Freight Transport Modal Shift in NZ:
Building Understanding of Shippers' Mode Choice

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ABSTRACT

The main objectives of this study are to identify the constraints on shifting freight in New Zealand (NZ) from road to rail and/or coastal shipping, and to quantify the trade-off between factors affecting shippers' perceptions, to assist in increasing the share of freight moved by non-road transport modes. This was done by three logistic regression methods. The ranked logit results show that NZ shippers ranked transport time as the most significant constraint upon distributing goods by rail, while accessibility and load size were the most significant constraints upon using coastal shipping. The study also identifies how NZ shippers' modal shift constraints vary according to the firm's individual or logistical characteristics (e.g. their use of logistics facilities, lead time, and delivery distance). Mode choice models, consistent with econometric theory and based on transport cost, time, reliability and modal frequency, are developed. Multinomial logit (MNL) and mixed logit (ML) models are estimated, to identify the factors influencing the choice between road, rail and coastal shipping, for domestic inter-island freight flows. Finally, the models are used, with empirical data on transport cost, time and reliability, to estimate the effect (on mode split) of policies to alter the values of these variables.

1 INTRODUCTION

Many nations are considering rail and coastal shipping as a sustainable economic infrastructure to transport freight. Freight modal shift offers strong benefits in terms of environmental benefits, the lower energy consumption, the economies of scale, and the lower costs needed for infrastructure expansion (Perakis and Denisis, 2008). Freight modal shift is also identified specifically as an important element of the New Zealand Government’s goal to limit its greenhouse gas emissions to 50% of 1990 levels by 2050 (Ministry for the Environment, 2009).

In 2003, the European commission launched the Marco Polo programme, which aims to ease road congestion and the associated pollution, and to promote reliable and efficient transport of goods, by switching to greener transport modes, such as railways, coastal or deep sea shipping, and inland waterways (European Commission, 2009). The programme runs until 2013, with an annual grant budget of about €60 million. More than 500 companies have already successfully shifted freight from road to greener modes. The Marco Polo programme target is to free Europe's roads of 20 billion tonne-kilometres of freight per annum, the equivalent of more than 700,000 trucks a year travelling between Paris and Berlin. In the UK, £19m of funding was allocated to support intermodal shift to rail in 2011 and the same amount was recommended for the following two years (European Reference Center for Intermodal Freight Transport, 2010).

The decision-makers’ perception is a major input component in mode selection. A logit model is estimated using 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 logit model in transportation include Ben-Akiva et al. (1991), Bradley and Daly (1994), Odeck (1996), Fridstrom and Elvik (1997), Hunt (2001), Kockelman et al. (2006), and Srinivasan et al. (2006).

The first objective of the research described in this paper is to identify the perceived constraints on modal shift from road to rail or coastal shipping, as transport modes for domestic shipments in NZ. The ‘rank-ordered logit’ method, based on a ‘conditional logit’ model, was used with data from a 2011 revealed preference survey of 183 NZ freight shippers and agents, to identify modal shift drivers and constraints on mode choice change.

The second objective is to estimate a mode choice model, consistent with the economic theory of mode choice, based on data from 233 freight shippers and agents during a stated preference survey conducted in 2012. A multinomial logit model (MNL) and a mixed logit (ML) model are estimated, to identify the nature of the influence of factors affecting mode choice decisions for domestic freight flows, involving the movement between the North and South Islands of large shipments (i.e. minimum shipment size being a 20 foot container). The models assumed shippers had a choice of three modes; road, rail and coastal shipping. The third objective is to identify how changes in the cost, time and reliability of the three modes, are likely to affect mode split. This information would be useful in assessing the effectiveness of transport policy options for altering mode split.

The remainder of this paper is organised into sections. Section 2 describes three logistic models used in this study. Section 3 describes the estimation of a rank-ordered logit model, to identify the relative importance of various drivers and constraints affecting the choice of the road, rail and coastal shipping. Section 4 describes the estimation of a MNL model and ML model, for identifying how the probabilities of choosing the road, rail or coastal shipping are affected by various factors. Section 5 describes how the mode split is likely to change with changes in the cost, time and reliability factors, as a result of changes in transport and/or other policy. The final section summarises the results and their implications.

