under different segments of shippers; and c) to determine the modal attributes most influential to develop SSS in SADC. The shipper in this context refers to the cargo-owner that is responsible for making sure that the goods are transported from the place of production to the place of consumption (though they usually do not carry out the transport themselves; instead they contract this out to freight forwarders). In practice, cargo owners typically have higher bargaining power in terms of mode selection, but in most cases they welcome the suggestions made by freight forwarders. More specifically, Konstantinus & Zuidgeest (2019) found that even though the cargo owner is generally the decision-maker in terms of mode choice selection and the freight forwarder typically occupies the position of an advisor, about 20% of mode choice decisions in SADC are made by freight forwarders. For this reason, this study focuses on both the cargo owner and the freight forwarder. We have for ease of reference termed them together as shipper in the remainder of this study.

However, SSS is not a widely available or used option, and we are thus in the domain of studying demand for a largely inexistent service. For this reason, we develop a stated preference survey that allows us to capture data on choices in the hypothetical scenarios where SSS is available. We use mathematical structures known as discrete choice models to study under which conditions shippers presented with road and a hypothetical SSS alternative will select SSS. We further postulate that these mode choices are subject to random heterogeneity and they will differ from one segment of shippers to another. For this reason, we investigate the use of more advanced models that incorporate such heterogeneity. The paper proceeds as follow: literature on freight mode choice is first studied in section 2, in particular the literature that has looked at shipper behaviour and the development of SSS. Subsequently, in section 3, the stated choice experiment is setup, and the associate choice modelling framework discussed. The analysed data is presented and discussed in section 4. Finally, the paper concludes with a summary of key findings and suggestions for further research in section 5.

2. Literature Review

This paper relies on literature on freight mode choice, the development of SSS, and choice studies to develop SSS. We focus on inter-urban freight mode choice studies to develop SSS.

Freight Mode Choice

A substantial body of freight mode choice research exists (see the review in Tavasszy and de Jong, 2014 and Raza et al., 2020), but it has traditionally received considerably less research attention than passenger mode choice research. The reasons put forward typically include the difficulties associated with data collection and the secrecy surrounding the business nature of freight transport (Figliozzi, 2006; Regan & Garrido, 2001).

Most notable work on shipper behaviour for inter-urban freight includes Feo-Valero et al., (2016); Kim et al (2014); Masiero & Hensher, (2010); Fries et al., (2010); Feo-Valero et al. (2011); de Jong & Ben-Akiva, (2007), Bergantino & Bolis (2004); Shinghal & Fowkes, (2002); and Fowkes, Nash, & Tweddle, (1991). Given the difficulty of accessing real world data on transactions, these studies generally collect Stated Preference (SP) data, which is then analysed using mathematical models, with typical structures adhering to the principle of random utility maximisation. Random utility maximization has been favoured due to the vast amount of research that has been conducted on utility theory and its grounding in microeconomic theory (Hensher et al., 2015). It is also widely employed in traveller (as opposed to operator) decision-making studies and is a common tool in providing inputs to policy work. This paper adds to this discussion, and it does so in a developing economy status, particularly so in SADC, where there is a reported 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).

Only two studies were found to have focused on inter-urban freight mode choice in SADC: Zamparini et al., (2011) and Konstantinus & Zuidgeest (2019). Zamparini et al., (2011) considered inter-urban freight mode choice in Tanzania by assessing the monetary values attached to flexibility, frequency, loss and damage, reliability, and transit time. The results show that shippers in Tanzania consider travel time, loss and damage and frequency as the most important modal attributes. Konstantinus & Zuidgeest (2019), in a predecessor to the present study, sought to determine which are the most important modal attributes when shippers make mode choice decisions. They conducted an online study with 86 shippers and third-party logistics companies from across the SADC region, wherein a ranking question was presented. They reveal the following ranking of importance: (1) reliability, (2) transport cost, (3) risk of damage, (4) frequency of service, (5) transit time, (6) customer service, (7) service flexibility, (8) monitoring, and (9) environmental friendliness. An earlier study, Konstantinus & Zuidgeest (2018) revealed that road is perceived the most reliable mode of transport in terms of arriving on time, with 74% perceived reliability, followed by air with 72%, then maritime with 71% and last, rail with 62%. The ranking of reliability as being most important in Konstantinus & Zuidgeest (2019) corroborate to the findings in Konstantinus & Zuidgeest (2018) wherein mode share was found to be directly proportional to perceived reliability. They also reveal that to mitigate the effects of unreliable transport, shippers in SADC, particularly those that employ road transport, adopt a number of strategies including using different carriers, employing their own means of transport and they often have to 'pay more' in the form of bribes.

Studies to develop SSS

Paixão Casaca & Marlow (2005) analyse the service attributes for European SSS operations within multimodal transport chains. They reveal that the development of SSS embraces five inter-related elements as follow: (1) the political framework, (2) the inter-regional trades, (3) the five underlying forces of SSS, (4) the action of SSS competitors, and (5) the short sea shipping operating environment. The five underlying forces cited by Paixão Casaca & Marlow (2005) refer to the five traditional forces of competitive strategy as described by Porter (1980). In the context of an SSS system, these refer to: (1) the threat of new market entrants, (2) the threat of substitute alternatives, (3) the bargaining power of SSS carriers, (4) the bargaining power of shippers, and (5) the rivalry among existing SSS operators. This paper is focused on decoding the bargaining power of shippers (i.e. SSS buyers). According to Paixão Casaca & Marlow (2005), SSS operators must struggle with the bargaining power of shippers as this relates to the economic viability of SSS.

Raza et al, (2020) conducts a systematic and detailed literature review on modal shift towards SSS (including 58 articles).and identifies six key areas for research: factors influencing the competitiveness of SSS, policy-oriented perspectives that favours SSS, environmental legislation, performance of SSS, port characteristics, and multi-agent perspectives. They propose that authorities should evaluate the performance of SSS against road on different corridors, and they suggest that this must be done against economic, service quality and environmental dimensions. They further suggest that researchers should employ real life data to identify the drivers and barriers for mode shift to SSS. The approach adopted in this paper is in line the suggestions put forward in Raza et al., (2020), namely we aim to evaluate the performance of SSS against road along a number of corridors in the SADC. region. The determinants of SSS in SADC are addressed by Konstantinus et al (2019) who highlight the historical development of SSS, its determinants, both from the SSS demand and supply sides; and subsequently contextualize their findings to the freight transport setting in SADC. They conclude that the determinants of SSS are significantly influenced by freight volumes, port competitiveness, geographical features, and the regulatory environment in which SSS must operate. What is apparent in the SADC region is that environmental concerns are not considered important by shippers (cf Konstantinus & Zuidgeest, 2019).

Konstantinus et al (2019) further reveal that SSS has the theoretical potential to work in SADC given the large geographic area and the projected freight volumes for the region. Notably, the SADC region projects growth of freight volumes passing through its regional ports to grow from 92 million tonnes in 2009 to 500 million tonnes by 2027 (SADC, 2013). Notwithstanding this, there exist certain hindrances that can inhibit the development of SSS. Notably, SADC is tainted by high port costs and poor-performing ports (NDoT, 2011). Decreased port costs coupled with increased port efficiency can reduce overall maritime transport costs and this is important because road users do not have corresponding intermediate handling costs. Many of the ports in SADC are also general ports that are not adapted to SSS (NDoT, 2011). Moreover, customs provisions in SADC have been criticized for being major deterrents to inter-regional trade (Kamau, 2014).

