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NZ TRANSPORT AGENCY

Valuing freight transport time and reliability

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Executive summary

Overview

This report presents the results of research into the willingness to pay (WTP) of shippers of freight (consignors or other freight payers) in New Zealand for improvements in expected journey time, reliability of journey times, frequency of services and loss/damage to freight in transit. The research focused on a stated preference (contingent valuation) survey of New Zealand freight shippers. It also included an extensive international literature review of evidence on the WTP of freight shippers and a more detailed appraisal of previous work undertaken in New Zealand.

Knowledge gap

All transport initiatives in New Zealand requiring funding contributions from government (at any level) are subject to assessment of their expected impacts using procedures set out in Waka Kotahi NZ Transport Agency's *Economic evaluation manual* (EEM). These procedures are based on social cost-benefit analysis (CBA) methods, which are intended to cover the scheme's expected costs (capital and operating) and the anticipated benefits to transport system users (persons and freight). However, while the present EEM evaluation procedures cover all benefit categories for person travel (eg expected travel time, reliability of travel time, service frequency for public transport users), for freight transport they do not cover the equivalent benefits to freight shippers.[1] This project was commissioned to fill this knowledge gap.

International literature review

The project involved an extensive review (of over 150 publications) of international research studies into WTP-based valuations of the land freight sector (principally road/truck and rail transport) for changes in freight transport journey characteristics – principally expected journey time, variability (reliability) of journey times, frequency of services and loss/damage to freight in transit. The various studies related to a very wide range of situations and commodities (particularly those likely to be most sensitive to travel time and reliability changes), and they also applied a wide variety of analytical methods. Unsurprisingly, even when suitably segmented (eg by commodity group), the studies showed a very wide range of results in terms of WTP values. Given this, the international review results were of limited use as a cross-check on values from New Zealand-specific market research.

Previous New Zealand research

One previous New Zealand-based research project focused on freight shipper WTP for changes in domestic freight service attributes (Kim 2014). This project covered only the general freight sector (retail and manufacturing), as being the sector most sensitive to journey time and reliability changes (with implications for transport pricing and modal choice of commodity movements in the sector).

[1] With one minor exception, relating to stock-holding costs for freight in transit.

Kim's research project used stated preference (choice modelling or choice experiment set) methods to estimate values of time, reliability and service frequency for less than container load (LCL) and full container load (FCL) freight movements, for shorter and longer distance categories – this resulted in a 2 * 2 matrix of values per consignment per unit change in the relevant attribute.

Project market survey

Survey scope and delivery

The centrepiece of our research was a comprehensive survey of the New Zealand domestic freight market, with a focus on deriving shippers' WTP for changes in expected freight travel time and its reliability, for all segments of the market.

Survey scope. This survey comprised six main sections:

- contextual questions
- commodity and freight movement information
- information on modes used and reasons for choice of mode and carrier
- attributes of existing services – including relative importance of different attributes (eg price, expected journey time, reliability)
- WTP for potential changes to the current journey attributes (refer further details below)
- other comments (open-ended).

Sampling approach. An 'opportunity sampling' approach was taken, with a sample largely derived from the researchers' own knowledge and contacts, and with the aim of covering a high proportion of all domestic freight movements. The interviewees were mainly shippers (ie consignors or consignees of the freight to be moved). A small number of interviews with freight transporters were also included.

The survey covered transport only within New Zealand, including the domestic legs of import/export movements. It primarily covered movements by road and rail.[2]

Survey delivery method and responses. Following piloting of the draft survey, it was decided to undertake the main survey through personal (phone-based) interviews. Each interview took between 20 and 60 minutes, depending largely on the complexity of the respondent's freight business. The interviews were undertaken by a member of the consultancy team with excellent knowledge of the New Zealand freight sector, thus helping to ensure high response rates of a high quality.

Fifty-nine completed responses were received, a response rate of 72% of those approached. In total, the respondents were responsible for an annual freight task of some 54 million (net) tonnes, which was about one-quarter of total New Zealand annual domestic freight tonnage and one-third of the corresponding tonne-km.

Freight market segmentation. The survey obtained information on the respondents' current freight movements, using a two-way segmentation of the market, by:

- five commodity groups

[2] A small proportion of New Zealand domestic freight movements are by coastal shipping. These were not specifically sought out in the survey but were included where they were part of movements also using road and/or rail modes.

- three distance bands (local, inter-regional, inter-island)[3].

Detailed information was obtained for (up to) the four largest commodity segments (ie commodity group by distance band) for each respondent. In total, this information was obtained for 143 commodity segments from the 59 respondents.

New Zealand freight market characteristics

The survey responses provided extensive information on the key characteristics of the respondent freight task by commodity segment. This information was aggregated to provide a good picture of New Zealand's overall domestic freight market, covering such characteristics as:

- relative sizes of freight task by commodity group and distance band
- survey proportions of total market by commodity group (using the results of an earlier national study of freight commodity movements)
- total freight transport expenditures and relationships to freight tonnage and tonne-km carried
- transport price versus distance relationships for each commodity group
- relationships between domestic transport prices and commodity values
- characteristics of the size of the transport task by mode and distance (road versus rail)
- factors affecting mode choice and carrier choice
- willingness to pay for improved transport performance – in terms of improvements in travel times, reliability, service frequency and loss/damage in transit

Shippers' willingness to pay findings

The heart of the market survey was a set of questions designed to determine shippers' estimates, for their current freight movements, of their willingness to pay for reductions (or to accept increases) in expected travel times and improvements in the reliability of travel times. Service frequency and loss/damage to freight in transit were also covered in similar questions.

A SP approach, using contingent valuation methods, was adopted for the WTP questions. For example, in relation to travel time reliability, respondents were asked: 'i) Is the variability in your travel time enough to cause concern? ii) If yes, what proportion of journeys are affected and what is their average lateness? iii) Where there is a potential trade-off between price and reliability, what is the maximum extra price you would be willing to pay in return for a more reliable journey (late 25%/50%/100% less often)?'