2 THREE LOGISTIC REGRESSION MODELS

The rank-ordered logit has been used extensively in marketing research. This model is an extended form of the conditional logit (CL) regression model introduced by McFadden (1974). 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 'rank-ordered logit model'. An alternative specification of the logistic regression model, based on random utility models 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 V_{ij} is a function of the attributes of the alternatives and the error component ε_{ij} is assumed to be independently identically distributed (IID), with an extreme value distribution, given by $Prob(\varepsilon_{ij} \leq t) = exp\{-exp(-t)\}$, and the probability of ranking j higher than k is given by $exp\{u_{ij} - u_{ik}\}$. McFadden's random utility model implies the following likelihood L_i for a single respondent. If δ_{ijk}=1 when $Y_{ik} > Y_{ij}$ and δ_{ijk}=0 otherwise, then

$$L_i = \prod_{j=1}^{J} \left[\frac{e^{V_{ij}}}{\sum_{k=1}^{j} \delta_{ijk} e^{V_{ij}}} \right] \quad (2)$$

It follows that the probability of item j being the most preferred item from the set J is

$$Pr(U_1 > U_2 > \cdots > U_j) = \frac{e^{V_1}}{\sum_{j=1}^{J} e^{V_j}} \quad (3)$$

which is the form of the classical MNL model. Because of the assumed independence from irrelevant alternatives (IIA) between the choices, the likelihood of a certain ranking of the alternatives in the entire choice set is thus the product of J logit probabilities (Allison and Christakis, 1994; Luce, 1959). This likelihood can be written as

$$Pr\big(U_1 > U_2 > \cdots > U_j\big) = \Pr\big(U_1 > U_j, = 2, \cdots, J\big) \bullet Pr\big(U_2 > U_j, j = 3, \cdots, J\big) \cdots \bullet Pr\big(U_{J-1} > U_J\big)$$

$$= \frac{e^{V_1}}{\sum_{j=1}^{J} e^{V_j}} \bullet \frac{e^{V_2}}{\sum_{j=2}^{J} e^{V_j}} \bullet \cdots \bullet \frac{e^{V_{J-1}}}{e^{V_{J-1}} + e^{V_J}} = \prod_{j=1}^{J-1} \left[\frac{e^{V_J}}{\sum_{m=j}^{J} e^{V_m}} \right] \quad (4)$$

Finally, 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. (4) implies a log-likelihood of

$$\log L = \sum_{i=1}^{n} V_{ij} - \sum_{i=1}^{n} \log[\sum_{k=1}^{j} \delta_{ijk} \exp(V_{ik})] \quad (5)$$

The MNL model assumes that the error components (of the utilities of the choice options) are independently and identically distributed, but this assumption is relaxed for the ML model, making the ML model more flexible. The ML model with random error component is

$$Pr(U_1 > U_j, j = 1, 2, \cdots, J) = \frac{e^{V_1 + \alpha}}{\sum_{j=1}^{J} e^{V_j + \alpha}} \quad (6)$$

3 MODAL SHIFT: DRIVERS AND CONSTRAINTS

During 2011, an on-line revealed preference (RP) survey was undertaken, and responses were received from 183 freight shippers. The survey asked shippers to rank factors in terms of how strongly they constrain mode choice and discourage the shippers from using rail or coastal shipping instead of road transport to move their goods. Respondents were asked to rank seven factors (Table 1) from one ('most important') to seven ('least important'). The results of that survey are described in Kim and Nicholson (2012).

TABLE 1. Mode-related factors constraining mode shift

Factors	Variable code	Descriptions
Transport time	time	Total transport time and on-time reliability
Accessibility	acces	Ease of reaching transport services
Frequency	freq	Frequency of service
Transport cost	cost	Total transport cost
Load size	load	Minimum load size requirement
Modal transfer	transf	Ease of road/rail, rail/road, road/sea & sea/road transfer
Door-to-door	dtod	Door-to-door service availability

The 183 respondents were asked to consider two options (shifting from road to rail, shifting from road to coastal shipping), and to rank the seven constraints. This gave a total of 2562 (=183×2×7) observations, or 1281 observations for each mode shift. Each of the 183 records included four types of data: (1) a unique identification number for the respondents; (2) the rank assigned by the respondent to that particular modal shift constraint; (3) a set of 6 dummy (or indicator) variables corresponding to 6 of the 7 different modal shift constraint (the 'base' or 'reference' factor, transport time, is omitted); (4) the 'socio-economic characteristics' of the firms.

First, a rank-ordered logit model was estimated, allowing for differences between the seven modal shift constraints but no differences between respondents. That is, it was assumed that every respondent in the study had the same probability distributions for the modal shift constraints and that the observed differences in the rankings were due only to random variation.

The statistical software SAS® was used to estimate the rank-ordered logit model. Table 2 shows the maximum likelihood estimates of the coefficients for each constraint, for the two mode change options. It should be noted that transport time is the 'base' (or 'reference') constraint, and is assigned a coefficient of zero, with the coefficients for the other constraints being either positive or negative. The coefficients, along with the standard errors of estimation, indicate whether the constraint has a statistically significant effect.