This earlier research directly feeds into the present paper, which investigates opportunities for SSS in SADC through choice modelling. SSS is modelled here as a composite mode of multi-modal transport that offers door-to-door transport, and that serves both as a supplement and an alternative to road-based transport. This approach is adopted in line with Paixão Casaca & Marlow (2005) who argue that to understand SSS as an alternative to road, we must consider that SSS may be operating within three different settings, namely: inter-urban; regional; and international SSS. Inter-urban SSS is applied if cities are located along the coastline or if they are accessible by river or inland waterways. Regional and international SSS is employed as an integrated mode in multimodal logistics supply chains on which goods can be shifted from road to sea. This study is concerned with all three settings.

Freight Mode Choice to Develop SSS

The literature on developing SSS and freight mode choice is even more limited and appears to be limited to a developed country/region context (with known research in North America, Europe, and Australasia). Prominent examples are found in Europe where most are conducted as part of a promotion strategy for the Motorways of the Sea (MoS) network of Europe.

In Europe, García-Menéndez et al., (2004) developed a binary logit model for road versus SSS from actual observations (so-called revealed preferences (RP)) collected from 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 transport. Subsequently, 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, INCOTERMS employed (see ICC, 2011), 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. More recently, Arencibia et al, (2015) used SP data based on hypothetical scenarios collected from shippers who ship between Madrid, Belgium, The Netherlands, Germany and France. They developed multinomial logit and mixed logit models and again reached the conclusion that the actions with the greatest impact are those that affect the cost of transport.

In North America, Brooks and Trifts (2008), studied what had to be done to convince Atlantic Canadian shippers to use SSS. Using SP data, they found that shippers were unwilling to accept service frequencies of once a fortnight in one of the studied corridors (the I-95 corridor from Florida, USA, to New Brunswick, Canada); but they would accept a weekly service. Puckett et al (2011) revisited the Brooks and Trifts (2008) data and revealed significant preference heterogeneity for frequency in the sample. They also found a high willingness-to-pay (WTP) for gains in service frequency for the routes, a finding that revealed opportunities for SSS.

In the Australasia region, Brooks et al (2012) investigated the potential competitiveness of SSS across three origin-destination pairs in Australia using SP data, with the following base attributes employed: reliability, frequency, transit time, freight distance, direction and transport cost. They found that SSS was truck-competitive in corridors under 1,000 nautical miles given specific conditions of the base attributes. Subsequently, Kim et al (2014) developed a freight choice model using both RP and SP data from freight shippers to identify the possibility of mode substitution effects towards SSS in New Zealand (Kim, 2014). The outcomes of that study revealed 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 et al (2014) conclude that a modal shift to SSS may be induced by increasing the cost of road transport.

While the literature on freight mode choice and SSS features a number of studies around the globe, no mode choice study was found to study the development of SSS in the context of developing economies, and thus in an African setting by extension. The present study considers the development of SSS and puts forward a framework to consider a modal shift from road to SSS in the SADC region. In our work and in line with the literature review, we postulate that shippers presented with road and a hypothetical SSS alternative will consider the modal attributes, the shipment characteristics and their own (decision-maker) characteristics when they make their mode choice.

3. Methods

3.1 Data collection

Data about freight mode choice were gathered with structured questionnaires collected through computer-aided personal interviews (CAPI). The interviews were conducted 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 period spanning 1 November 2017 to 31 May 2018. The interviews were conducted by five specially trained interviewers who had a working background in shipping and logistics. The interviews were conducted using a tablet computer using the offline survey software *Lighthouse* (Sawtooth software, 2017).

For each corridor under study, a unique questionnaire was developed. The questionnaire was divided into eight parts as follow:

(1) General information to capture descriptive information of the respondent.

(2) Transport information to capture the respondent's shipping activity, notably the product mostly shipped as all subsequent questions would be based on this product.

(3) Product information to capture information about the product including value, perishability, and lead time.
(4) A RP part to capture information about a previous trip made with the specified product on the corridor.
(5) The SP game, which contained 13 choice tasks, including one diagnostic task, to measure the respondents' mode choice preference using the full twenty-foot equivalent unit container as the unit of measure.
(6) Diagnostics questions, which assessed whether the SP tasks were understood and whether they were realistic.
(7) Attitudes and perceptions, which captures the attitudes and perceptions towards freight transport modes in SADC.
(8) Conclusion, allowing the respondent to make comments and give suggestions before the survey end. In particular comments were sought from respondents regarding how the freight transport system in SADC could be improved.

Not all the above information is relevant to this study. We are mainly interested in selected information collected under sections 1, 2, 3 and 5 of the questionnaire.

3.2 Sample Statistics

Data were analysed after being grouped to ensure the anonymity of the respondents (Table 1). The sample had a total of 139 respondents, made up of a mix of respondents varying by company sizes, type of decision makers (i.e. freight forwarder or shipper), business industries, frequency of shipments, product types, value of products and product urgency. Additionally, covariates were captured to understand the context of the freight trip. This includes decision maker characteristics, product characteristics, situational variables and trip characteristics, all captured using a mix of dummy coded and continuous variables as shown in Table 1.

Despite achieving a reasonable sample size (for statistical analysis), it is worth noting that data collection was constrained by the unwillingness of some shippers to participate in freight studies through fear of disclosing confidential information that could hinder their competitiveness, which is not uncommon in freight studies (Figliozzi, 2006; Regan & Garrido, 2001). There was also a language barrier considering the study was conducted only in English whereas in some countries like Angola and Mozambique, English is not a first language. To overcome this problem, Portuguese speaking interviewers were recruited to conduct the survey in Portuguese for the interviews in Beira and Luanda.

Table 1: Shipper and product characteristics in the interviewed sample

Attribute	Characteristics	Percent (%)
Type of decision maker	Shipper	41%
	Freight Forwarder	59%
Company Sizes in terms of number of employees	Minimum	2
	Maximum	800
	Mean	92
	1st IQR	8
	3rd IQR	62
Business Industry	Retail	25%
	Mining	11%
	Energy	3%
	Fisheries	1%
	Agriculture	9%
	Manufacturing	3%
	Transport and Storage	26%
	Automobile	8%
	Construction	3%
	Other	12%
Shipping frequency	Daily	22%
	Weekly	27%
	Monthly	17%
	Annually or less	34%
Shipment Urgency	A: Urgent Stock	31%
	B: Non-urgent Stock	69%
Shipment Direction	Head-haul	67%
	Back-haul	33%
Product type	Raw	15%
	Semi-Processed	17%
	Finished	68%
Value (US$) of Full container load of primary product	Minimum	US$ 2025
	Maximum	US$ 100,000
	Mean	US$ 7500
	1QR	US$ 6000
	3QR	US$ 43,500
Total number of respondents		139

3.3 Stated preference survey

As the selected origin-destination (OD) pairings (corridors) run only between port cities where no rail alternative is available, the stated preference experiments consider only a binary choice between road and a hypothetical SSS option. In line with this setting, choice surveys were developed for each freight corridor, with unique values adopted to each respective corridor (OD pair).