Potentially answers could be provided for all the 143 commodity segments covered by the survey, with three responses for each segment (corresponding to the three levels of change in travel time and reliability specified), giving a potential total of 429 data points. In practice, the majority of respondents said they were not willing to pay any significant additional amount for improved journey time or reliability, ie they were largely satisfied with their current journey time and reliability performance.

Table ES.1 provides a summary of the WTP results for travel time and reliability, separating results for the most time-sensitive commodity group 1 (general manufacturing and retail) and the other groups. It is evident that:

[3] New Zealand consists of two main islands (North Island, South Island), with a short sea crossing (for both trucks and rail wagons) between the two islands.

- Only a minority of commodity segments have non-zero values.
- Averaged over all segments, the average WTP for travel time improvements is $0.45 per tonne per hour ($1.13 for group 1, $0.26 for the other groups combined); and for reliability improvements is $2.52 per tonne per hour reduction in standard deviation ($8.95 for group 1, $0.57 for the other groups).

Table ES.1 Summary of willingness to pay for travel time and reliability improvements[a]

	Commodity group 1	Commodity groups 2–5	Total commodity groups 1–5
A: TRAVEL TIME			
Response statistics:			
% tonnes with non-zero WTP values	**54%**	**8%**	**29%**
WTP values ($/tonne/hr):			
Non-zero segment responses (weighted)	**$10.98**	**$3.40**	**$5.45**
All segment responses (weighted)	**$1.13**	**$0.26**	**$0.45**
B: RELIABILITY			
Response statistics:			
% tonnes with non-zero WTP values	31.5%	2.6%	8.9%
WTP values ($/tonne/hr SD):b			
Non-zero segment responses (weighted)	$28.44	$27.96	$28.33
All segment responses (weighted)	**$8.95**	**$0.57**	**$2.52**

[a] All prices in NZ$ (2017).
[b] SD = standard deviation (of travel time distribution).

While similar questions for service frequency and for loss/damage to goods in transit were included in the survey, in both cases either zero or minimal WTP values resulted: for frequency, in the great majority of cases shippers were able to specify their own service timings, so would gain no further benefit from increased frequencies; for loss/damage, current rates of damage were minimal (in almost all cases less than 1% of the commodity value) and therefore shippers showed little interest in paying more to further reduce current levels.

Comparisons of study WTP results with previous New Zealand research

While the previous New Zealand research on this topic by Kim (see chapter 5) only covered our commodity group 1 and adopted different SP methods, it was possible to compare Kim's estimated values for travel time savings with our study values, both expressed in a common unit (ie NZ$ per tonne per hour travel time reduction):

- Our average value for group 1 was $1.13.
- Kim derived estimates for four sub-groups of group 1: $0.55 for long-haul FCL, $1.03 for short-haul FCL, $2.76 for long-haul LCL and $3.20 for short-haul LCL.
- On the basis that our figure is dominated by FCL movements (more long haul than short haul), the correspondence is very satisfactory.

For travel time for other commodity groups and for reliability, no comparisons between the two studies were possible. Similarly, no comparisons were possible of WTP for frequency improvements or loss/damage reductions: our study indicated that almost all respondents considered that current levels of these attributes were satisfactory and would not be willing to pay for any marginal improvements.

Formulation of new EEM values for shipper time and reliability

It was decided to base new EEM values for shipper journey time and reliability directly on the results of the project's WTP survey (refer table ES.1), given that:

- Where direct comparison of our results with Kim's results was possible (ie value of time for commodity group 1), the two sources are very consistent (as noted above).
- The results from the international literature review covered such a wide range that no useful comparisons with our project results could be made, except at the broadest level.

For application in EEM, we:

- converted our survey values (all expressed per tonne) into values (per truck) for the various truck categories used in EEM, making allowance for appropriate truck capacities and evidence on average load factors for each category[4];
- noted the current EEM allowance of NZ$3.18/truck/hour for time savings relating to freight stockholding costs.

Our recommended travel time and reliability values for inclusion in EEM are given in table ES.2 in NZ$ (2017) (based on an average heavy truck).

Table ES.2 Recommended new EEM values for freight travel time and reliability changes

	Values for 'average' heavy truck (NZ$ 2017) ,b	
	Travel time values (per truck per hour)	Reliability values (per truck per hour SD)
Recommended new values:		
Group 1	21.87	173.25
Group 2–5	4.24	9.32
All groups average	8.12	45.46
Current values – all groups (to be replaced)	3.18	–

Notes:

[a] Values given in NZ$ (2017) (current EEM base values in 2002 prices)

[b] Values shown relate to a 40:60 mix of heavy commercial vehicles with 44 tonne gross capacity (HCV2) and 50 tonne gross capacity (50MAX vehicles). Further details for other vehicle categories are given in tables 9.1, 9.2 and 9.3.

[4] We also added a category to represent high productivity motor vehicles, not currently covered in EEM.

Conclusions and recommendations

The primary objective of this project was to develop new WTP values of travel time savings and reliability improvements for freight transport in New Zealand, for inclusion in the EEM. This objective has been fully achieved – with our recommendations summarised in table ES.2 above.

A secondary objective of the project was to illustrate the application of the recommended methods and values through case studies. It was not possible to meet this objective, as Waka Kotahi was not able to provide suitable data relating to a sample of previous project evaluations. Depending on future data availability, we recommend that further work be undertaken to demonstrate the use of these methods in practice.

In the light of the work undertaken in the project, we also recommend that Waka Kotahi reviews the current structure of the sections of EEM covering operating cost and benefit parameters (for all modes), to more clearly and consistently distinguish between transporter cost items and user (including shipper) benefit items.

Abstract

This research project investigated the willingness to pay of shippers of freight within New Zealand for improvements in expected journey time, reliability of journey times, frequency of freight services and loss/damage to freight in transit. It focused on a stated preference survey (using the contingent valuation methodology) of New Zealand freight shippers, covering some one-third of the New Zealand domestic freight task (measured in tonne-km). It included an extensive international literature review of evidence on the willingness to pay for journey attributes by freight shippers. The primary output was a set of travel time and reliability values for road and rail freight movements in New Zealand, for inclusion in the New Zealand *Economic evaluation manual* used for the ex-ante economic appraisal of transport projects.