TABLE 2. Rank-ordered logit model: coefficients of mode-related variables

	Variables	Coefficient Estimates	S.E.	Exponents of Coefficients	Mean Rank	Model Statistics
Rail	Transport time	0.000	0.000	1.000	2.901	Wald χ^2: 109.56, DF:6, p<.0001, Number of observation = 1281
	Accessibility	-0.250*	0.133	0.779	3.461	
	Loading size	-0.462***	0.142	0.630	3.532	
	Door-to-door	-0.901***	0.150	0.406	3.915	
	Transport cost	-0.972***	0.142	0.379	4.596	
	Modal transfer	-1.196***	0.148	0.303	4.766	
	Frequency	-1.052***	0.142	0.349	4.830	
Coastal shipping	Loading size	-0.056	0.153	0.946	2.944	Wald χ^2: 158.91, DF:6, p<.0001, Number of observation = 1281
	Accessibility	0.139	0.143	1.149	2.968	
	Transport time	0.000	0.000	1.000	3.056	
	Frequency	-0.803***	0.148	0.448	4.544	
	Transport cost	-0.940***	0.154	0.391	4.600	
	Door-to-door	-1.382***	0.167	0.251	4.824	
	Modal transfer	-1.167***	0.156	0.311	5.064	

***p<.01, **p<.05, *p<.10

The overall statistical significance of the model can be assessed using the Wald chi-square statistic, and it was found that this was 109.56 for shifting from road to rail and 158.91 for shifting from road to coastal shipping, with 6 degrees of freedom in both cases. The null hypothesis is that all the explanatory variables have the same ranking or importance, but this hypothesis can be rejected at the 0.01% significance level (or 99.99% confidence level), given the very large values of the Wald chi-square statistics. There is very strong evidence that NZ freight shippers have statistically different rankings for the seven modal shift constraints.

On average, NZ shippers rank transport time as the greatest constraint upon freight modal shift from road to rail, with modal transfer and frequency being ranked much lower. These results are largely consistent with the mean ranks shown in Table 2. However, while not statistically significant, NZ shippers rank accessibility 1.149 times as important as transport time, as a constraint on modal shift from road to coastal shipping, and apparently do not feel constrained by transport cost and ease of modal transfer between road and coastal shipping.

Table 2 shows the mean ranks across respondents for each explanatory variable. While the average mean rank is 4, as expected, it can be seen that the mean rank orderings are not the same for the two mode shift options (i.e. the relative importance of a constraint factor depends upon which mode shift is being considered). The exponent of the coefficient for each constraint factor can be used to identify the odds of the constraint factor being ranked lower (i.e. less important) or higher (i.e. more important) than the 'base' (or reference) constraint factor, transport time. It should be noted that a decrease in the odds means an increase in the probability; the probability of occurrence of an event with odds of 'two to one' is twice the probability of occurrence of an event with odds of 'four to one'.

The next stage was to identify the effects of characteristics of the firms, in addition to the effects of the seven above-mentioned factors relating to the transport modes. Six extra 'dummy' variables were included in the rank-ordered logit model shown in Table 3.

TABLE 3. Firm-related factors constraining mode shift

Characteristic	**Descriptions and coding**
Modal Shift Decision-maker	1 = 'Top' managers (e.g. CEOs, Managing Director)
	0 = Other staffs
Export Volume	1 = Exported less than 50% of its produce in 2010
	0 = Exported 50% or more of its produce in 2010
Transport Distance	1 = Average freight delivery distance less than 250 km and within-island
	0 = Average freight delivery distance more than 250 km and NZ-wide
Logistics Facilities	1 = Does not have logistics facilities (e.g. warehouses, distribution centre)
	0 = Has logistics facilities
Lead-time	1 = Order-to-shipping lead time policy of not exceeding 1 month
	0 = Lead time exceeds 1 month
Length of Contracts	1 = Length of contract with transport carriers not exceeding 3 years
	0 = Over 3 years

The maximum likelihood estimates associated with the firms' characteristics from the rank-ordered logistics model, with transport time as the 'base' category, are shown in Table 4.

It can be seen from Table 4 that for firms considering shifting from road to coastal shipping:

1. modal transferability and door-to-door capability are significant factors if the decision-maker is a high-level manager;
2. cost is a significant factor if the firm exports 50% or more of its production;
3. door-to-door service is a significant factor if the transport distance is short;
4. load size, transferability and door-to-door service are significant factors if the firm does not operate logistics facilities;
5. accessibility to the port is a significant factor if the lead time is less than one month;
6. frequency and cost are significant factors if the firm does not have contracts (with carriers) exceeding three years.

It can also be seen from Table 4 that for firms considering shifting from road to rail transport:

1. load size, modal transferability and door-to-door capability are significant factors if the decision-maker is a high-level manager;
2. frequency, load size and door-to-door service are significant factors if the firm exports 50% or more of its production;
3. cost is a significant factor if the transport difference is short;
4. frequency, load size and door-to-door service are significant factors if the lead time is less than one month.

5. none of the mode-related variables has a statistically significant interaction with two of the firm related variables, ‘length of contract with carriers’ and (the presence of) ‘logistics facilities’.

