DETERMINANTS OF FREIGHT TRANSPORT MODE CHOICE IN NEW ZEALAND: FINDINGS OF A REVEALED PREFERENCE SURVEY

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ABSTRACT

A shipper's freight modal choice depends on demand and infrastructure as well as the quality of service characteristics of alternative modes, such as delivery time, reliability and frequency of service. Freight logistics characteristics, such as the attributes of the shipper, the commodities to be transported, and the spatial attributes of shipments, strongly influence modal choice. This paper describes a revealed preference (RP) survey of 183 freight shippers, including Small and Medium Enterprises (SMEs), and freight agents in New Zealand (NZ). The RP survey allows us to explore the relative importance of different transportation service attributes, based on a sample of shippers across a range of industries. A rank-ordered logit model is used to analyse ranked response mode choice data. The results show several distinct types of transport mode choice behaviour within the sample and show how the preferences for timeliness, cost, accessibility, restitution, customer service, and suitability vary between industry groups and business types. Also, the rank-ordered logit method allows us to identify substantial heterogeneity in preference for mode choice factors across respondents in NZ as transport modes for domestic shipments. The results imply that firms in NZ rank timeliness and transport cost as the most important factors in determining freight transport mode choice, regardless of the firms' characteristics, such as physical structures, logistics and operations. Damage and suitability factors were the two lowest ranked factors for most of respondents. In terms of the effects of firms' characteristics on their mode choice decisions, there is a strong emphasis on timeliness and cost as mode choice factors for those firms with integrated supply chains.

Keywords: freight transport, mode choice, revealed preference survey, rank-ordered logit model

INTRODUCTION

Market globalization and developing service economies have increased the demand for reliable, flexible, cost-effective, timely, and viable door-to-door freight services from the shippers in the world. In New Zealand (NZ) freight transport demand has grown by more than 32% during the last decade. Freight transport (in tonne-kms) is expected to grow about 70% between 2005 and 2020 (NFDS, 2008). The Ministry of Transport expects the strong growth of freight movements to continue, up to 100 percent by 2040. Concurrently, the modal share of road transport has increased significantly and is expected to increase further in the coming years. In addition, with rising fuel prices and growing awareness about the challenge of global climate change, innovative policies and technologies are being introduced for reducing the negative impacts (i.e. congestion, pollution, etc) of the dependency on road transport.

The National Freight Demand Study (Richard Paling Consulting, 2008) was the first comprehensive freight movement study in NZ. The study conducted surveys with 100 key firms across the industries, addressing the factors influencing freight mode choice qualitatively. The key factors identified by this study were cost, reliability, modal connectivity, restitution, mode-to-mode transfer, customer service, environmental and sustainability issues, and some logistics issues within the supply chain. Rockpoint (2009) mainly focused on NZ sea and coastal freight issues from both the shipper's and the carrier's points of view. This study provided a better understanding of how NZ shippers choose the appropriate mode of transportation through interviewing 45 firms across various industries. The study offered a choice of five service criteria, which were: product care, cost, timeliness, reliability and safety. Reliability was cited as the most important service factor, followed by product care and safety. Interestingly, this study uses ‘reliability’ and ‘timeliness’ as different service factors. However, ‘timeliness’ often encompasses both average shipment time (variables affecting the average include standard transit times and directness of service) and variations in shipment time (reliability of service) (Evers et al., 1996). A limitation of previous NZ studies is the lack of quantitative information about how those choosing between modes make trade-offs between conflicting objectives and factors.

Discrete-choice models permit the construction of a very general utility function incorporating many freight demand characteristics and transportation service attributes (Jiang et al., 1999). Different freight transportation modes are distinguished by their service attributes. The transportation cost is affected by such attributes as equipment availability, transit time, fare, flexibility of the service, reliability, insurance cost, loading facilities, etc. In addition, the level of service component of each mode introduces risk into the shipper’s decision regarding mode and destination. Daugherty and Inaba (1978) provided a more extensive but similar economic theory modelling framework, constructing a measure for the availability attribute, and evaluating decisions confronting an elevator shipper sending corn to various markets, using a logit model. Gilmour (1976) analysed the modal choice of distribution and transport managers for freight movement between Melbourne and Sydney. He examined the attitudes of shippers towards modal choices based upon their perception of particular modes of transport offered. He discovered that cost was the most important factor. In 1990, McGinnis identified that the transport decision is typically affected by at least six factors: (1) freight

rates, including cost and charges; (2) delivery time reliability; (3) transit times; (4) over, short and damaged goods; (5) shipper market considerations, and (6) carrier considerations. According to the study, shippers' overall perceptions are more greatly affected by timeliness and availability than cost, which is often the last criterion for selecting a transport service provider. Evers et al. (1996) found, based upon a survey of shippers in the state of Minnesota in the U.S., that this overall perception is driven largely by six factors. They used a questionnaire to collect shipper ratings information for three transportation modes, based on characteristics that included timeliness, availability, suitability, firm contact, restitution for loss and damage, and cost. These were the same factors used by McGinnis (1990) in an earlier study. Their study found that timeliness and availability are more important than the other four factors, with cost being the least important criterion.