1 Introduction

This report on valuing freight transport time and reliability has been prepared by consultants Ian Wallis (Ian Wallis Associates Ltd) in association with Murray King (Murray King & Francis Small Consultancy Ltd) as part of Waka Kotahi's 2015/16 research programme.[5]

Current New Zealand procedures for the economic evaluation of road transport projects (set out in Waka Kotahi's *Economic evaluation manual* (EEM) include unit parameter values relating to the operating and maintenance costs of road (including truck-based) transport in New Zealand. They also include unit parameter values relating to user benefits (principally related to travel time and reliability changes) of transport system improvements to person travel (by private car, public transport, walk and cycle modes); but, with one minor exception[6], they exclude any parameter values related to travel time and reliability changes of transport improvements from the perspectives of freight owners (shippers, consignors and/or consignees). This project was intended to fill that knowledge gap.

The primary objectives of the research were to:

- develop enhanced/updated unit mean values of travel time (savings) and of travel time reliability (savings) for freight transport movements in New Zealand, by building on previous New Zealand and international research and analysis methods
- provide the outputs in a form appropriate for incorporation in the EEM.

At the start of the project, it was envisaged that a formal market research survey (eg using stated preference (SP) methods) would not be included (having regard to budget constraints). Rather, it was proposed that values of freight shipper time and reliability would be developed from three main sources:

1 A previous New Zealand study (Kim 2014) that involved a SP (choice modelling) survey of the shippers of New Zealand general freight/manufactured and consumer goods, had investigated shipper preferences between travel time, reliability and other freight attributes and had also developed a freight modal choice model for domestic freight movements.

2 A review of the international literature on freight shipper trade-offs and valuations of freight journey attributes (travel time, reliability and a range of other attributes).

3 Limited semi-structured interviews with a selection of New Zealand freight shippers, to ascertain their relative valuations of journey attributes across a range of freight market segments. The interview findings were then to be 'triangulated' with the previous New Zealand study and the international literature review findings to provide a full set of estimates for New Zealand freight shipper travel time and reliability values across all domestic freight market segments.

In the event, the spread of results in the international literature review was found to be extremely wide, and so this source was of very limited use in helping to establish relevant values for New Zealand. As a consequence, it was determined that a more extensive survey of New Zealand shippers than originally intended would be necessary if the project were to provide useful results. Therefore, the original semi-structured interview approach was replaced by a larger and more comprehensive SP survey that covered a substantial proportion of all New Zealand shippers and freight movements.

[5] The research was contracted in December 2016 and commenced in early 2017.

[6] Refer table A.1 for details.

The amended project scope therefore comprised three main tasks:

1. A review of international research studies (which principally involved SP methods) to investigate freight shippers' valuations of travel time and reliability benefits and other significant freight attributes.
2. An appraisal of the previous New Zealand market research (principally by Kim 2014) as to its potential application in the current research.
3. Primary market research (using SP methods) with a substantial sample of New Zealand shippers across the domestic freight sector, to determine their valuations of freight travel time and reliability benefits and other significant freight transport attributes.

The structure of this report, incorporating these three main tasks, is set out in 12 chapters, as listed on the contents page. The various appendices provide further details on the main tasks undertaken and their analyses and findings.

We also note the following points relating to the scope of the research:

- It covered New Zealand domestic freight movements only (including the domestic sectors of international freight movements but excluding the international sectors).
- The project was 'modally neutral', covering road-based and rail-based freight identically. (No attempt was made to develop a mode-specific freight model, although the New Zealand survey results could provide much information that would be useful in the development of such a model.)
- Its primary emphasis was on movements by rail and road (truck), although the market survey also covered some movements by coastal shipping.

2 Project scoping and relationship with current EEM road freight evaluation procedures

2.1 Exploration of project scope

At the start of the project, some 'grey areas' remained in terms of the scope of work required. Given this, an initial project task was to resolve which aspects of the costs and benefits associated with the movement of (land-based) freight were within the scope of the project investigations and which aspects were outside the project scope.

When the project was originally developed by Waka Kotahi the intention was that, in broad terms, costs incurred by the transporter of the freight (carrier, transport operator), often loosely called 'operating costs' would be out of scope; but costs and benefits as experienced by the freight shipper (end user, consignor or consignee) would be within scope. However, this distinction was not clearly specified in the original terms of reference, nor were its implications for the project methodology clear.

Following initial discussions with Waka Kotahi, the following recommendations were put forward:

- Out-of-scope items: The direct costs of transporting the cargo, as incurred by the transport operator (carrier).
- In-scope items: The costs and benefits associated with the dispatch and delivery of the cargo (other than the direct transport costs), as experienced by the 'shipper' (consignor or consignee).

The major costs and benefit components within each of these two categories are specified in box 2.1.

As is evident from box 2.1, the in-scope economic costs and benefits largely relate to time, convenience and quality factors as perceived and valued by the shipper/end user. These include expected travel time, travel time uncertainty/unreliability, frequency convenience (principally relating to scheduled rather than on-demand services) and other quality and convenience factors. In general, these are 'non-market' factors, and so their valuations have to be determined through WTP evidence; this is typically derived from SP surveys of various types which investigate shippers' trade-offs between the various time-related etc components and financial costs.

Box 2.1 Cost and benefit categories – out-of-scope versus in-scope

A. OUT-OF-SCOPE (direct costs of transport task, vehicle operating costs (VOC)

A1. Cost of freight vehicle time

- Distance-variable costs – related to vehicle km operated.
- Time-variable costs – related to vehicle hours operated.
- Vehicle standing costs – incurred on a periodic (monthly/annual) basis: includes depot-related costs, registration/certificate of fitness etc costs, administration and fixed overheads.
- Note: Vehicle depreciation (including interest charges) may be regarded as a combination of:
  - use-related depreciation (per km or hour operated)
  - age-related depreciation (a combination of age-related obsolescence and physical deterioration unrelated to use).