TABLE 4. Rank-ordered logit model: coefficients of mode and firm-related variables

Firm-related Variable	Mode-related Variable	Coastal shipping			Rail		
		Coefficient Estimates(β)	Standard Errors	Exp(β)	Coefficient Estimates	Standard Error	Exp(β)
Modal Shift Decision Maker	acces	-0.069	0.396		0.291	0.362	
	freq	-0.491	0.407		0.229	0.393	
	cost	-0.045	0.425		0.073	0.390	
	load	-0.270	0.420		0.846**	0.390	2.33
	transf	0.712*	0.429	2.04	0.820**	0.403	2.27
	dtod	0.854*	0.464	2.35	1.186***	0.416	3.27
Export Volume	acces	-0.125	0.294		0.398	0.275	
	freq	0.006	0.307		0.581*	0.297	1.79
	cost	-0.947***	0.312	0.39	0.256	0.296	
	load	0.284	0.314		0.928***	0.295	2.53
	transf	-0.044	0.323		0.220	0.308	
	dtod	0.294	0.350		1.292***	0.319	3.64
Transport Distance	acces	0.012	0.329		0.314	0.295	
	freq	0.110	0.337		-0.040	0.319	
	cost	0.098	0.353		0.619**	0.310	1.86
	load	-0.212	0.353		-0.031	0.312	
	transf	-0.251	0.365		0.221	0.326	
	dtod	-0.837**	0.406	0.43	-0.307	0.336	
Logistics Facilities	acces	-0.607*	0.366	0.54	0.111	0.324	
	freq	-0.476	0.386		0.283	0.345	
	cost	-0.225	0.389		0.078	0.346	
	load	-0.936**	0.391	0.39	-0.405	0.353	
	transf	-0.913**	0.417	0.40	-0.278	0.373	
	dtod	-1.402***	0.462	0.25	-0.143	0.375	
Lead-time	acces	0.981**	0.481	2.67	-0.374	0.462	
	freq	0.830	0.529		-0.907*	0.536	0.40
	cost	-0.576	0.505		0.229	0.478	
	load	0.608	0.520		-0.842*	0.493	0.43
	transf	0.332	0.529		-0.288	0.517	
	dtod	0.546	0.570		-1.447**	0.563	0.24
Length of Contracts with Carriers	acces	0.453	0.321		0.214	0.303	
	freq	0.746**	0.331	2.11	0.246	0.321	
	cost	0.692**	0.348	2.00	-0.126	0.321	
	load	-0.061	0.343		0.140	0.320	
	transf	0.393	0.353		0.154	0.338	
	dtod	0.291	0.375		-0.197	0.338	

***p<.01, **p<.05, *p<.10

In general, the higher the position of the person who makes transport mode choice decisions in a firm, the greater the importance attached to modal transferability and door-to-door capability of both rail and coastal shipping. NZ shippers’ ranking of factors, when determining whether to shift from road to coastal shipping, is strongly related to the firms’ logistics characteristics, such whether they operate warehouses, transhipment facilities and other logistics facilities. For firms considering whether to shift from road to rail transport, however, the firms' lead time policies are more important.

As mentioned before, the exponential values can be interpreted as the odds of ranking mode choice factors over transport time (the reference factor). For example, in rail, the exponent of the coefficient of the door-to-door factor, for a firm with low export volume, is 3.64, indicating that the odds of ranking the door-to-door factor are 3.64 times the odds of ranking transport time.

4 MODE CHOICE MODELLING

The 2012 on-line stated preference (SP) survey was developed using:

1. the results from the 2011 Revealed Preference (RP) survey;
2. information about similar surveys overseas;
3. comments from freight industry professionals in NZ.

Several designs were tested via thorough pre-test piloting with industry and academic professionals, with an orthogonal factorial design being selected, to reduce the number of choice scenarios to eighteen.

The questionnaire was divided into three parts. The first part included three questions and aimed to identify respondents' freight transport patterns in terms of business types (e.g. manufacturers, wholesalers and retailers), typical transport distance and size of shipments. In the second part, respondents were asked to answer eighteen choice questions, based upon the characteristics of the respondent's typical freight movement task (based on the typical length and size of their freight movements). The respondents were divided into four groups based upon the typical transport distance and size of shipments (see Figure 1).