3.3.1 Modal Attributes

The attributes employed were taken from an earlier cited paper, Konstantinus & Zuidgeest (2019), that reveals that the top five attributes that SADC shippers consider most important in terms of freight mode choice are: (1) reliability in terms of arriving on time, (2) door-to-door transit time, (3) door-to-door transport cost, (4) risk of damage and (5) frequency of service. These are the base attributes employed in this study; but they were slightly modified after a pilot survey revealed that the factor 'risk of damage', even though perceived important in Konstantinus & Zuidgeest (2019), did not show a statistically significant impact on choices in the pilot study. This is not entirely surprising given the low risks involved and potentially different understanding of risk levels. It also emerged that shippers wanted to know more about the extent of delay if a mode was not fully reliable. The attributes were thus modified to include 'delay' whilst 'risk of damage' was removed.

3.3.2 Attribute Definitions

'Reliability' may be defined as the expected steadiness of transport service in its intended function, on demand without declining with reference to timeliness. Reliability has been an important factor in freight transport for some time; enough so that the International Transport Forum dedicated an entire workshop to the issue in 2010 (ITF, 2010). That said however, very few studies of mode choice have identified exactly what reliability means to shippers (Tryworth & Saldanha, 2014). We have defined it in this study as the number of times, the shipment was on time in the last three freight trips. Being 'on time', must be understood within the context of each mode. Generally, in SSS, an arrival or departure time within 1 day of schedule is considered to be reliable service, although this is not always acceptable to shippers (Leach, 2004). Accordingly, reliability will differ across cargo types. For instance, for 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 as opposed to non-time sensitive cargoes (Eisele et al, 2011).

Related to reliability is 'transit time' and 'extent of delay'. Transport time refers to the time it takes to transport a shipment 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 generally decrease as the distance increases, and vice versa. Subsequently, most shippers prefer to use SSS over longer distances, where the inherent nature of shipping to achieve scale and distance economies can be exploited.

'Transport cost' refers 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, 2013). Virtually all freight studies agree that transport cost is an influential attribute in terms of utility maximization, and this is because the cost of freight is a direct out of pocket expense which affects the profitability of shippers. In this study, transport cost is presented as the total transport cost incurred for the entire door-door transport chain.

'Delay' or 'extend of delay' in the context of the study refers to the unplanned delays in the transport mode at border posts and cargo transfer points. Numerous studies including Paixão Casaca & Marlow (2005); Papadimitriou (2001); Strandenes & Marlow (2000) conclude that SSS is perceived as slower than road, and this observation can be put down to time spent in port and to undue delays being experienced. Maritime carriers (SSS operators) estimate that about 50 percent of the transport time is taken up by the approach and time the ship spends in port (CEMT, 2000).

Lastly, 'frequency' is related to the number of shipments offered by a mode, transport company, or any freight forwarding agent, in a determined period of time (Zamperini et al., (2017). Mode choice studies conducted by Puckett et al (2011) and Brooks and Trifts (2008), reveal that frequency is a key service attribute in mode choice studies, and more so, in studies to develop SSS.

3.3.3 Attribute levels

The current levels for the attributes were determined from a number of industry players in SADC. Specifically, the transport price and transit time attribute levels were obtained from quotations requested from the Namibia Ports Authority, Ocean Africa Lines, TRANSNET (Port and Rail) and six trucking companies in Angola, South Africa, Namibia and Zimbabwe. Base levels for reliability, extent of delay and frequency of service for road were mostly obtained from informal interviews with truck drivers, border post customs officials at Noordoewer (Namibia-South Africa) and Beitbridge (South Africa- Zimbabwe), whilst the same for SSS were obtained from the Namibia Ports Authority, Angola Ports Authority and Beira Corridor Project and TRANSNET. Table 2 shows the baseline attribute levels.

Given that SSS does not yet exist as a mode in SADC, the levels for the hypothetical SSS service were collated from current industry service levels. For instance, the total transport cost for SSS was made up of sea freight, expenses for port health inspection and any road freight to and from shipper premises; and port costs (which include port dues charged to the ship for the use of a port and terminal handling charges charged to the shipper for handling, storage, shipment and packing of goods). Even though some of these costs (like port dues) are charged directly to the carrier, they are eventually carried over to the shipper, and thus would eventually form part of the total cost consideration for the shipper.

Table 2: Modal attributes as per current transport conditions

	Cape Town–Walvis Bay		Walvis Bay-Luanda		Durban-Beira	
	SSS	Road	SSS	Road	SSS	Road
Total Distance (km)	1,300 km	1,720 km	1720km km	2,218 km	1,178 km	1,792 km
Current levels of attributes						
Total Cost (door-to-door)	$2,000	$3,500	$2,300	$5,250	$2,000	$4,500
Total time (door-to-door)	6 days	4 days	7 days	4 days	6 days	4 days
Frequency (p/wk)	1 p/wk	Every day	1 p/wk	Every day	2 p/wk	Every day
Reliability	67%	100%	33%	67%	33%	67%
Damage/Loss	Low	Low	High	Med	Med	Med
Delay	12 hours	6 hours	48 hours	72 hours	48 hours	96 hours

These attributes levels were subsequently verified in a focus group discussion with two freight transport service providers (a trucking company, a shipping line) and two shippers before the final survey was tested and launched.

The experimental design for the SP scenarios was then developed using *Ngene* software (Choice-Metrics, 2017) and following this, the survey was hosted freely using *Lighthouse* software (Sawtooth, 2017). Table 3 shows the attribute levels employed in the SP scenarios and Figure 2 provides an example of one of the 12 choice games employed in addition to one diagnostic question. As can be seen, the levels were chosen in such a way to test a situation where the performance of SSS is improved and/or the performance of road is made worse.

Table 3: Attributes and corresponding attribute levels

Attributes	**Description**	**Reference value**	**Levels**	
Modal attributes			Road	SSS
Transit time	Total time taken for the door to door transport in days.	Relative to transit time per corridor as captured in Table 2.	+1 +2 +3	-1 -2 -3
Transport cost	Total cost incurred for door to door transport in US$.	Relative to total cost per corridor as captured in Table 2.	+500 +1000 +1500	-500 -1000 -1500
Reliability	Number of times the shipment arrives on time.	Relative to reliability per corridor as captured in Table 2.	+0% -33% -67%	+0% +33% +67%
Extent of delay	Extent of time the current shipment is late in hours.	Relative to extend of Delay per corridor as captured in Table 2.	+0% +50% +100%	-25% -50% -100%
Frequency	Number of departures per week	Relative to frequency per corridor as captured in Table 2.	+0 -1 -2	+0 +1 +2