A2. Driver/crew time costs

==

B. IN-SCOPE (shipper costs and benefits associated with cargo movement, excluding direct transport costs)
B1. Stockholding costs • Opportunity costs (applying an appropriate weighted average costs-of-capital value) of the difference between the sale price of the goods and the costs of production (ie the added value) over the time between production and sale. • Except for long-haul/international freight, internal road or rail transport delays would generally result in minimal (incremental) stockholding costs. **B2. Time-related deterioration of goods in transit ('perishability')** • Reflects any loss in market value of goods in transit, which may be significant for perishable products (eg fresh produce, flowers). • Damage to goods in transit may also be covered here (in practice these are likely to have a mixture of distance-related and time-related components). • Any costs required to maintain the condition of perishable goods during transit (eg for climate control) may be best considered as a component of vehicle operating costs (ie item A.1 above). **B3. Value of earlier/later receipt of goods** • Relevant to situations where a (reliable) shortening of the time between ordering the goods and their receipt has a value to the purchaser of the goods. • Examples may include items relating to medical emergencies, or for repair of critical equipment. • Any benefits in such cases relate to minimising the costs associated with the non-availability of the goods at the point of receipt, rather than to the intrinsic value of the goods concerned.

2.2 Relationship to current EEM road freight evaluation procedures

With reference to box 2.1, it is notable that the current EEM provides methodologies and appropriate parameter values for:

- all direct operating costs incurred by the 'transporter' in the transport task (ie items A1, A2).
- the stockholding cost component (item B1) of the shipper costs and benefits – although the basis for the parameter values applied in this item is open to question[7].

However, the current EEM does not provide any parameter values for items B2 and B3, which in general comprise the larger components of the overall shipper costs[8]. The estimation of values for items B1, B2 and B3 is the main focus of this research study.

It is also notable that, in relation to freight transport, the current EEM does not make a clear distinction between transporter cost and benefit components, and shipper cost and benefit components. Further proposals on restructuring EEM in this respect are provided in appendix D.

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[7] This may be contrasted with EEM's treatment of public transport parameter values, that provides a clear separation between transport (public transport operator) costs and public transport user (passenger) costs and benefits.

[8] For instance, the freight shipper's stockholding cost component is not identified separately from the freight transporter's time-related cost component (covering driver wages etc).

3 Review of international economic evaluation procedures

This chapter reports on our investigations on the scope and approach taken to the inclusion of freight values of time (VoT) and values of reliability (VoR) in the economic evaluation procedures and practices adopted in seven selected countries internationally (which included New Zealand for comparative purposes). The focus of these investigations was on the inclusion/exclusion of cargo-related VoT and VoR in the economic evaluation procedures (usually set out in national economic evaluation manuals), rather than on the detailed methodology used to derive these values or on the resulting values themselves.

The emphasis of this comparative assessment has been on the values applicable to road freight (truck) movements; of the seven countries investigated, only one (Netherlands) appears to have undertaken any substantial research on WTP values for other freight modes.

Table 3.1 provides a summary of the scope and approaches taken to freight VoT and VoR in the economic evaluation manuals of each of the seven countries.

Salient points from this assessment include the following:

- *New Zealand*. While the EEM procedures include estimation methods and values for freight-related VoT and VoR, there is considerable doubt as to whether these procedures adequately cover i) VoT components as perceived by shippers (as well as those experienced by transport operators), and ii) VoR as perceived by shippers. These doubts were a major consideration leading to the commissioning of this research project.
- *Australia (Federal).* These procedures appear to be particularly weak in regard to freight VoR methods and estimates, and it is unclear to what extent the (rather limited) Australian SP-based research undertaken 15–20 years ago has been incorporated in the current evaluation procedures. Additional SP-based market research has been suggested at government level (by the Australian Transport Industry Council) but has not yet been initiated.
- *England*. No cargo-related VoT appear to be incorporated in current economic evaluation analyses (for benefit:cost ratio (BCR) etc). While methods (but not the results) for estimating freight VoR are included in these procedures, the procedures state that any such benefits are to be excluded from economic results (BCR etc) but are to be included in the overall value for money presentation (via the appraisal summary table widely used for summarising evaluation results – refer table 3.1).
- *Netherlands*. Freight VoT and VoR unit values were derived from an extensive SP-based study (2012) and are incorporated in current evaluation procedures (although the cargo-related components are not readily separable). The Netherlands is the only one of the seven countries that has researched values for modes other than road freight.
- *Sweden*. Current procedures incorporate both cargo-related VoT and VoR unit values. However, it is not apparent that these values include realistic allowances for cargo-related (shipper) valuations.
- *Germany.* As far as we could ascertain, no cargo-related VoT or VoR unit values are incorporated in current German procedures.
- *USA (Federal)*. As for Germany, no cargo-related VoT or VoR values are incorporated in current US procedures, and rather limited research appears to have been undertaken on this topic.