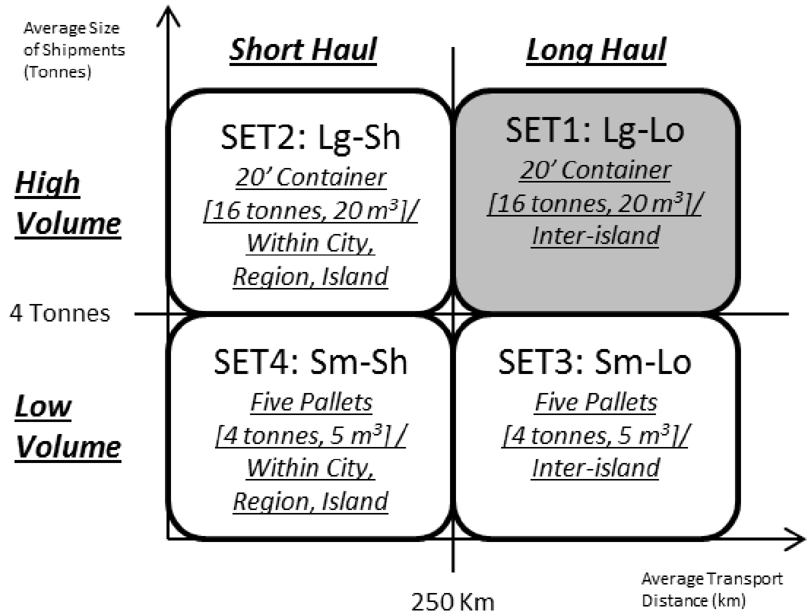

FIGURE 1. Respondent grouping system

Note that a 20-foot container (20 feet long, 8 feet tall) can typically hold 9-11 pallets. Note also that the distance and size thresholds were determined from an analysis of the shipping patterns of the 183 respondents to the RP survey.

A range of empirical studies on freight mode choice (Gilmour, 1976; McGinnis, 1990; Murphy and Daley, 1994; Murphy and Hall, 1995; Evers et al., 1996) indicated that the transport decision is typically affected by reliability, transport cost and time. In addition, it has been found (Richard Paling Consulting, 2008; Rockpoint, 2009; Kim and Nicholson, 2012) that the key drivers of freight mode choice of NZ shippers' are timeliness and cost. The RP survey (Kim and Nicholson, 2012) revealed that the low frequency of rail and coastal shipping were more often mentioned as discouraging factors by freight agents than by shippers. Hence, the SP survey choice questions involved varying the four main mode attributes (transport time, cost, reliability and service frequency) for rail and coastal shipping, and an example of the choice questions in the SP survey is shown in Figure 2. In addition, the responses of shippers and freight agents were analysed separately.

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In this section, we would like to know how you would react if the transportation modes for your freight were as described below. You will be select one of the three freight transportation options.

The conditions may be very different from what you currently face, they are imaginary. Keep in mind that conditions on your current mode may change in the future.

E1~2: You are responsible for sending a ***20 foot container [16 tonnes, 20 m^3]*** (NZ$20,000 value of cargo) of products from the nearest warehouse of your company to the customer's warehouse located in ***inter-island location***[*e.g. Auckland (your firm) --> Christchurch (customer), The service provided is **door-to-door***].
Given the characteristics of the carriers, please select which of the following options would you choose for this shipment.

Transport options	**By truck**	**By truck & coastal shipping**	**By truck & rail**
Price($ NZ)	**$3766**	**$1533**	**$1897**
Expected Transport Time	**24 hours** (1 day)	**72 hours** (3 days)	**36 hours** (1.5 days)
On-time Reliability*(%)	**100 %**	**80 %**	**85%**
Service Frequency	**Anytime**	**5 per WEEK**	**2 per DAY**

*(Probability of arriving within a given transport time)

○ **By truck** ○ **By truck & coastal shipping** ○ **By truck & rail**

FIGURE 2. Example of a choice questionnaire from the stated preference questionnaire

Finally, the third part of the SP survey included eight questions relating to characteristics of the firm, including business type, product types, transport distance, number of owned trucks, number and duration of contracts with transport service providers. Kim and Nicholson (2012) found that such factors affect mode choice. Table 5 presents the full set of factors (commonly called attributes in choice theory) and levels for the SP survey. Note the increase in the number of firm-related factors (or socio-economic attributes).

The sampling and on-line survey procedures for the SP survey were similar to those for the RP survey (Kim and Nicholson, 2011). The survey yielded 233 usable responses from shippers and agents (i.e. nearly 30% more responses than for the RP survey). Among the responses, there were 46 usable responses from shippers whose business involves large shipments over long distances. Their responses to the 18 questions yielded a total of 828 observations, with which to estimate both MNL and ML models.

Due to the space limitation, this paper describes only the MNL and ML models obtained for shippers whose business involves large shipments over long distances between islands. MNL and ML models have also been developed for shippers and agents separately, for the other combinations of distance and load size.