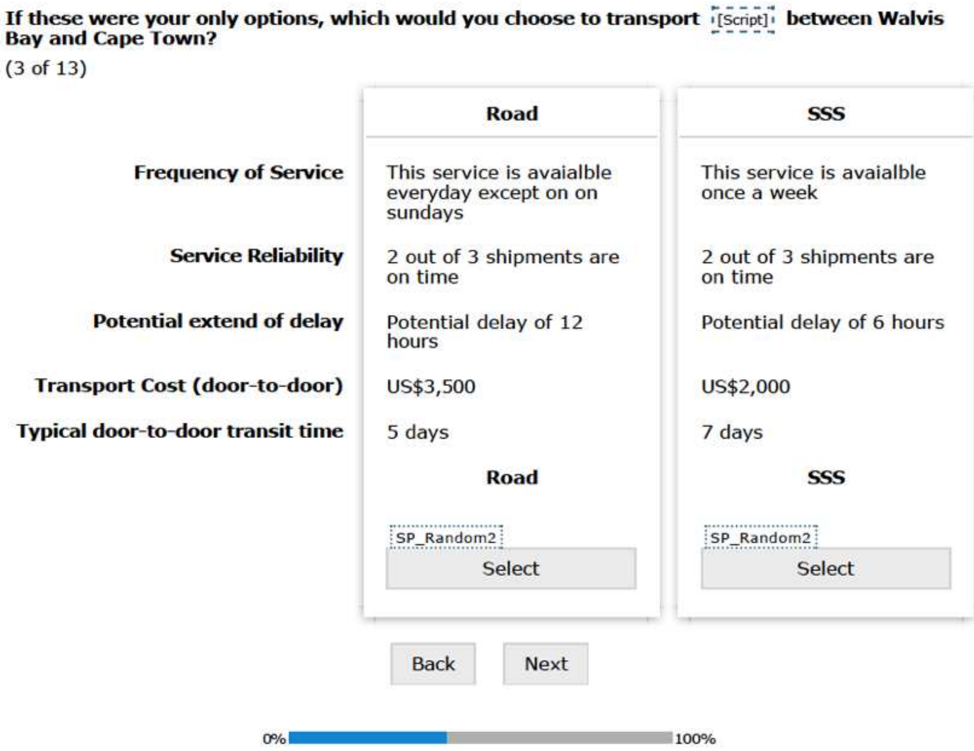

Figure 2: Depiction of choice task on the CT~WB corridor in Sawtooth

3.4 Model specification

As mentioned earlier, the data from the stated choice scenarios was analysed with the help of mathematical structures belonging to the family of discrete choice models. We first developed a base Multinomial Logit (MNL) model before turning our efforts to capturing heterogeneity in behaviour, initially by incorporating covariates in the MNL model and then by allowing for random heterogeneity in Mixed Multinomial Logit (MMNL) and Latent Class (LC) models. In what follows, we describe the specification of the models.

3.4.1 Multinomial Logit model

The MNL model is the workhorse of discrete choice modelling and has been extensively employed in freight mode choice and SSS related studies (Brooks et al., 2012; Feo-Valero et al., 2011; García-Menéndez et al., 2004; Kim et al., 2014; Puckett et al., 2011), and generally remains the base on which more sophisticated models are built.

Within the formulation of the MNL, the general utility U_{nsj} for respondent n for mode j in choice task s is specified as:

$$U_{nsj} = V_{nsj} + \varepsilon_{nsj} \quad (1)$$

where V_{nj} is the systematic component of the utility of alternative j, and ε_{jns} is the random component (with an IID Gumbel distribution). In a typical linear in attributes specification, we have that $V_{nsj} = \delta_j + \beta'_j X_{nsj}$, where δ_j is an alternative specific constant (ASC) (normalised to zero for one alternative) capturing baseline preferences, β_j is a vector of coefficients to be estimated and X_{nsj} the vector of attributes of alternative j in choice scenario s faced by respondent n. With the IID Gumbel error assumption, the probability P_{nsj} for respondent n to select (mode) alternative j from J alternatives in task s is given by:

$$P_{nsj}(\theta) = \frac{\exp(V_{nsj})}{\sum_{k=1}^{J} \exp(V_{nsk})} \tag{2}$$

where $\theta =< \beta, \delta >$, i.e. the coefficients that we are estimating.

The choice probabilities in a MNL model thus take a closed form solution (cf. Train, 2009), leading to an easy specification for the likelihood of the sequence of choices for decision maker n, L_n:

$$L_n(\theta) = \prod_{s=1}^{S} P_{j_{ns}^{*}nsj}(\theta) \tag{3}$$

where j_{ns}^{*} represents the choice alternatives available to the decision maker n in choice situation s (out of S choice situations).

We started with a 'base' model which uses only the explanatory attributes from the stated choice experiment, with all attributes employed generically across modes. Afterwards, incremental changes are made to the model to incorporate the covariates describing respondent characteristics. All covariates collected in the survey were tested for an impact on the utility of SSS relative to road, and the significant ones were retained. The final random utility function for the MNL model is shown in equation 4 below:

$$\begin{aligned} V_{nsj} = {} & \delta_j + \beta_{\text{cost}} x_{\text{cost},nsj} + \beta_{\text{time}} x_{\text{time},nsj} + \beta_{\text{freq}} x_{\text{freq},nsj} + \beta_{\text{rel}} x_{\text{rel},nsj} + \\ & \beta_{\text{delay}} x_{\text{delay},nsj} + (\text{j} == 2) \cdot (\beta_{\text{CT-WB}} x_{\text{CT-WB}} + \beta_{\text{WB-LUA}} x_{\text{WB-LUA}} + \\ & \beta_{\text{DUR-BEI}} x_{\text{DUR-BEI}} + \beta_{\text{urgent}} x_{\text{urgent}} + \beta_{\text{head}} x_{\text{head}}) \end{aligned} \tag{4}$$

where $j = 1$ for road and $j = 2$ for SSS. The ASC δ_1 is fixed to zero, thus using road as the reference alternative. Accordingly, β_{cost}, β_{time}, β_{rel}, β_{freq}, β_{delay}, $\beta_{\text{CT-WB}}$, $\beta_{\text{WB-LUA}}$, $\beta_{\text{DUR-BEI}}$, β_{urgent}, and β_{head} are the coefficients associated with the attributes (x) for Transport cost, Transit time, Reliability, Frequency, Expected Delay, Corridors (×3), Shipment urgency and the Shipment direction (head leg) respectively. The additional covariates capture a shift in the utility for SSS, with $(j == 2)$ being equal to 1 for alternative 2 (i.e. SSS) and 0 otherwise.

3.4.2 *Models allowing for random heterogeneity: Mixed Logit and Latent Class*

The simple MNL models allow us to capture differences in behaviour linked to observed characteristics of the shipper or the corridor. However, there is extensive scope for additional unobserved heterogeneity.

As a first step, we investigate the use of Mixed Multinomial Logit (MMNL) models. MMNL models assume that some parameters are randomly distributed across individual decision makers according to a predefined probability distribution for which the parameters are estimated.

In particular, we have that $\theta_n \sim f(\theta_n \mid \Omega)$, where $f()$ is a multivariate random distribution of θ and Ω is a vector of estimated parameters characterising the shape of that distribution. The likelihood in Equation (3) is then replaced by:

$$L_n = \int_{\beta_n} \prod_{s=1}^{S} P_{j_{ns}^{*}nsj}(\beta_n, \delta) \quad (5)$$

MMNL places heavy demands on the data, and with a small sample such as ours, it was only possible to capture continuous random heterogeneity in the baseline sensitivity for SSS, δ_{SSS}. This captures additional differences across respondents not captured by the covariates in Equation (4). This random heterogeneity was incorporated in the ASC parameter as follow:

$$\delta_{SSS,n} \sim N(\mu_{SSS}, \sigma_{SSS}) \quad (6)$$

where $\delta_{SSS,n}$ now follows a Normal distribution across individual respondents but is kept constant across choice situations *s* for the same individual. This means that the estimates of μ_{SSS} and σ_{SSS} now provide the mean and standard deviation of the baseline preference for SSS.