The decision-makers' perception is a major input component to the decision making process in mode selection. A rank-ordered logit model, also known as an exploded logit model, can be used to analyse data on the preferences of individuals over a set of alternatives, where the preferences are partially observed through surveys or conjoint studies. Empirical applications describing preferences using the rank-ordered logit model can be found in the field of transportation include Ben-Akiva et al. (1991), Bradley and Daly (1994), Odeck (1996), Fridstrom and Elvik (1997), Hunt (2001), Calfee et al. (2001), Kockelman et al. (2006), and Srinivasan et al. (2006).

In this paper, we present a rank-ordered logit model to examine the freight transport mode choice determinants for New Zealand shippers. The data used in the empirical analysis are obtained from a revealed preference (RP) survey collected in NZ.

Rank-Ordered Logit Model

The rank-ordered logit model has been used extensively in marketing research. This model is an extended form of the conditional logit regression model introduced by McFadden (1974). In economic literature, the logistic model for ranking was proposed by Beggs et al. (1981) and further developed by many marketing researchers (Hausman and Ruud, 1987; Pundj and Staelin, 1978; Chapman and Staelin, 1982; Allison and Christakis, 1994) under the name of rank-ordered logit model.

An alternative specification of the logistic regression model, based on random utility models (e.g. Block and Marchak, 1960; Luce and Suppes, 1965; Marchak, 1960), is often used in econometrics (e.g. Maddala, 1983). In random utility models the rank of an alternative is determined by its utility. Therefore, the utility U_{ij} provided to individual i by product j is modelled as

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

where the error component ε_{ij} is assumed to be independently identically distributed (IID) with an extreme value distribution (Allison and Christakis, 1994), given by $Prob(\varepsilon_{ij} \leq t) = exp\{-exp(-t)\}$, and the probability of ranking j higher than k is given by

$$exp\{u_{ij} - u_{ik}\} \tag{2}$$

McFadden's random utility model implies the following likelihood L_i for a single respondent. Let δ_{ijk}=1 if $Y_{ik} > Y_{ij}$, and 0 otherwise. Then we have

$$L_i = \prod_{j=1}^{J} \left[\frac{e^{V_{ij}}}{\sum_{k=1}^{j} \delta_{ijk} e^{V_{ij}}} \right] \tag{3}$$

Each of the terms in the product now has the term of a conditional logit model. We now get the probability of item j being the most preferred item from the set J is

$$Pr\left(U_1 > U_j, j = 1, 2, \cdots, J\right) = \frac{e^{V_1}}{\sum_{j=1}^{J} e^{V_j}} \tag{4}$$

When the first choice has been made, the second most preferred item can be chosen from the remaining (J – 1) items. The probability of item *j* being the second most preferred item is

$$Pr\left(U_2 > U_j, j = 3,4, \cdots, J\right) = \frac{e^{V_2}}{\sum_{j=1}^{J} r} = \frac{e^{V_2}}{\sum_{j=1}^{J} e^{V_j}} \tag{5}$$

Because of the assumed independence between these choice tasks, the likelihood of a certain ranking of the alternatives in the entire choice set K is thus the product of J logit probabilities. This likelihood can be written as

$$Pr\left(U_1 > U_2 > \cdots > U_j\right) = Pr(U_1 > U_j, j = 1, 2, \cdots, J) \bullet Pr\left(U_2 > U_j, j = 3, 4, \cdots, J\right)$$

$$\bullet Pr\left(U_3 > U_j, j = 4, 5, \cdots, J\right) \cdots \bullet Pr\left(U_{J-1} > U_J\right)$$

$$= \frac{e^{V_1}}{\sum_{j=1}^{J} e^{V_j}} \bullet \frac{e^{V_2}}{\sum_{j=2}^{J} e^{V_j}} \bullet \cdots \bullet \frac{e^{V_{J-1}}}{e^{V_{J-1}} + e^{V_J}} = \prod_{j=1}^{J=1} \left[\frac{e^{V_J}}{\sum_{m=j}^{J} e^{V_m}} \right]$$

$$Pr(U_1 > U_2 > \cdots > U_K, K \leq J) = \prod_{j=1}^{K} \left[\frac{e^{V_j}}{\sum_{k=j}^{K} e^{V_k}} \right] \tag{6}$$