TABLE 5. Attributes, levels, and corresponding variables

	Attributes	Definition	Levels	Unit
Attributes used in choice set	COST	Door-to-Door transportation cost	Truck:$3766 (fixed cost) Coastal shipping:$1533~$2044 Rail:$1897~$2609	$NZ
	TIME	Door-to-Door transportation time	Truck:24 hrs (fixed time) Coastal shipping:72~96hrs Rail:36~60 hrs	Hours
	RELIAB	Ontime reliability*	Truck:100 % (fixed) Coastal shipping:80~90% Rail:85~95 %	%
	FREQ	Service frequency	Truck:Anytime (fixed) Coastal shipping:5~7/week Rail:2~4/day	#/Day
Socio-economic attributes	EMP	Number of employee		Persons
	SLIFE	Shelf life of products		Days
	EVOL	Percentage of exports		%/year
	NTSP	Number of transport survice providers		Number
	LTSP	Length of contract with transport service providers		Years
	DTOPORT	Distance to seaport		Km
	DTORAIL	Distance to railhead		Km
Non-attribute	ASC	Alternative specific constants**		ASC

* The probability of arriving within a given transport time, **Coastal shipping and Rail

The MNL model is widely used for mode split prediction for passenger transport, but does not appear to have been used in NZ for freight transport. In this study, both the MNL and ML models were estimated using the data from the SP survey, using the NLOGIT 5.0 statistical software, with separate utility functions for each mode (road, rail and coastal shipping). Estimates of the coefficients of the attributes and variables are shown in Table 6, along with definitions of those attributes and variables.

Economic theory provides some guidance in terms of the expected signs of several of the coefficients, and it can be seen that most of the coefficients have the expected sign and are statistically significant. The coefficients of the cost and time variables are negative, indicating that alternatives with higher cost and longer transport time are less likely to be chosen. In addition, the coefficients of the reliability and frequency variables are positive, as expected, as shippers are expected to favour choosing modes with higher reliability and higher service frequency. However, these coefficients are not statistically significant determinants of mode choice in this specific case (large shipments and long distances), but they are statistically significant for other cases. They are also statistically significant the case of large shipments and long distances, when the socio-economic terms in the model are removed, consistent with the finding of Ortuzar and Willumsen (2001).

TABLE 6. Parameters of MNL and ML models

		Multinomial Logit Model			**Mixed Logit Model**		
Random Parameter in Utility Functions	Attributes	Coefficient	t-value	p-value	Coefficient	t-value	p-value
	COST	-0.002***	-6.70	0.000	-0.002***	-4.47	0.000
	TIME	-0.020***	-2.88	0.004	-0.025***	-2.62	0.009
	RELIAB	0.020	1.21	0.225	0.019	0.95	0.342
	FREQ	0.036	0.96	0.335	0.043	0.98	0.329
Non-Random Parameter in Utility Functions	ASC_CS	-4.451***	-4.16	0.000	-5.776***	1.98	0.048
	ASC_RAIL	-3.976***	-4.31	0.000	-4.939***	-3.43	0.001
	EMP	-0.171**	-2.44	0.015	-0.287**	-2.11	0.035
	SLIFE	0.397***	4.01	0.000	0.582***	3.05	0.002
	EVOL_CS	0.686***	7.81	0.000	1.051***	3.55	0.000
	EVOL_RAIL	0.425***	4.59	0.000	0.722***	2.97	0.003
	LTSP	0.143**	2.30	0.021	1.409***	3.23	0.001
	DTOPORT	0.222***	3.94	0.000	0.275***	3.20	0.001
	DTORAIL	0.109**	2.05	0.040	0.110*	1.67	0.094
Standard Deviation of Parameter Distributions	COST				0.003**	2.21	0.027
	TIME				0.008	0.10	0.917
	RELIAB				0.031	0.11	0.914
	FREQ				0.186	0.59	0.558
Model Statistics	Log Likelihood			-507.550	-505.115		
	McFadden *Pseudo-* R^2			0.1383	0.2018		
	AIC			1041.1	1044.2		
	Observations			828	828		

***p<.01, **p<.05, *p<.10

In terms of socio-economic values interacting with mode choice attributes, in general, three major groups of respondents (firms with a high proportion of their products being exported, firms with products with a longer shelf life, and firms located close to a seaport or railway) are more likely to choose coastal shipping or rail instead of road. Shippers involved in exporting tend to choose coastal shipping instead of rail, as evidenced by the coefficients for EVOL_CS and DTOPORT being larger than the coefficients for EVOL_RAIL and DTORAIL, respectively. This is likely to be because there is one less modal transfer involved if rail is not used.

Both the alternative specific constants (ASC), which represent the mean of the distribution of the unobserved effects, are negative and statistically significant. The negative signs of the ASCs indicate that, ceteris paribus, the effect of excluded variables is to make road transport more attractive than rail and coastal shipping, for large shipments moving long distances within NZ. It also indicates what might be called ‘status quo bias’.

Regarding the relative merits of the MNL and ML models, the model statistics indicate that the ML model is better than the MNL model. Note that the lower the ‘log likelihood’ and the

'AIC' statistics, and the higher the McFadden 'Pseudo-R^2', the better the model. There is little difference in the values of the 'log likelihood' and the 'AIC' statistics, but the McFadden 'Pseudo-R^2' is higher for the ML model than for the MNL model.