The situation of only allowing for random heterogeneity in the constant is unsatisfactory, as it assumes that there is no random heterogeneity in the sensitivities to the explanatory variables (e.g. time, cost, …) and that all these differences are explained deterministically in the model. However, incorporating random heterogeneity in these other components was not possible with a MMNL model given the small sample size. We thus also developed Latent Class (LC) models. A LC model not only more conveniently captures heterogeneity in all parameters at the same time but seeks to explain that random heterogeneity in part through covariates. In a LC model (see e.g. Hensher 2015: 114), we assume that the population consists of a finite number (*c*) of classes of individuals. The preferences differ across classes, i.e. there are differences in the parameters for individuals in different classes. However, individuals within a class have the same sensitivities, i.e. we have homogeneity in behaviour within a class. The probability that an individual *n* belongs to a given class *c* out of *C* latent classes, P_{nc}, is:

$$P_{nc}(\theta) = \frac{\exp(V_{nc}^{a})}{\sum_{k=1}^{C} \exp(V_{nk}^{a})} \tag{7}$$

with $\theta = <\beta, \delta>$ and where V_{nc}^{a} the utility in the class allocation model for class c for respondent n, where this utility is normalised to zero for one class. Now the probability that a member of class c chooses alternative j (out of J alternatives) in choice situation s, $P_{nsj|c}$, is:

$$P_{nsj|c}(\theta) = \frac{\exp(V_{nsj|c})}{\sum_{k=1}^{J} \exp(V_{nsk|c})} \tag{8}$$

with $\theta = <\beta, \delta>$ and where $V_{nsj|c}$ is the choice model utility in class c. Finally, the unconditional probability that a decision-maker n chooses alternative j, P_{nj}, is given by:

$$P_{nj}(\theta) = \sum_{c=1}^{C} P_{nsj|c} P_{nc} \,. \tag{9}$$

The LC model was estimated to assess the underlying latent preferences not captured by the MNL and MMNL models. Specifically, the LC model was employed to link unobserved taste heterogeneity to the characteristics of the decision-maker, the product and the situational variables (cf. Beck et al., 2013). This allowed us to assess for differences in all the parameters, as opposed to the difference in the constant δ only as was the case in the MNL and MMNL model. This approach was necessary because one of the research objectives in the study was to identify shipper segments that differ according to their preferences. To that extent, the LC model approach provides an appropriate framework for interpreting results, proposing policies, and making decisions based on respondents' taste heterogeneity. To estimate the LC model, a series of models with varying numbers of classes were estimated and the models were assessed as detailed in Section 3.4. Since the focus was to understand the heterogeneity underlying different segments, each class was expected to be distinctive in terms of model outputs.

In our work, we estimated a LC model with two classes, with all parameters varying across classes, and where the class allocation model included a constant as well as the product type, estimating parameters for raw and finished, with semi-finished as the base. In particular, we then have that:

$$V_{n1}^{a} = \lambda_1 + \gamma_{\text{raw}}\, x_{\text{raw,n}} + \gamma_{\text{finished}}\, x_{\text{finished},n} \tag{10}$$

while $V_{n2}^{a} = 0$ for normalisation.

3.5 Model estimation and selection

All models were estimated in *R* (R Core Team, 2016) with the *Apollo* choice modelling package by Hess & Palma, (2019). Because the MMNL model no longer has a closed form solution, a simulation-based estimation was required for the likelihood function. The Halton sequence-based simulation was employed (Halton,1960). To make a decision on a final specification, informal judgement-based tests, goodness-of-fit measures and statistical tests are employed (Train, 2009). Especially with the latent class models, there is a proliferation in the number of parameters by adding classes, and in addition to the likelihood ratio (LR) test and ρ^2 measure, we also considered the Akaike and Bayesian Information Criterion (AIC, BIC) as they imply larger penalties for additional parameters (see Hensher et al., 2015).

4. Results

The results for the different models are shown in Table 4 and the interpretations follow thereafter. From a total of 1,668 observations (139 respondents, 12 choice tasks each), 67.6 percent of the respondents selected SSS and 32.4 percent selected road.

4.1 Comparing model goodness of fit

The results in Table 4 shows that each additional layer of model flexibility leads to improvements in the log-likelihood. The addition of the covariates in the MNL model leads to an improvement of 73.222 units with the addition of four parameters, where this rejects the null hypothesis of no difference at any reasonable level of confidence for a likelihood ratio test. The MMNL model, which captures random heterogeneity, yielded a further improvement of 79.928 units with the addition of a single random parameter, where this is again highly significant. While we can use likelihood ratio tests to show that the LC model also convincingly outperforms the two MNL models, a non-nested test is needed to compare MMNL and LC. Here, we see that LC outperforms MMNL according to all three goodness-of-fit statistics.

Table 4: Model Results

	Base			MNL			MMNL			LC					
										Class 1			*Class 2*		
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	Coeff	r.s.e	r.t-r
Randomized parameters															
ASC_{Road} (fixed)	0.000	NA	NA	0.0000	NA	NA	0.0000	NA	NA	0.0000	NA	NA	0.0000	NA	NA
δ_{SSS} (MNL/LC) / μ_{SSS}	0.022	0.1445	0.16*	-0.2150	0.406	-0.53*	-0.1622	0.5150	-0.31*	-0.2784	0.577	-0.48*	1.0694	0.754	1.42*
σ_{SSS}				-	-	-	1.3072	0.1760	7.43	-	-		-	-	
Non-randomized parameters															
β_{time}	-	0.0387	-7.73	-0.3171	0.041	-7.6	-0.3997	0.052	-7.68	-0.5856	0.119	-4.91	-0.2388	0.090	-2.65
β_{cost}	-0.001	0.0001	-8.29	-0.0012	0.000	-8.92	-0.0015	0.0002	-8.97	-0.0028	0.000	-6.36	-0.0001	0.000	-0.77*
β_{delay}	-	0.0036	-3.16	-0.0151	0.003	-3.82	-0.0149	0.0036	-4.09	-0.0259	0.008	-3.03	-0.0094	0.006	-1.42*
β_{freq}	0.121	0.0185	6.56	0.1457	0.020	7.27	0.185	0.0248	7.46	0.1377	0.042	3.26	0.2343	0.045	5.20
β_{rel}	0.003	0.0015	2.11	0.0023	0.001	1.86*	0.0033	0.0016	2.13	0.1435	0.046	3.11	0.0509	0.039	1.28*
Decision-maker characteristics: impact on SSS															
Dur ~ Bei ($\beta_{DUR\text{-}BEI}$)				0.3776	0.368	1.03*	0.5248	0.4633	1.13*	1.4714	0.879	1.67*	0.0877	0.618	0.14*
WB ~ Lua ($\beta_{WB\text{-}LUA}$)				0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
CT ~ WB ($\beta_{CT\text{-}WB}$)				0.8543	0.290	2.94	0.9704	0.3575	2.71	0.3267	0.440	0.74*	1.2162	0.633	1.92*
Shipment direction (β_{head})				-0.4321	0.235	-1.84*	-0.5035	0.3199	-1.57*	-0.7999	0.231	-3.46	-0.5316	0.344	-1.54*
Urgent shipment (β_{urgent})				-1.9884	0.265	-7.5	-2.4888	0.3328	-7.48	-3.388	0.503	-6.73	-1.2090	0.522	-2.31
LC model specific parameters															
λ_1										-0.0854	0.433	-0.20*	-		
γ_{raw}										-0.5773	0.709	-0.81*	-		
$\gamma_{finished}$										1.2027	0.508	2.36	-		
Model Statistics															
Observations	1668			1668			1668			1668					
Parameters	6			10			11			21					
LL(0)	-1156.1690			-1156.1690			-1156.1690			-1156.1690					
LL(final)	-994.3211			-921.0990			-841.1715			-774.7746					
LL(class specific)										-1394.7132			-1167.502		
Rho-square (0)	0.1400			0.2033			0.2724			0.3299					
Adj.Rho-square (0)	0.1348			0.1947			0.2629			0.31					
AIC	2000.64			1862.21			1704.34			1595.55					
BIC	2033.16			1916.39			1763.96			1720.2					