Finally, an estimation of a rank-ordered logit model can be accomplished with most partial likelihood procedures for estimating proportional hazard models. For a sample of n independent respondents, Eq. (6) implies a log-likelihood of

$$\log L = \sum_{i=1}^{n} V_{ij} - \sum_{i=1}^{n} \log[\sum_{k=1}^{j} \delta_{ijk} \exp(V_{ik})] \tag{7}$$

The linear model for the V_{ij}'s in Eq. (1) can be substituted into Eq.(7), which can then be maximized with respect to the coefficient vectors. Beggs et al. (1981) proved that the likelihood is globally concave, which means if a maximum is found, it is a global rather than a local maximum.

DATA ANALYSIS

Ranked data on relative preference for freight transport modes for this study comes from two major groups of freight transport user; freight shippers and consigners, who actually owned freight, and freight agents, such as freight forwarders, transport service providers (contracted carriers, warehousing) and 3PL (3rd party logistics) companies. Both types of information are termed 'shipper information' in this paper. A revealed preference survey of freight shippers and agents was conducted on-line during 2011 and 2012. The survey sample was chosen randomly from the list of firms registered with the New Zealand Stock Exchange (NZX), and firms that are members of industry associations, groups and councils. Firms were assigned to four business categories; 'primary/raw material providers', 'manufacturers', 'wholesalers/retailers', and 'logistics service providers'.

Table I – The sample statistics

Characteristics	Descriptions		Percent (%)
Position of respondents	Chief officers (e.g. executives, CEO)		52.9
	Operational managers (e.g. Transport, Logistics)		47.1
Freight Transport User	Shippers and Consignors	Primary sector	24.3
		Manufacturers	37.6
		Wholesalers/retailers	17.7
	Agents (Forwarders, Carriers, 3PLs, Logistics service providers)		20.4
Export Volume	Domestic distribution only, No exports		25.1
	Exports 1 ~ 24% of produce		29.7
	Exports 25 ~ 49 % of produce		34.2
	Exports 50 ~ 74 % of produce		5.8
	Exports 75~100 % of produce		9.7
Transport/Delivery Distance	Within City/Region (< 100km)		20.6
	Within South or North Island (<250km)		20.2
	All over New Zealand		67.9
Integrated Supply Chain*	Integrated Supply Chain		38.7
	Not integrated		61.3
Size of company*	Less than 19 employees (SMEs)		56.5
	20~99 employees		26.6
	Over 100 employees		16.9
Logistics Facilities*	No warehouse		30.6
	One warehouse		38.8
	More than one warehouse		30.6
Use of Contracted Carriers*	1~2 contracted carriers		47.5
	3~4 contracted carriers		35.3
	Over 5 contracted carriers		17.3
Length of Contract with Carriers*	Less than 3 years of contract		22.7
	3~9 years of contract		31.2
	10 or more years of contract		46.1

*User specific questions, only answered by freight shippers and consignors

A detailed company profile (including business summary, products/services, and industry/sector information) was carefully considered prior to selecting potential survey participants. We also considered the structure of supply chains for major industry sectors. A

typical supply chain consists of multiple firms, both upstream stages (i.e. suppliers) and downstream stages (i.e. distribution), and the ultimate consumer (Mentzer, 2001).

Invitations to participate were sent via email to a sample of 2000 NZ based companies, with 207 shippers replying and completing all or almost all of the survey. Twenty four respondents did not complete the ranking questions and were excluded from analysis. Therefore, our sample for this study consisted of 183 respondents, with 146 firms from three different business divisions (primary/raw material providers, manufacturers, and wholesalers/retailers) and 37 freight agents. In this study, freight shippers are either the owner of goods or freight agents, such as freight forwarders, contracted carriers and 3PLs.

Of the 146 firms who responded, 48% were categorized as 'durable/non-food product' shippers, with 52% being classed as 'non-durable/food product' shippers. In terms of firm size, 56% of responding firms were SMEs (i.e. Small and Medium Enterprises, with 19 or fewer employees). New Zealand is the third smallest national market in the OECD, with a total national market which is equivalent in scale to only a medium sized urban market in the U.S.A. In terms of its accessibility to inter-national markets, New Zealand (NZ) is also one of the two most geographically isolated countries in the world (Shangquin et al. 2009). Table 1 shows the distribution of survey respondents among the various business types.