Table 3.1 Summary of treatment of cargo-related travel time and reliability in economic evaluation procedures for selected countries[a]

Country	Expected travel time	Travel time reliability
New Zealand	• Procedures include component (per hour, by vehicle category) relating to value of freight carried – allows for stockholding, perishability, etc costs. • Further details in appendix A.	• Fully included. • Benefits estimated based on i) any change in travel time variability (TTV) (SD) over total trip; ii) VoT for relevant truck category; and iii) VoR/VoT factor (reliability ratio (RR) = 1.2). • Further details in appendix A.
Australia (Federal)	• Current shipper cost component based on results from pilot surveys (1998, 2000) – adopted by Austroads (2003) and recently updated/incorporated in TIC(b) evaluation estimates. • Further SP-based research on freight values suggested by TIC, but not proceeded to date.	• Pilot SP surveys (1998, 2000) investigated reliability values, but not been incorporated into current standard evaluation procedures. • Further SP-based research has been suggested by TIC(b) (as for VoT), but not yet undertaken.
England	• Not included.	• Partially included: reliability benefits are not to be included in economic evaluation results (BCR etc) but should be included in the appraisal summary table and thus taken into account in overall VfM assessment. • Reliability measure is travel time SD; detailed procedures are given for estimating SD (by road type, degree of congestion, etc), then apply RR value (0.8) and value of freight time.
Netherlands	• Fully included (but incorporated in one single VoT value for freight movements). • Values based on major SP research interviews with shippers and carriers (2012).	• Fully included. • Values based on 2012 study (as for travel time). • Derived values for truck, rail for travel time SD and for VoR/VoT.
Sweden	• Included. • Values allow for interest on values of goods in transit and also for damage (per km) to goods.	• Included, but method and values not specific to freight. • Use travel time SD as reliability measure, with VoR/VoT = 0.9.
Germany	• No allowance for value of freight in transit etc.	• Uncertain – research undertaken (2015) but believe not yet incorporated into evaluation procedures.
USA (Federal)	• No allowance incorporated into current evaluation procedures – said to be subject of further research.	• No allowance incorporated into current evaluation procedures.

Note:

[a] Except where noted, material in this table relates to road freight (truck) mode only: it appears that only the Netherlands has undertaken significant research relating to other modes.

[b] TIC = (Australian) Transport and Infrastructure Council.

4 Market segmentation

It is widely recognised (and almost self-evident) that changes in freight expected travel time and in travel time reliability are regarded as much more important (valuable) for some commodity movements than for others. While the values placed on changes in travel time (VoT) and in reliability (VoR) will be situation-specific, useful generalisations may be made on relative values for different commodity groups. An important aspect of the research was thus to: i) classify commodity movements into groups based on their expected sensitivity (values) to time and reliability changes; and then ii) estimate the relevant (averaged) values within each of the defined commodity groups. The definition of these commodity groups, for use in the market research, is the subject of this chapter.

Our work reviewed how other researchers have segmented the freight transport market, as a prelude to seeking a segmentation that reflects the whole market in New Zealand, based on the National Freight Demand Study (NFDS) (Deloitte 2014).

Most of the international literature does not segment the freight market, although it is likely in most cases that the implicit market surveyed is for general freight, manufacturing and retail goods. Where the market is broken down into segments, there is a great variety in the segments chosen, reflecting the economy of the country concerned, or the availability of statistics, and/or standard classifications. For example, our study has identified segments for livestock and dairy, both significant for New Zealand, but no other study identifies these commodities. Nor are there many studies that identify aggregates, possibly because researchers were looking to test methodologies to derive values of time and reliability, and aggregates would not have high values on either. There are also examples of market segments important internationally, but not in New Zealand, such as chemical industries.

The few New Zealand studies have more useful classifications but are still not comprehensive:

- Bone et al (2013) suggested a mode-based split, and a distance split. We have approximated their commodity split in the way we have chosen our commodity groups, and chosen similar, though not the same, distance groups. They also suggested a consignment size classification, which we did not use, although it informed our choice of commodity groupings.
- Kim (2014) focused on non-bulk, general cargoes commonly moved on containers or on pallets. One of our segments matches this grouping. However, we have chosen a greater range than Kim in order to fully cover the New Zealand domestic freight sector.

We have chosen the NFDS as the basis for the following five principal commodity groups and various sub-groups within them, which can be related to the data on freight flows in the NFDS. Our groupings also try to segment the market by mode (road and rail), with at least one group (4) dominated by rail:

- Group 1 comprises retail, manufacturing and domestic freight, including domestic food.
- Group 2 comprises perishable exports, raw milk, meat, and fish.
- Group 3 comprises other containerised exports and their precursors. This includes manufactured dairy, logs, sawn timber, panels, pulp and paper, grain, wool, other agricultural products, other minerals and livestock.
- Group 4 comprises bulk exports – coal, iron and steel.
- Group 5 comprises other domestic traffic – petroleum, lime/cement/fertiliser, waste, concrete and aggregate.

Table 4.1 sets out the annual tonne kilometres for each commodity group (based on NFDS data for 2012), and their split between road and rail (excluding any coastal shipping movements). Road dominates all groups except 'bulk exports', which was defined so as to cover principally rail traffic, to see if time and reliability values could be estimated specifically for rail. Further details on the commodity split by mode are given in table E.1.

We also classified the movements geographically (by commodity) into intra-regional, inter-regional (within either island) and inter-island. This classification represents broad distance bands.

Table 4.1 Principal commodity groups and road/rail shares

Commodity group	Rail tonne- km (bn)[a]	Road tonne-km (bn)	Total tonne-km (bn)	Road: total (%)
1. Retail, manufacturing, general freight	1.47	7.46	8.93	84%
2. Perishable exports	0.35	2.30	2.65	87%
3. Other containerised exports, + precursors	1.17	6.07	7.24	84%
4. Bulk exports	1.15	0.22	1.37	16%
5. Other domestic	0.07	2.47	2.54	97%
	4.21	18.52	22.73	81%

[a] billions

Source: Deloitte 2014.

Table 4.2 shows the main specific commodities involved in our survey within each of these five principal commodity groups.

Table 4.2 Detailed commodity groupings

Group 1	Group 2	Group 3	Group 4	Group 5
Retail	Fruit	Dairy products	Coal	Aggregate
Manufacturing	Bulk wine	Logs	Steel	Minerals
Drink	Meat	Livestock		Liquid fuels
Groceries	Fish	Grain		Cement
Machinery	Raw milk	Honey		Fertiliser
Rubber	Grape juice	Stock food		Lime
Cars	Squash	Timber		Waste
Tyres		Pulp		Concrete

5 International literature review

5.1 Overview

This chapter summarises the findings from our review of the international (including New Zealand) market research evidence on the values that shippers place on savings in (expected) travel time and in travel time reliability. This literature is extensive; over 160 studies were examined (although in many cases their merits and their relevance to the New Zealand market were doubtful). Most of these looked at particular countries where researchers or governments have taken an interest in the topic, especially in the Netherlands, Britain and Scandinavia, and also in the US, Australia, and New Zealand. Some studies also consider service frequency and loss or damage.