5 POLICY IMPLICATIONS

Due to the environmental and social benefits of rail and coastal shipping compared to road, many countries are adopting policies to induce a modal shift. Some transport policies (e.g. higher fuel taxes or road user charges) are used by governments to directly suppress increases in the use of road transport. An alternative approach is to indirectly suppress increases in road transport (e.g. subsidising transport by rail or coastal shipping, as in the case of the Marco Polo programme (European Commission, 2009), and/or improving the infrastructure associated with rail and coastal shipping, to reduce the total transport time and increase reliability.

The sort of mode choice models described in this paper can be used to estimate the change in mode choice for a change in one or more of the mode choice attributes. Table 7 presents the mode share findings from previous studies in NZ and an estimate of the base (or current) mode shares from this study, using the MNL and ML models. Note that estimating mode shares is quite difficult, due to the large variations between sources of aggregate-level data. It is therefore not surprising that the estimated mode shares from previous NZ freight studies (Bolland et al., 2005; Richard Paling Consulting, 2008; Rockpoint, 2009) were inconsistent.

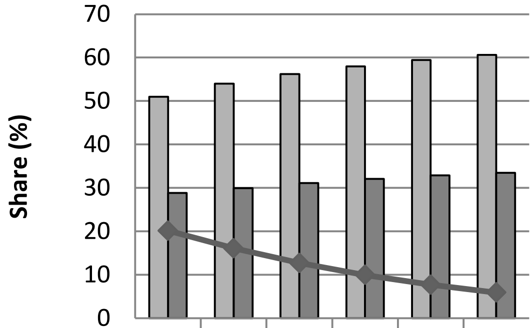
TABLE 7. Estimated current mode shares for inter-island domestic freight movement

		Road	**Coastal Shipping**	**Rail**
Richard Paling Consulting (2008): Inter-island		12.4%	56.8%	30.8%
Rockpoint (2009) : Auckland – Christchurch		19.0%	38.0%	43.0%
This study	MNL model: Inter-island	20.1%	51.0%	28.9%
	ML model: Inter-island	34.2%	44.5%	21.3%

Note that the mode shares for inter-island freight movements are approximate, and have been derived using the Richard Paling Consulting (2008) O/D matrix. Also, the estimated mode shares on the Auckland to Canterbury route have been derived from Rockpoint (2009). It can be seen (Table 7) that the estimated current mode shares from the MNL and ML models indicate that the MNL model predictions are generally better aligned with the results of the earlier studies, and the MNL model has consequently been used for estimating the effects of changes in transport costs, times and reliabilities.

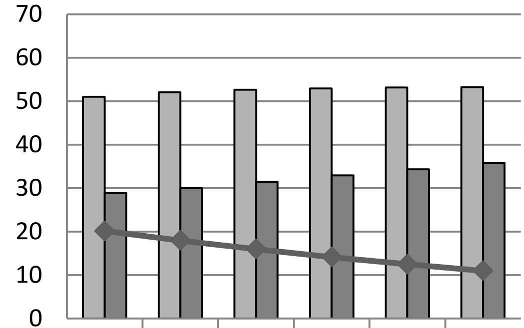
The change scenarios all favour greater use of rail and/or coastal shipping. The scenarios include: (1) increasing the road transport cost; (2) decreasing coastal shipping and rail transport costs; (3) decreasing coastal shipping and rail transport time; (4) increasing coastal shipping and rail transport reliability. Figure 3 shows the estimates of mode splits for incremental implementation of the four change scenarios.

It can be seen that increasing the road transport cost yields the largest increase in the mode share for coastal shipping, and the largest decrease in the mode share for road transport. On the other hand, decreasing coastal shipping and rail costs yields a larger increase in mode share for rail than for coastal shipping.



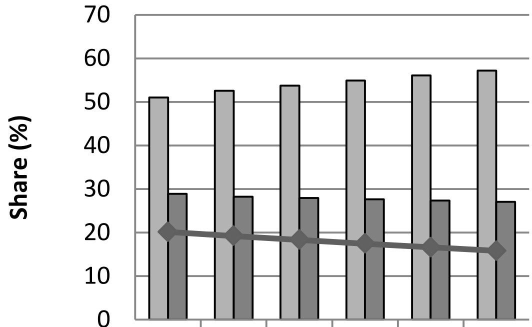
	Base	5%	10%	15%	20%	25%
Sea	51.00	53.99	56.18	57.97	59.43	60.59
Rail	28.86	29.91	31.11	32.09	32.88	33.50
Road	20.14	16.09	12.71	9.94	7.69	5.91