The questionnaire for this study distinguished between four different transport modes (road, rail, air, and sea) and two types of destinations (domestic and international). Not surprisingly, regardless of product types or business types, the most widely used mode of freight transport by NZ is road transport, followed by sea, air, and rail. Firms in the primary sector are the highest road transport users with the road transport share being 11% higher than for manufacturers. Figure 1 shows that mode shares change by business groups and with the volume of exports respectively. When the volume of exports increases, modal shares of non-road modes (especially sea and air) gradually increase.

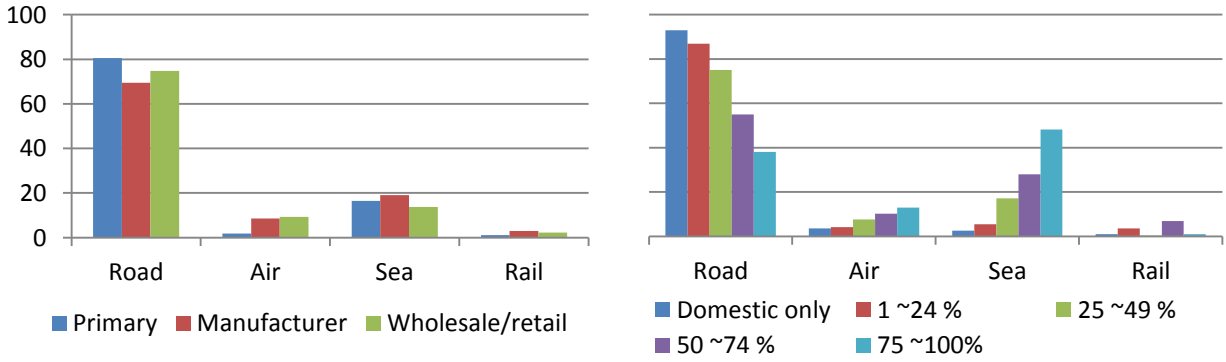


Figure 1 – (a) Mode Share by Business Division and (b) Export Volume

Often the shippers perceive there to be benefits in having a long contractual agreement with contracted carriers. When medium-long term contracts are offered by contracted carriers, shippers can get lower freight rates. Also, some contract carriers even offer dedicated equipment for a customer and tailor service to that customer. Longer term contracts also provide some security to the contract carriers to continue to provide and even increase

capacity. Survey responses also revealed that 86% of NZ firms have contracts with one to four trucking companies for over 10 years.

Rank-Ordered Logit Analysis for Mode Choice Preference

In the survey, respondents were asked to rank the importance of six factors in determining freight mode choice, from the factor they consider the most important to the one they consider the least important. These six factors were damage and loss, timeliness, cost, customer service, accessibility and suitability. A full description of the dependent variables is shown in Table 2.

Table 2 – Description of mode choice factors

Choice Factors	Code	Descriptions
Damage and loss	damg	Amount of loss and damage, processing of loss and damage claim
Timeliness	time	Transport time, transit time and on-time reliability
Transport cost	cost	Transport cost
Customer service	c_serv	Firm contact, after sale service and personal service
Accessibility	acces	Availability of mode or equipment at origin or destination
Suitability	suita	Suitability for shipment size, suitability for commodity to be carried

In practice with any paper-based or self-administered survey, respondents often assign the same rank to two or three items, but the on-line survey tools used for this study did not allow equal or tied rankings, thereby making the data analysis more straight-forward.

We analysed the rank data using a parametric statistical model, the rank-ordered logit model, and the PHREG procedure in SAS 9.2. This method takes advantages of the fact that when respondents rank a series of items, they provide more information about their preferences than when they simply select the most preferred item from the list. Parameter estimates provided by these models represent the differences in the log-odds of preferring a mode choice factor compared to an omitted factor, and so provide an estimate of the size of differences within a ranked list. Table 3 provides the maximum likelihood estimates from the rank-ordered logistic model with damage as a base category.

Table 3 – Maximum likelihood estimates from rank-ordered logit model

Choice Factors	Code	Estimate of coefficient (β)	Standard Error	Exponent of coefficient	Mean Rank
Timeliness	time	2.5328***	0.1577	12.588	**1.694**
Cost	cost	1.7987***	0.1461	6.042	**2.372**
Customer Service	c_serv	0.6411***	0.1329	1.898	**3.765**
Accessibility	acces	0.6301***	0.1348	1.878	**3.803**
Suitability	suita	-0.4621***	0.1412	0.630	**4.295**
Damage	damg	0.0000	0.0000	1.000	**5.071**
Wald Chi-square: 415.7886 DF:5 p<0.0001					

*** p<0.01

The Wald Chi-square statistic for the test of the global null hypothesis (H0: there are no choice differences in shippers' preference) for the overall model is 415.79 (with 5 degree of freedom), yielding a p-value much less than 0.0001, which means that NZ shippers, in general, have statistically significant different preferences among the six mode choice factors.