The focus of our study was on the costs to the freight owners of their freight taking longer to arrive, or its arrival being unpredictable. It did not include VOC, which tend to be substantially greater than the values associated with the freight itself (refer chapter 2). Some of the studies included the VoT from a carrier perspective, which directly includes VOC, and do not separate them from the freight costs. Where this was obvious, the studies have been excluded.

We looked at studies from before 1990 up to 2017. Their values were in a variety of currencies. To make them consistent, we converted them all to New Zealand dollars of 2017.[9] We were cautious about including the very old studies, given that this conversion might distort their importance, and that the modelling techniques had moved on. In addition, we focused on values per tonne for comparability, but also reported on some expressed only in values per shipment, vehicle or pallet.

Where possible, we have presented the data in the studies by commodity, in groups corresponding to the five groups we used for the overall study (refer chapter 4). However, one of the variabilities in the studies is the units chosen. Many studies do not identify any commodity, but look at mode, or transport type such as containers. Others just present a value without differentiating by mode or commodity. We have presented the data from these studies separately.

5.2 Value of time

This heading covers studies that estimate the value to freight shippers of changes in the scheduled or normal/expected journey times. The actual data varies widely, even within these categories. Over all the studies assessed, values of time by commodity vary from zero to NZ$ (2017) 10.61 per tonne per hour; and from $2.12 to $525.40 per shipment per hour. Clearly the shipment size may vary, but that size is not always stated. Some of the values are very low, but that may simply reflect the commodity: time may be of little or no consequence for some commodities. Many of the studies, however, do not consider such commodities, and focus on general manufacturing, consumer goods and the like, reflecting the market they examined, and the fact that they are often seeking to test valuation models, and deliberately choose commodities that are expected to have significant values for time savings.

Our commodity group 1 covers this type of commodity, where it is identified. There were 17 data points for this group (one study might report on more than one group 1 commodity). Group 2, perishable exports, had no directly comparable studies, but two identified ‘perishable’ goods, which we have used as

[9] Values were converted to NZ$ by applying New Zealand purchasing power parity conversion factors and then scaling up the results to March 2017 prices by application of New Zealand GDP per capita factors.

a proxy. Group 3, containerised exports and precursors, was represented by only one study (of forestry in Finland). There were four data points for group 4, bulk exports, and six for group 5, other domestic commodities, giving an overall total of 30 studies where the commodity was identified.

Studies that expressed their data in terms of mode included seven data points for road and eight for rail. Some also distinguished between own account and third-party transport, a distinction that does not appear to be important in New Zealand. Further studies simply presented a value without differentiation. All these studies had wide ranges of values.

With such a range of values, it is difficult to generalise and one conclusion has to be that the picture is very diverse. For analysis and reporting purposes, we have focused on the median and quartile values[10] and hence the inter-quartile ranges (thereby ignoring outliers).[11] Median and quartile values are given in table 5.1 on a per tonne per hour basis. Fuller details including the full ranges given are in appendix B, table B.6.

In terms of commodity groups, those commodities that are likely to have higher commodity values per tonne typically have higher values of time, which is as expected. The highest median value of time is for perishables (group 2), and then general manufacturing (group 1). The single value for containerised exports and precursors (group 3) represents a lower end of that market and is perhaps anomalous. Group 4 includes coal and heavy metal industries, and the low value for group 5 probably reflects the inclusion of aggregates as well as higher value petroleum and chemicals. The overall median value for the 30 commodity data-points of $2.60/tonne/hr is weighted heavily by group 1. However, the weight of that group is much less in the overall total, which includes both modal classifications and those studies that did not make any differentiation by commodity or mode: the overall median (for all 49 data-points) is almost the same as for group 1. The wide inter-quartile ranges for the various commodity groups are notable, with ranges of around 10:1 for all commodity groups combined (30 data points) and for groups 4 and 5 individually. Even for the full dataset (49 data-points), the inter-quartile range is around 6.5.[12]

The median value for freight by rail is less than 40% of that for road (although based on only modest sample sizes). This difference is probably a reflection of the different mix of cargoes involved (which itself will reflect a greater tendency to use rail for less urgent cargoes).

Table 5.1 Summary of values of time per tonne per hour (NZ$ (2017)[a]

	Commodity group						By mode		Undiffer-entiated	All data
	Group 1	Group 2	Group 3	Group 4	Group 5	All comms	Road	Rail		
1st quartile	$1.03	$2.35	$0.82	$0.34	$0.35	$0.62	$3.41	$0.83	$1.59	$0.86
Median	$2.76	$3.67		$1.66	$0.96	$2.60	$3.42	$1.33	$2.17	$2.72
3rd quartile	$5.76	$4.98		$3.66	$3.79	$5.46	$13.65	$2.53	$3.75	$5.66
Data points[b]	17	2	1	4	6	30	7	8	7	49

[a] Further details given in appendix B, table B.6.

[b] Note that a single study may provide multiple data points.

[10] In our view, given the relatively high proportions of outliers, this focus on the inter-quartile range is more appropriate than focusing on the SD of the distributions.

[11] The quartile values are the 25th and 75th percentile values when the data points are ranked in order.

[12] The inter-quartile ranges given here are derived as the ratio 3rd quartile value: 1st quartile value.

5.3 Value of reliability

Fewer studies covered the reliability (variability) of travel time. Different definitions of 'reliability' are used in different studies; where possible in this chapter we have used $/tonne/1 percentage point improvement[13]. Values range from NZ$0.23 to $16.86 per tonne per percentage point. Some data is available by commodity, again with large ranges. There were, however, only a few studies in each group, with only group 1 having more than one study (as shown in table 5.2) and none at all for groups 2 and 3. Again, we have sought to narrow the ranges by using the inter-quartile range figures. Further details are given in appendix B, table B.15.