Notes: coeff = coefficient, rob.s.e = robust standard error, rob.t-r = robust t-ratio, * insignificant to 95% CI

4.2 Headline findings

Result interpretation is continued by looking at the parameter estimates for the base attributes in all the models in Table 4. The robust t-ratio provides the measure of significance for individual parameters.

All the parameters for the base attributes, in all the models, had the expected signs and projected reasonable inter-attribute differences. Notably, the parameters for transit time, transport cost and expected delay were negative, meaning that an increment in these attributes will result in proportional disutility for the alternative where this change is applied. 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. Transit time and frequency had marginally higher contributions per unit to utility compared to the other base attributes. Generally, all the base attributes were statistically significant at the 95% confidence interval in all the models, the exception being reliability in the MNL model and the second class of the LC model. Cost and delay were also insignificant in the second class of the LC; however, they were retained based on professional intuition. Recalling that the parameters in the LC model were varied along two classes of product type, raw and finished products.

With regard to socio-economic factors, the lower part of Table 4 shows the covariates classified according to decision-maker characteristics and situational variables. 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. The attribute level for *Walvis Bay ~ Luanda* ($\beta_{\text{WB-LUA}}$) was fixed as the reference level. From the results, we deduced that holding all else equal, shippers on the *Durban ~ Beira* ($\beta_{\text{DUR-BEI}}$) corridor have more preference for SSS than shippers on the *Walvis Bay ~ Luanda* ($\beta_{\text{WB-LUA}}$) corridor. Moreover, shippers on the *Cape Town ~ Walvis Bay* ($\beta_{\text{CT-WB}}$) corridor have more preference for SSS than on both the *Walvis Bay ~ Luanda* and *Durban ~ Beira* corridor. The inclusion of this variable was important in the discussion of developing SSS in SADC, seeing some key freight transport corridors in SADC are constrained by inefficient ports. Consider for example the *Durban ~ Beira* corridor which is burdened with port congestion in both the ports of Durban and Beira (Parida, 2014), and the frequent occurrences of bad weather which exacerbates the port inefficiency (Rennie, 2002).

With regard to situational variables; the negative coefficient for shipment urgency (β_{urgent}) shows that when a shipment is urgent, SSS is significantly less preferred. 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 will be less appealing to the SADC shipper who values time.

Lastly, on the question of shipment direction, the attribute direction of shipment (β_{head}) captures the head-haul. The head-haul 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 *Walvis Bay ~ Luanda*, the journey from Walvis Bay to Luanda was captured as the head-haul and the journey from Luanda to Walvis Bay was captured as the return or back-haul. It follows therefore that the negative coefficient for direction of shipments means shippers prefer road over SSS on the head haul. This is understandable in SADC as most shipments from source to demand have a minimum lead time within which they need to arrive (cf. Konstantinus & Zuidgeest, 2018). Moreover, two concerning issues of freight transport in SADC have been the directionally imbalanced traffic flows which emanate mostly from South Africa to the rest of SADC (Vilakazi et al., 2014); and a high share of shippers who employ own transport as a reliability enhancing measure (Konstantinus and Zuidgeest, 2018). This situation causes road transport to be more expensive on the head leg than on the return leg, as the return leg is often empty (ibid).

4.3 Heterogeneity among shippers

Starting with the MMNL model, the statistically significant standard deviations of the randomized coefficients suggest the existence of additional unobserved heterogeneity in response to SSS, where this standard deviation of the random parameter relates to the amount of dispersion around the mean that exists in the sample data. These results are in line with findings by Kim et al (2014) and Feo-Valero et al (2011) who similarly found that freight mode choice is a result of an array of interactions including transportation characteristics, logistics characteristics and product characteristics.

When it comes to the LC model, we already discussed earlier that the model uses two classes, i.e. probabilistically splitting the individual respondents into two groups, with differences in preferences/sensitivities between these two groups. The results show some clear differences in preferences between the two classes. The baseline difference between road and SSS is not significant in either class (like in the MNL models), but the dislike of SSS for urgent shipment or those on the head leg, is much stronger in class 1. More importantly, we see differences in the sensitivities to the explanatory variables. In class 1, all explanatory variables have statistically significant impacts on the utility, while in class 2, only time and frequency matter. This suggests a different behavioural process, with individuals in class 2 focussing on fast and convenient service, while those in class 1 are willing to trade this against reduced cost. The allocation of an individual to a class is not observed, i.e. is latent. Every individual in the data has a non-zero probability of falling into either class. However, these probabilities vary across individuals as a function of their characteristics. The allocation to the classes is driven in part by the product type (i.e. raw, semi-finished or finished). In particular, for a raw product, the probability of falling into the first class is 34%, where this increases to 47.9% for semi-finished products, and 75.3% for finished products. This, together with the higher utility for SSS in class 2, is entirely in line with the notion that SSS is more acceptable for less valuable/urgent products.

4.4 Implications of Results

The modelling outcomes demonstrate the extent to which key SSS variables could be adjusted to develop SSS in SADC. Firstly, we learned that transit time and frequency of service have the greatest impact on utility in the base attributes. This conclusion is in line with Feo et al. (2011) who argue 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. Thus, unlike Brooks et al (2012) and Kim (2014) who implied that a modal shift to SSS can mainly be induced by increasing the cost of road transport, the results in this study seem to suggest that it is more the attributes associated with transport quality that require adjusting to make SSS more viable.

The results further reveal that quality of transport using SSS is still worse than road transport across long distance corridors in SADC. The finding is in line with the special report on Coastal Shipping by the South Africa Department of Transport which reports that SADC ports are characterized by high port charges, long turnaround times for ships and lack of infrastructure for SSS (NDoT, 2011). Looking furthermore to the current transport conditions as captured in Table 2, it becomes apparent that the biggest problem facing the development of SSS could be low port efficiency of most ports in SADC.