Also, all of the tests were significant with p-values less than 0.0001. The overall rank order results are largely consistent with the mean ranks, except for last two factors (suitability and damage). All of the factors contrast with the reference category, damage. On average, these estimates indicate that NZ shippers significantly rank timeliness, cost, customer service and accessibility ahead of damage in terms of important in considering mode choice factor, but ranked suitability lower than damage. The estimated factor coefficients can be interpreted as differences in log-odds. Thus, the exponent of the coefficient for timeliness ($e^{2.53275}$= 12.59) indicates that the odds of preferring timeliness are 12.59 times the odds of preferring the damage choice factor. Similarly, the odds of preferring cost, customer service, accessibility and suitability are 6.04, 1.90, 1.88, 0.63 times the odds of preferring the damage choice factor, respectively.

Rank-Ordered Logit Analysis for Mode Choice between Groups

The preceding model assumed that every respondent included in this study had the same probability distribution of mode choice preferences and that the observed differences in their rankings were due only to random variation. We now extend the model to capture the heterogeneity in mode choice preference across respondent's firm or individual.

The freight transport task in NZ is conditioned by many factors including the geography, topography, climate, and the pattern of natural resource distribution, as well as the resultant patterns of historical settlement and varying regional economic growth (Cavana et al., 1997).

NZ is a country greatly dependent on international trade, particularly in agricultural and horticultural products, fishing, forestry, and mining. Geographically, NZ encompasses two main islands, The North and South Islands. The two main islands are separated by a 30 kilometre wide channel, the Cook Strait, and the road and rail networks are connected by ferry services. NZ is remote from major international markets; the trade-route between Australasia and the west coast of the U.S. is about 8,000 miles and is one of the longest in the world (Byrne et al, 1994). Despite this, many industries are oriented towards exports, because of the small domestic market. In 2011, NZ has an estimated population of approximately 4.4 million. About 77% of the population lives in North Island and 32% of the country's population lives in the Auckland metropolitan area. The low and dispersed population density (16.5 people/km^2), combined with NZ's mountainous terrain and disconnected islands, makes transport systems less efficient and difficult to achieve *the economies of density* enjoyed by other countries.

In the modern supply chain environment, including the JIT (just-in-time) concept of lean production, the firms with integrated supply chains benefit from cost reductions and increased levels of reliability through reduced delivery lead times and improve inventory

turnovers, supplier reliability and maintainability. Integrated supply chains also give firms more competition strategy options by gaining bargaining power, for example, negotiating better transport rates with carriers or 3PLs (Basnet et al. 2000). As at 2009, 97% of firms in NZ were SMEs and the proportions have remained relatively constant over time. The small size of NZ firms makes it very difficult to include all components of the supply chain. Boehme et al. (2007) found that most NZ companies face higher uncertainty, with weakly integrated and inefficient supply chains. Due to the unique business environments, NZ firms are under pressure to lower logistics costs. The case study (Ministry of Transport, 2010) shows that NZ firms spend 8.4% of annual turnover on total logistics cost and its major components are the direct transport cost (about 60% for both international and domestic transport).

To address these issues, we included the attributes of the respondents in the model. The following six characteristics were included:

- A firm's size, represented by the number of employees
- A firm's supply chain management system
- Operations of logistics facilities
- Length of contract with transport service providers
- Volume of exports
- Average distance of domestic deliveries

To capture the effects of respondents' individual or firm characteristics on their preferences for mode choice factors, the products of each of the five factor dummies and each of these characteristic variables (i.e. independent variables) are included in the rank-ordered logit model. Table 4 presents the description of independent variables and coding.

Table 4 – Description of explanatory variables

Characteristic	Descriptions and coding
Size of Company	1 = A company has less than 19 employees (SMEs: Small and Medium Enterprises)
	0 = Over 20 employees
Integrated Supply Chain	1 = A company with integrated supply chain (vertical, horizontal)
	0 = Not integrated
Logistics Facilities	1 = A company does not have logistics facilities
	0 = A company has more than one logistics facilities (i.e. warehouses, trans-shipments facilities or distribution centre)
Length of Contract with Carriers	1 = A company has less than 3 years of contract with transport service providers or contracted carriers
	0 = Contract length of 3 or more years
Export Volume	1 = A company exports less than 50% of its production in 2010
	0 = Exports over 50% of its production in 2010
Transport Distance	1 = The average distance for the delivery of freight is less than 250 km or within Island
	0 = All over New Zealand (over 250 km)

Apparently, NZ shippers' preferences for factors in determining mode choice are significantly related to the firms' 'logistics' characteristics, such as the length of contract with transport service providers and operating logistics facilities. Table 5 shows that firms who have a

shorter length of contract with transport service providers are significantly less likely to choose the mode choice factors of cost, customer service, accessibility and suitability, when compared to those firms which have longer contracts with transport service providers.