Scenario 1 :
Increase Road Cost



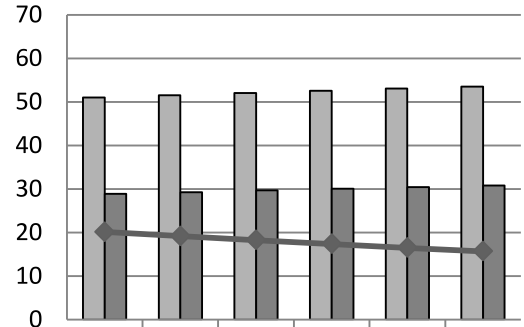
	Base	5%	10%	15%	20%	25%
Sea	51.00	52.07	52.59	52.95	53.16	53.22
Rail	28.86	29.96	31.43	32.90	34.35	35.79
Road	20.14	17.97	15.98	14.15	12.49	10.99

Scenario 2 :
Decrease Coastal shipping & Rail Cost



	Base	5%	10%	15%	20%	25%
Sea	51.00	52.57	53.74	54.90	56.05	57.19
Rail	28.86	28.21	27.94	27.65	27.34	27.02
Road	20.14	19.22	18.32	17.45	16.61	15.80

Scenario 3 :
Decrease Coastal shipping & Rail time



	Base	5%	10%	15%	20%	25%
Sea	51.00	51.55	52.07	52.57	53.05	53.50
Rail	28.86	29.27	29.68	30.07	30.45	30.82
Road	20.14	19.18	18.25	17.36	16.50	15.68

Scenario 4 :
Increase Coastal shipping & Rail reliability

FIGURE 3. Policy implications and modal shift estimations

If rail and coastal shipping times are reduced, the mode share of coastal shipping is expected to increase, while the mode share of rail (and road) transport is expected to decrease; the decrease in rail's mode share is counter-intuitive, and underlines the complexity of the problem of estimating the effects of change scenarios. It can be seen that increasing the reliability of coastal shipping and rail transport is expected to result in only small increases in their mode shares.

It is worth noting that the mode share for road transport declines most when the cost of road transport is increased. This suggests that road transport users are more sensitive to dis-incentives (i.e. 'sticks') than they are to incentives to switch to other modes (i.e. 'carrots').

This result is consistent with the findings of Nicholson and Laird (1995), who found that staff and students at the University of Canterbury were more likely to reduce their travel to/from the University by car if car parking charges were to be implemented, than if a high quality public transport service were to be implemented.

6 CONCLUSIONS

This paper has identified what freight shippers in NZ perceive as constraints on modal shift from road to rail or coastal shipping as transport modes for domestic shipments. Seven perceived constraints have been analysed using a parametric statistical method, the rank-ordered logit model. Our findings show that, on average, NZ shippers rank transport time as the highest modal shift constraint for moving goods by rail, followed by accessibility, with modal transfer to/from road and service frequency ranking much lower. With shifting to coastal shipping, however, shippers rank accessibility higher than transport time as a constraint. That is, the rank ordering of constraint factors depends upon whether one is considering shifting to rail or coastal shipping.

It has also been found that NZ shippers' rank ordering of the constraint factors, when considering a shift to coastal shipping, is strongly related to the firms' logistics characteristics, such as whether they operate warehouses, transhipment facilities and other logistics facilities. When considering shifting to rail, however, the firm's lead time policy is the firm-related characteristic with the greatest influence.

Multinomial logit (MNL) and mixed logit (ML) models have been estimated, to identify the magnitude of the effects of the factors influencing the choice between road, rail and coastal shipping for domestic inter-island freight flows. The models have revealed that:

- for shippers, sending large shipments long distances (between islands) are more sensitive to cost and time than reliability and frequency;
- firm-related factors (or 'socio-economic attributes') interact with the mode-related choice attributes, with three major groups of respondents (firms that are 'export-oriented', firms whose products have a longer shelf life, and firms located close to a seaport or railway) more likely to choose coastal shipping or rail transport rather than road transport.

In addition, firms with a high proportion of products being exported, and are located close to a seaport or railway, prefer coastal shipping over rail transport, while firms with long-duration contracts with road transport service providers are less likely to shift to rail or coastal shipping.

The results of the mode choice modelling provide quantitative measures of the intensity of preference for the various mode choice factors. Such quantitative information is very useful in identifying how shippers make trade-offs between conflicting objectives and factors when choosing between freight transport modes.

Four change scenarios were tested with the MNL mode choice model to estimate the effect on the modal split. It was found that an increase in the cost of road transport has the greatest effect, with a substantial shift from road transport to rail and coastal shipping, the coastal shipping share increasing by about twice as much as the rail transport share. However, the modelling indicates that a decrease in the cost of rail and coastal shipping will result in almost all the freight mode shift being to rail, with the coastal shipping share increasing only very slightly, while increasing the reliability of both rail and road transport is expected to have little effect on mode split. In addition, if the times for both rail and coastal shipping are reduced, the modal share of road transport declines (as expected), the modal share of coastal shipping increases (as expected), but the modal share of rail decreases (not as expected). The results of the scenario testing highlight the complexity of the interaction between the factors influencing freight mode choice.

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