Transit time and frequency of service are also important factors to consider because they can be influenced by direct actions and intervention from political action. For instance, transit time for SSS can be reduced by reducing the turnaround time for SSS ships in ports; and this can be achieved by docking and tending ships on arrival, and by speedy administrative procedures for preparing to load and unload ships (Talley, 2014). Similarly, frequency of service can be improved by stimulating more freight volume for SSS to make it more viable for ships to offer more frequent service. 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 (Konstantinus et al., 2019). A key approach in many regions has been in the form of outright political action that favours SSS (ibid).

Additionally, the modelling results reveal that *shipments on the head-haul* of the transport journey and *urgent shipments* have a baseline preference for road over SSS, suggesting that strategies to develop SSS must prepare to capture different freight and shipper types that are suitable to its service levels. Indeed, SSS would have inferior service levels to road, therefore we do not expect it to serve all cargo types, especially the time strict shipments such as *just-in-time* shipments. These types of shipments are more likely to use road or even air transport, which are quicker in terms of transit time and service reliability.

5. Conclusion

The motivation of this research is rooted in the need to develop SSS to realise a seamless and sustainable freight transport system in SADC. Fittingly, this paper investigated the potential for developing SSS in SADC by studying mode choice preference along three inter-urban corridors in SADC that run between *Walvis Bay ~ Luanda, Cape Town ~ Walvis Bay and Durban ~ Beira*. In so doing, the paper addressed the need of empirical research to inform policy and initiatives to develop SSS in SADC.

For each transport corridor studied, a stated choice survey with twelve scenarios was defined for hypothetical SSS and road transport using the following service attributes: frequency of service, reliability in terms of arriving on time, expected delay, transport cost and transport time as attributes. From the data, the multinomial logit, mixed multinomial logit and latent class models were estimated. The modelling results reveal that freight mode choices are driven principally by transit time and frequency of service, and accordingly the paper suggests improvement in these attributes should be key target areas if SSS is to be developed. The use of the mixed logit model further revealed the existence of random heterogeneity in shipper preference, suggesting that freight mode choice will differ based on shipper characteristics. The use of the latent class model furthermore revealed the presence of shipper segments that differ according to the underlying latent preferences defined by product type. The results show that the segment most likely to shift to SSS is low value/ non-urgent products.

Although the paper makes a number of contributions to both the literature on maritime transport and shipper behaviour, there are possible future areas of research. For instance, the study setting considered SSS between port cities. Future study approaches could consider intermodal SSS, whereby either origin or destination is in the hinterland away from the port, or corridors spanning a greater network of ports, for example Cape Town ~ Walvis Bay ~ Luanda instead of just a single O-D pairing as done in this study. Also, the study considered the modal preference of shippers and freight forwarders, which constitute a perspective from the demand side. A future area of research could look at the supply side, studying the take up of SSS by maritime carriers. Having both the maritime carrier and shipper perspective could better inform studies on developing SSS in SADC.

Author Statement

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References

Arencibia, A.I., Feo-Valero, M., García-Menéndez, L., Román, C., 2015. Modelling mode choice for freight transport using advanced choice experiments. Transp. Res. Part A Policy Pract. 75, 252–267. https://doi.org/10.1016/j.tra.2015.03.027

African Union, 2010. Revised African Maritime Transport Charter; African Union: Addis Abeba.

Beck, M.J., Rose, J.M., Hensher, D.A., 2013. Environmental attitudes and emissions charging: An example of policy implications for vehicle choice. Transp. Res. Part A Policy Pract. 50, 171-182.

Bergantino, A., Bolis, S., 2004. An analysis of maritime ro-ro freight transport service attributes through adaptive stated preference: an application to a sample of freight forwarders. European Transport \ Trasporti Europei, ISTIEE, Institute for the Study of Transport within the European Economic Integration, 25-26, 33-51.

Brooks, M., Trifts, V., 2008. Short sea shipping in North America: understanding the requirements of Atlantic Canadian shippers. Marit. Policy Manag. 35, 145–158. https://doi.org/10.1080/03088830801956805

Brooks, M.R., Puckett, S.M., Hensher, D. a, Sammons, A., 2012. Understanding mode choice decisions: A study of Australian freight shippers. Maritime Economics and Logistics. 14, 274–299. https://doi.org/10.1057/mel.2012.8.

CEMT/CM (2000)9. Short sea shipping: an alternative to European inland transport, or a complementary mode? available at https://trid.trb.org/view/680594 (accessed 3.9.19).

Choice-Metrics, 2017. Ngene Software 1.2.1, choice-metrics.com.

de Jong, G., Ben-Akiva, M., 2007. A micro-simulation model of shipment size and transport chain choice. Transp. Res. Part B. 41(9), 950-965.

Eisele, W.L., Tardif, L.-P., Villa, J.C., Schrank, D.J., Lomax, T.J., 2011. Developing and applying fluidity performance indicators in Canada to evaluate international and multimodal freight system efficiency. Presented to Transportation Research Board's 90th Meeting, Washington DC.

Feo-Valero, M., Garcia-Menendez, L., Saez-Carramolino, L., Furio-Prunonosa, S., 2011. The importance of the inland leg of containerised maritime shipments: An analysis of modal choice determinants in Span. Transp. Res. Part E Logist. Transp. Rev. 47 (4), 446-460.

Feo-Valero, M., Arencibia, A.I., Román, C., 2016. Analyzing discrepancies between willingness to pay and willingness to accept for freight transport attributes. Transp. Res. Part E Logist. Transp. Rev. 89, 151–164. https://doi.org/10.1016/j.tre.2016.03.004

Figliozzi, M. A., 2006. Modeling impact of technological changes on urban commercial trips by commercial activity routing type. Transportation Research Record: Journal of the Transportation Research Board, 1964(1), 118-126.

Fowkes, A.S., Nash, C.A., Tweddle, G., 1991. Investigating the market for inter-modal freight technologies. Transp. Res. Part A Policy Pract. https://doi.org/10.1016/0191-2607(91)90002-8

Fries, N., de Jong, G.C., Patterson, Z., Weidmann, U., 2010. Shipper Willingness to Pay to Increase Environmental Performance in Freight Transportation. Transportation Research Record: Journal of the Transportation Research Board, No. 2168, Transportation Research Board of the National Academies, Washington, D.C., 2010, pp. 33–42. DOI: 10.3141/2168-05

García-Menéndez, L., Martínez-Zarzoso, I., Piñero De Miguel, D., Garc, L., Mart, I., Pinero De Miguel, D., 2004. Determinants of Mode Choice between Road and Shipping for Freight Transport: Evidence for Four Spanish Exporting Sectors Determinants of Mode Choice between Road and Shipping for Freight Transport Evidence for Four Spanish Exporting Sectors. J. Transp. Econ. Policy J. Transp. Econ. Policy 38, 447–466.