Table 5 – The results of rank-ordered logit model for mode choice factors

Explanatory variables	Choice factors	Estimate of Coefficient (β)	Standard Error	X^2	Exponent of coefficient	$\%\Delta = 100(e^{\beta}-1)$
SMEs (< 19 employees)	time	0.1033	0.3507	0.0867	1.109	
	cost	0.3206	0.3239	0.9801	1.378	
	c_serv	-0.0039	0.2928	0.0002	0.996	
	acces	-0.1230	0.2988	0.1696	0.884	
	suita	-0.2183	0.3118	0.4904	0.804	
Supply chain Integration (integrated)	**time**	**0.6503***	**0.3491**	**3.4701**	**1.916**	**91.6**
	cost	**0.6717****	**0.3213**	**4.3691**	**1.957**	**95.7**
	c_serv	0.3424	0.2956	1.3420	1.408	
	acces	0.4867	0.3000	2.6315	1.627	
	suita	0.5113	0.3190	2.5699	1.667	
Logistics facilities (No facility)	time	-0.3593	0.3940	0.8318	0.698	
	cost	0.0888	0.3582	0.0614	1.093	
	c_serv	0.2733	0.3271	0.6979	1.314	
	acces	**-0.6600***	**0.3404**	**3.7591**	**0.517**	**-48.3**
	suita	**-0.7877****	**0.3424**	**5.2933**	**0.455**	**-54.5**
Length of Contract with Carriers (< 3 years)	time	-0.6555	0.4541	2.0834	0.519	
	cost	**-1.2319*****	**0.4374**	**7.9323**	**0.292**	**-70.8**
	c_serv	**-1.0909*****	**0.3962**	**7.5810**	**0.336**	**-66.4**
	acces	**-1.0403*****	**0.3966**	**6.8818**	**0.353**	**-64.7**
	suita	**-1.0686*****	**0.3907**	**7.4807**	**0.343**	**-65.7**
Export Volume (< 50 %)	time	-0.0043	0.3273	0.0002	0.996	
	cost	0.2617	0.3060	0.7315	1.299	
	c_serv	**-0.4033****	**0.2736**	**2.1741**	**0.668**	**-33.2**
	acces	0.6125	0.2842	4.6465	1.845	
	suita	-0.1250	0.2964	0.1779	0.882	
Transport Distance (<250 km; within Island)	time	0.4267	0.3436	1.5426	1.532	
	cost	0.3368	0.3214	1.0987	1.401	
	c_serv	0.0582	0.2941	0.0391	1.060	
	acces	-0.2098	0.2991	0.4920	0.811	
	suita	0.1938	0.3214	0.3635	1.214	

***p<0.01, **p<0.05, *p<0.10

NZ firms with an integrated logistics and supply chain are more likely to rank timeliness and cost ahead of damage in determining transport mode than the firms without such an integrated system, with the difference in the coefficients between integrated and non-integrated groups being 0.65 (p<0.10) for time and 0.67 (p<0.05) for cost. We may then say that the odds of firms with an integrated logistics and supply chain preferring time to damage are about 1.916 times, and cost to damage are about 1.957 times the odds for firms in the firms not with integrated system.

For the coefficient of the mode choice factors indicated as statistically significant, we computed $100(e^{\beta}-1)$, which is the percentage change in the odds in preferring that choice

factor over each explanatory group for each percentage increase in coefficient. Of the five mode choice factors in logistics facilities characteristics, parameter estimates for accessibility and suitability are statistically significant. The exponent value of the accessibility factor coefficient is 48.3, which implies that with each 1.0 increase in the coefficient of accessibility, the odds of preferring accessibility over damage goes down by 48.3%. Similarly the odds of preferring cost over damage go down by 54.5%.

The Wald test did not show that respondents' preferences are statistically significantly related to the firms' 'physical' characteristics or the size of firm, but these results indicate that SMEs are more likely than bigger firms to rank timeliness and cost ahead of damage. The results also not indicated how the 'geographical' characteristics of firms (i.e. the distance freight is typically shipped) affect mode choice. Although not statistically significant, the firms that transport products within a city or region are more likely to consider timeliness and cost very important (in deciding mode choice) than firms that transports products nationwide, with the odds being are 1.5 times higher for timeliness and 1.4 for cost.