Table 5.2 Summary of reliability values in $/hour/1 percentage point improvement[a]

	Commodity group					
	Group 1	Group 2	Group 3	Group 4	Group 5	All groups
1st quartile	$1.15					$1.18
Median	$2.44			$1.50	$3.67	$2.44
3rd quartile	$2.94					$3.43
Data points[b]	7	0	0	1	1	9

[a] Further details given in appendix B, table B.15.

[b] Note that a single study may provide multiple data points.

5.4 Reliability ratios

The reliability ratio (RR) is defined as the unit value of reliability (ie the SD of the arrival time) divided by the unit value of (expected) arrival time. This has been calculated by some studies, in some cases by commodity (as shown in table 5.3) which covers both European and US studies. Overall RR inter-quartile ranges in UK/European studies are between 0.8 and 1.2 for all commodities combined, with values for individual commodities ranging from 0.4 (coal) up to 2.1 for 'other bulk goods'. In a recent US study, however, the ratios have a much higher upper range, with values between 0.5 and 7.0, and an overall average value of 2.5 (Jin and Shams 2016).

A RR value of less than one means that a change of one hour in the SD of travel time is valued less than a change in the expected (average/typical) travel time of one hour – in layman's terms, reliability is valued less highly than (expected) travel time. This is a typical finding for the European and UK studies (but not the US study).

[13] Note that the market research undertaken in this project uses a different definition of reliability (refer chapter 8), and therefore the project market research values are not directly comparable with those in table 5.2.

Table 5.3 Summary of reliability ratios[a]

	Commodity group						
	Group 1	Group 2	Group 3	Group 4	Group 5	All comm groups	Overall values
1st quartile	0.4			0.6	0.4	0.4	0.8
Median	0.6			0.8	0.5	0.8	1.1
3rd quartile	1.3			1.1	2.1	2.1	1.2
Data points[b]	4	1	0	3	5	13	6

[a] Further details given in appendix B, tables B.11, B.12, B.14.

[b] Note that a single study may provide multiple data points.

5.5 Value of frequency

Values for frequency changes (along with loss and damage) are less studied than values for time and reliability, probably because people value frequency changes less highly than other attributes. Internationally, studies of frequency have looked primarily at the marine market, and the impact of adding an additional weekly departure: this often means a significant increase in perceived service levels and is valued up to NZ$2,350 per departure per week. In New Zealand, the Kim study estimated the value per tonne of an additional departure per day for rail and sea at between $1.00 (for inter-island less than container load (LCL) and $7.21 (for inter-island full container load (FCL). Given the very few quantified data points, it was not possible to draw any conclusions on the ranges and median values for frequency changes, analogous to those for expected time and reliability (in tables 5.1 and 5.2).

5.6 Value of damage

Only a few studies have considered damage, expressed in terms of the value of a reduction in damage of 1% (of the existing value of damage). Values range from negligible (for some commodities in Tanzania) to $1,135, with higher values for specific rail and air shipments.

5.7 Rank order of service attributes

A number of studies identify further service attributes, such as security, equipment availability and cargo tracking. Some classify the attributes as factors influencing mode choice, and others just as influencing transport choices generally. In the absence of direct quantification of these attributes, we attempted a rank order comparison of various studies. There is little agreement between the studies, save that reliability (variability) is usually the most important attribute with (expected) time being usually lower down the order of importance (as low as ninth in at least one study).

5.8 Willingness to pay versus willingness to accept

Most research in this field focuses on WTP more for service improvements. Only a few studies have addressed willingness to accept (WTA) reductions in service attributes in return for lower transport prices. Such studies generally find that WTA values are higher than WTP values, that is shippers expect a higher discount for reduced service than they would be willing to pay for enhanced service. In Kurri et al (2000), WTA values were found to be about 2.3 times WTP for road mode, and 2.6 times for rail mode (although it is not clear that this difference between road and rail is significant). Zamparini et al (2011) show a very similar ratio of 2.2 over the four key attributes. Our market research focused on WTP, although questions were also asked on WTA. Further comment is given in chapter 8.

5.9 New Zealand findings by Kim

The only relevant New Zealand study was undertaken by Kim (2014). This is discussed in sections 8.5 and 8.6.

6 Market survey – approach and methodology

6.1 Need for a market survey

Originally, the concept for this research was to use the PhD thesis by Kim (2014) as the benchmark for our commodity group 1, and to scale from there for other groups, based on their share of the transport task and using international literature for values of time and reliability. In the event, this proved not to be possible, because:

- We needed independent estimates to compare our methodology with Kim's.
- The international literature was inadequate in terms of commodity-specific information.
- The New Zealand economy's structure is very different from the economies in countries typically studied internationally.
- Most importantly, this study was required to obtain values relating to all sectors of the freight market, not just the general freight sector researched by Kim and by many overseas studies.

Given these deficiencies, in order to meet the project objectives, we judged it was necessary to conduct a comprehensive survey across the whole of the New Zealand domestic freight market. A key component of this market survey was to obtain estimates of shipper willingness to pay for changes in expected travel time and in travel time reliability (variability) across all sectors of the market. Further comments on survey methodology are given in sections 8.1, 8.2.

6.2 Survey scope overview

This survey comprised 16 main questions, each involving a number of sub-questions. The 16 questions fell into the following six groups (further details given in appendix F2.2):

1. Contextual questions, such as the nature of the shipper company, the size of its freight task (tonnes and tonne-km), and transport spend.
2. Commodity and freight flow information. In this section we used the concept of 'commodity segments', ie movement of a commodity (in one of five commodity groups) in one of three origin-destination (O-D) groups. We asked for information on the respondent's four largest commodity segments (by tonnage). This information also included detailed origin and destination, average haul distance, and the value of the commodity being transported. Most of the following questions asked for information by commodity segment.
3. Information on modes used and reasons for choice of mode.
4. Service attributes – as an introduction to item 5 below– asked about the relative importance (at a broad level) in choice of carrier of price, expected journey time, reliability of arrival time, frequency of service and loss/damage to goods in transit.[14]
5. WTP for potential changes to the current journey service attributes. An initial question here was to ask for each service attribute whether it could be traded-off against price. If it could, then respondents

[14] These performance ratings were not used in the analysis of willingness to pay, which is covered in the questions in bullet point 5.

were asked about their (maximum) WTP for a specified (positive) change in the attribute; and also for their (minimum) WTA a price reduction for a specified (negative) change in the service attribute.