García-Menéndez, L., Feo-Valero, M., 2009. European Common Transport Policy and Short-Sea Shipping: Empirical Evidence Based on Modal Choice Models. Transp. Rev. 29,

239–259. https://doi.org/10.1080/01441640802357192
Hare, J., 2009. Shipping Law and Admiralty Practise in South Africa 2nd ed. JUTA, Cape Town.
Halton, J.H., 1960. On the efficiency of certain quasi-random sequences of points in evaluating multi-dimensional integrals. Numer. Math. 2, 84–90. https://doi.org/10.1007/BF01386213
Hensher, D., Rose, J., Greene, W., 2015. Applied Choice Analysis, 2nd ed. Cambridge University Press, Cambridge.
Hess, S., Palma, D., 2019. Apollo : a flexible , powerful and customisable freeware package for choice model estimation and application User manual.
ICC, 2011, International Chamber of Commerce: INCOTERMS rules. Available at https://iccwbo.org/resources-for-business/incoterms-rules/
ITF (International Transport Federation), 2010. Improve Reliability on Surface Transport Networks, available at https://www.itf-oecd.org/improving-reliability-surface-transport-networks, accessed 20 May 2020.
Kamau, N., 2014. The regulation of trade barriers under SADC and EAC. University of Cape Town, Cape Town, 2014.
Kim, H.C., Nicholson, A., Kusumastuti, D., 2014. Freight Transport Mode Choice and Mode Shift in New Zealand: Findings of a Revealed Preference Survey, in: Sustainable Logistics. pp. 165–192. https://doi.org/10.1108/S2044-994120140000006007
Konstantinus, A., 2019. Opportunities for Short-sea shipping in SADC: Evidence based on discrete choice modeling. Ph.D. Dissertation. Department of Civil Engineering, University of Cape Town, Cape Town, South Africa (2019)
Konstantinus, A., Christodoulou, A., Raza, Z., Zuidgeest, M., Woxenius, J., 2019. Barriers and Enablers for short-sea shipping in the Southern African Development Community, Sustainable Short Sea Shipping. Sustainability 2019, 11(6), 1532.
Konstantinus, A., Zuidgeest, 2019. An investigation into the factors influencing inter-urban freight mode choice decisions in the Southern African Development Community region, Journal of Transport and Supply Chain Management, Vol 13, available at https://jtscm.co.za/index.php/jtscm/article/view/463.
Konstantinus, A., Zuidgeest, M., 2018. Freight Transport Decisions and their considerations in the Southern African Development Community (SADC), in: Browne, M. (Ed.), . VREF Urban Freight Conference, Gothenburg, 35.
Leach, P.T., Can Short-Sea Measure Up? Journal of Commerce, 5(16). April 19-25, 2004, 30–31.
Masiero, L., Hensher, D.A., 2010. Analyzing loss aversion and diminishing sensitivity in a freight transport stated choice experiment. Transp. Res. Policy Pract. 44, 349–358.
Mutambara, T.E., 2009. Regional transport challenges within the Southern African Development Community and their implications for economic integration and development, Journal of Contemporary African Studies, 27:4, 501-525, DOI: 10.1080/02589000903399488
Naudé, W., 2009. Geography, transport and Africa's proximity gap. J. Transp. Geogr. 17, 1–9. https://doi.org/10.1016/j.jtrangeo.2008.04.011
NDoT, 2011. Part 2: Coastal and Short-Sea Shipping, SA Maritime Transport Sector Study.
NDoT, 2017 - Department of Transport of the Republic of South Africa Comprehensive Maritime Transport Policy for South Africa; Government of South Africa: Pretoria, 2017; p 137.
Ombo, G., 2012. Coastal Shipping in Africa : Prospects and Challenges. South Africa Marit. Ind. Conf. 1–9.
Paixão Casaca, A.C., Marlow, P.B., 2005. The competitiveness of short sea shipping in multimodal logistics supply chains: service attributes. Marit. Policy Manag. 32, 363–382. https://doi.org/10.1080/03088830500301469
Papadimitriou, S., 2001. Short Sea Shipping in Europe: Experience and Prospects. Avalaible at https://www.itf-oecd.org/sites/default/files/docs/01shortsea.pdf (accessed 3.9.19).

Parida, P., 2014. Unlocking Mineral Resource Potential in Southern African Countries: Is Rail Infrastructure up to the Challenge? Transp. Res. Procedia 1, 206–215

Porter, ME. 1980. "Competitive Strategy". In Techniques for Analysing Industries and Competitors, New York: The Free Press. [Google Scholar]

Puckett, S.M., Hensher, D.A., Brooks, M.R., Trifts, V., 2011. Preferences for alternative short sea shipping opportunities. Transp. Res. Part E Logist. Transp. Rev. 47, 182–189. https://doi.org/10.1016/j.tre.2010.10.002

Raza, Z., Svanberg, M., Wiegmans, B., 2020, Modal shift from road haulage to short sea shipping: a systematic literature review and research directions, Transport Reviews, 40:3, 382-406, DOI: 10.1080/01441647.2020.1714789

R Core Team, 2016. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org

Regan, A. C., Garrido, R. A., 2001, Modelling Freight Demand and Shipper Behaviour: State of the Art, Future Directions (7), pp.185-215, Pergamon, New York.

Rennie, C.D., 2002. the Role of Coastal Shipping Within Southern Africa'S Transport Infrastructure, in: 21st Annual South African Transport Conference "Towards Building Capacity and Accelerating Delivery." MoT, Pretoria.

Rodrigue, J.-P., 2017. The Geography of Transport Systems, 3rd ed. Routledge, New York.

SADC, 1996. Southern Africa Development Community Protocol on Transport, Communication and Meteorology.

SADC, 2015. official website [WWW Document]. South. African Dev. Community. URL http://www.sadc.int/member-states/ (accessed 3.11.15).

SADC, 2013. SADC Regional Infrastructure Development Master Plan [WWW Document]. South. African Dev. Community. URL http://www.sadc.int/files/9313/5293/3536/Regional Infrastructure Development Master Plan Transport Sector Plan.pdf (accessed 3.9.15).

Sawtooth Software, 2017. Available at: www.sawtoothsoftware.com

Shinghal, N., Fowkes, T., 2002. Freight mode choice and adaptive stated preferences. Transp. Res. Part E Logististics Transp. Rev. 38, 367–378.

Strandenes, S.P., Marlow, P.B., 2000. Port pricing and competitiveness in short sea shipping. Int. J. Transp. Econ. 27, 315–334.

Talley, 2014. Maritime transport chains: carrier, port and shipper choice effects. Int. J. Production Economics 151 (2014) 174–179.

Tavasszy, L, Jong, G.C. de, 2014 Modelling freight transport, Elsevier Insights Series, Elsevier.

Train, K., 2009. Discrete Choice Methods with Simulation, 2nd ed. Cambridge University Press. https://doi.org/10.1017/CBO9780511753930

Tyworth, John E. & Saldanha, John, 2014. The lead-time reliability paradox and inconsistent value-of-reliability estimates. Transportation Research Part E: Logistics and Transportation Review, 70(C), 76-85.

Vilakazi, T., Ncube, P., Roberts, S., 2014. Study of competition in the road freight sector in the SADC region-case study of fertilizer transport & trading in Zambia, Tanzania and Malawi.

Zamparini, L., Layaa, J., Dullaert, W., 2011. Monetary values of freight transport quality attributes: A sample of Tanzanian firms. J. Transp. Geogr. 19, 1222–1234. https://doi.org/10.1016/j.jtrangeo.2011.01.002