The Probability of a Factor being Ranked as the Most Important

To further understand the effects of freight agents and firm's characteristics on mode choice preferences, we predict both the unconditional and conditional probabilities of a factor being ranked as the most important of the explanatory variables which have significant effects on respondents' ranking of factors.

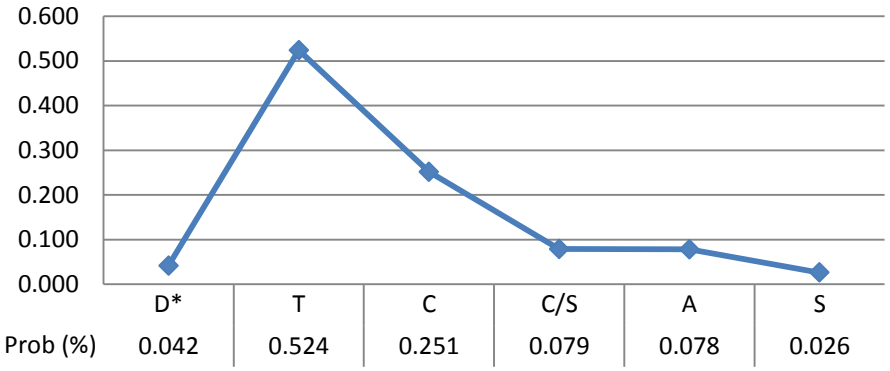
The unconditional probabilities are predicted by assuming all exogenous variables are constant; the conditional probabilities are obtained by assuming all exogenous variables, except the specified one, are constant.

As seen earlier, timeliness is most likely to be ranked as the most important factor followed by cost. We now use Eq. (4) to calculate the conditional probability of the timeliness factor being ranked as the most important.

$$Pr\left(U_{time} > U_j\right) = \frac{e^{V_1}}{\sum_{j=1}^{J} e^{V_j}} = 0.524$$

As shown in Figure 1, the probability of cost being ranked as the top factor is only 0.251, but it is still significantly higher than the probabilities for customer service (0.079), accessibility (0.078), damage (0.042), and suitability (0.026).

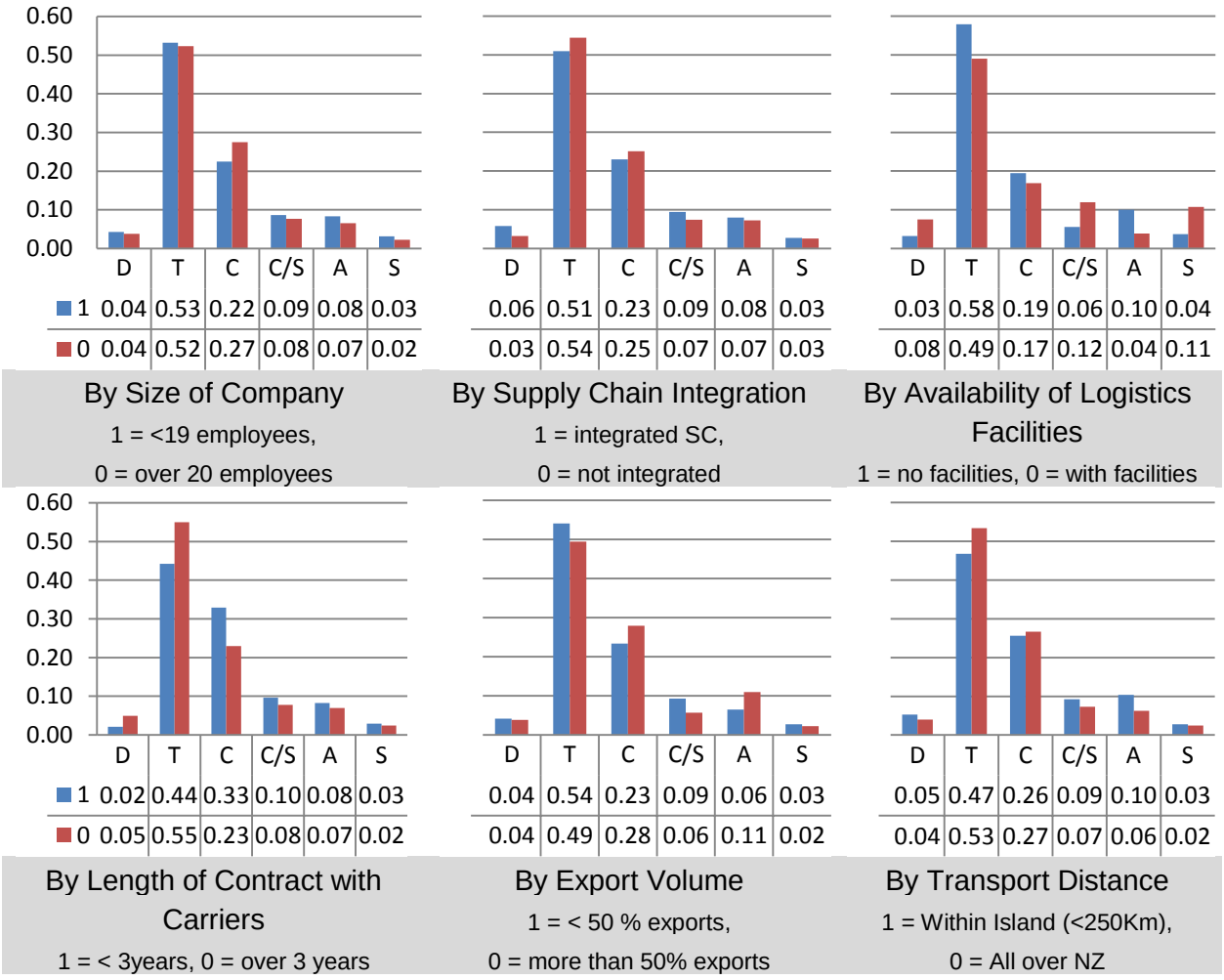
The probability of ranking a factor as the most important varies with the respondents' characteristics, as shown in Figure 2. Firstly, the probability of ranking timeliness as the most important in determining mode choice is 0.58 for the firms which do not have logistics facilities, 0.54 for the firms with non-integrated supply chains, and 0.53 for SMEs.



* D: Damage, T: Timeliness, C: Cost, C/S: Customer Service, A: Accessibility, S: Suitability

Figure 1 - Conditional Probability of ranking a factor first

Secondly, the firms with shorter contractual relationship with carriers or transportation services provider have a 10% to 16 % higher probability of ranking cost as the most important factor compared to other groups.



*D: Damage, T: Timeliness, C: Cost, C/S: Customer Service, A: Accessibility, S: Suitability

Figure 2 - Unconditional and Conditional Probability of ranking over all other alternatives

Thirdly, the firms with operating logistics facilities have the lowest probability of ranking cost as the most important factor. This group has a considerably higher probability of choosing other factors, such as customer service or suitability, than other groups.

Finally, it is shown that customer service and suitability are not highly important mode choice factors and are always ranked below timeliness and cost. However, damage and suitability is the least important consideration for the majority of NZ freight shippers.

CONCLUSIONS

This paper analyses how New Zealand shippers choose freight transport modes. Our findings show that timeliness and transport cost were the two most important factors for shippers' mode choices, while customer service, accessibility, suitability and loss and damage were distinctly less important. There is increased emphasis on timeliness and cost as mode choice factors, compared with previous studies, which found the most important factors were reliability and product care.

Shippers' factor preferences vary with their firms' supply chain integration, use of logistics facilities and length of contract with transport service providers. For example, firms with an integrated supply chain were more likely to rank timeliness and cost ahead of damage than firms which do not have such a production management system; firms with a shorter length of contract with carriers or transport service providers are least likely to rank cost, customer service, accessibility and suitability factors higher than damage.

The methodology applied to measure and analyse freight transport mode choice factors has implications for perceptions and assumptions about the quality of service characteristics of NZ freight transport modes and infrastructures. Using a parametric modelling technique to rank-order mode choice preferences, this study lends support to some qualitative findings in previous NZ freight studies. The results of this study provide quantitative measures of the intensity of preference for the various choice factors. For instance, it has been shown that timeliness, in addition to being the most important choice factor, has a probability of 52.4% of being ranked as the most important factor, with the odds of the mode choice being based on timeliness being 12.59 times the odds of the mode choice being based on the damage factor. Such quantitative information is very useful in identifying how shippers make trade-offs between conflicting objectives and factors when choosing between freight transport modes.

This study did not include the environmental factors as mode choice factors. During the pilot study phase, we interviewed practitioners across several industry sectors, and found NZ shippers were unlikely to consider environmental factors when choosing a freight transport mode. However, environmental impact should be considered in future research, as concerned about environmental sustainability increases.

This study was undertaken in preparation for a stated preference survey, to probe in greater depth how the various factors affect the trade-offs shippers make when choosing the mode

of transport for freight. The stated preference survey was conducted in late 2012, and analysis of the data and estimation of mode choice models is under way.

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