6 Other comments – an open section.

6.3 Sampling approach

To recruit candidates for the survey we developed an 'opportunity sample', largely derived from the researchers' own knowledge and enquiries, and with the aim of covering a high proportion of all domestic freight movements, as measured by the NFDS. The interviewees were mainly 'shippers'[15], ie producers or managers of the freight to be moved. A small number of those responsible for transporting the freight ('transporters') were also included[16].

The survey covered transport only within New Zealand, including the domestic legs of import/export movements. It primarily involved movements by road and rail[17]. Together the survey responses covered about one-quarter of the country's annual domestic freight tonnage and one-third of tonne-km.

6.4 Survey delivery methods and responses

A small pilot survey by email indicated that the survey would be best carried out by personal (phone-based) interviews. Often this needed a number of calls, but the effort was worthwhile, as illustrated by the high response rate in terms of completed and high-quality interviews. The survey took from 20 to 60 minutes to complete, depending on the complexity of the respondent's business and the number of segments covered.

The use of an interviewer knowledgeable about the industry proved to be very helpful in resolving a number of problems that arose during the survey, for example understanding the concept of commodity segments, and particularly in tackling the key questions on trade-offs between transport price and level of service attributes (travel time, reliability etc).

Of the 76 firms approached, only three refused outright and another 18 expressed willingness to participate in principle but were unable to do so in practice (largely because of their time constraints). This left 55 respondent firms (an overall response rate of 72% of those approached). A further four respondents were people in different parts of the same firm (dealing with different commodity movements), resulting in a total of 59 responses: 10 of these responses were from transporters, the remainder from shippers.

The 59 respondents were responsible for a total annual freight task of some 65 million (net) tonnes. The 143 commodity segments for which detailed freight movement data was obtained accounted for 54 million tonnes and some 9,000 million t km of the respondents' total freight task (with an average haul distance of some 170 km).

[15] Shippers may be either consignors or consignees.

[16] Questions posed to transporters asked for their views on the choices of shippers rather than the transporters' own views on time and reliability savings.

[17] The survey was 'mode neutral': it also covered domestic shipping mode where identified. Trip legs on the Cook Strait ferry services were categorised as by road/truck or rail/train as appropriate.

7 Market survey – New Zealand freight market characteristics

7.1 Key market characteristics

This chapter provides an overview of key characteristics of the survey responses, at an aggregate level. Further details of the freight market characteristics, as represented by the survey responses, are provided in appendix F3[18].

Relative size of freight tasks (as surveyed) by commodity group. The largest group of respondents in terms of tonnes was other containerised exports (group 3), followed by other domestic commodities and by general freight. In terms of tonne kilometres, general freight was the most important, reflecting its longer than average haul distances. This was followed by other containerised exports and other domestic commodities.

Survey proportions of total market by commodity group. The responses for the commodity segments surveyed accounted for approximately 23% of total annual tonnes and 34% of total tonne-km estimated in the NFDS. In terms of tonne-km, the highest proportion of the NFDS[19] total was for bulk exports (group 5), where the commodity segment returns accounted for 77% of the total NFDS group 5 freight, followed by retail, manufacturing and general freight (group 1) at 38% of the NFDS group total.

Transport expenditures. The annual domestic transport expenditure of the 55 companies surveyed totalled some $2,350 million, an average of about $33 per tonne of freight. Annual transport expenditures for the individual companies ranged between $50,000 and around $60 million, with a median of about $12 million. The three companies with the highest expenditures were all transporters, with expenditures between $330 million and $610 million: the highest expenditure for a producer (shipper) was $120 million.

Transport price structures. Transport prices per tonne followed a broadly parabolic curve with distance, ie the incremental price per kilometre gradually decreases as the distance increases. For a given distance, transport prices per tonne are generally higher than average for group 1 (retail and manufacturing) and group 5 (liquid fuels), and lower than average for groups 2, 3 and 4 (largely bulk commodities)[20] .

Transport prices relative to commodity values. The total value of the freight in the segments analysed was $79 billion, giving an average 'value density' of some $1,300 per tonne. This average figure varied widely, from $3,600/tonne for group 1 to $300/tonne for the bulk goods in groups 4 and 5. The ratio of domestic transport price to commodity value also varied widely, from under 5% (for around half the retail and manufacturing, group 1) to over 20% (for about 90% of the perishable exports, group 2).

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[18] No attempt has been made (in this chapter or elsewhere in this report) to differentially expand the surveyed sample to represent the total New Zealand domestic freight market (as estimated through NDFS): such expansion was considered unnecessary for the purpose of this project. However, we note that group 1 (which has the highest survey WTP values, with the greatest deviation from the average for all groups) accounted for 38% of NFDS group 1 tonne-km, which compares closely with the survey all groups overall average of 34% of NFDS.

[19] We note that the survey data relates to freight movements in 2017, whereas the NFDS data reflects estimates of 2012 freight volumes. Overall, total domestic freight volumes are estimated to have increased by some 8% over the 2012–2017 period.

[20] As rail freight has its highest share of the total market in commodity group 4 (bulk exports), on average its transport price/tonne for a given haul distance tends to be lower than the overall price/tonne for road freight.

Transport task by O-D category. Of the three O-D categories, the 'local' category accounts for some 62% of total survey segment tonnes, but only 22% of tonne-km (average haul length c57 km). Inter-regional (within one of New Zealand's two main islands) traffic accounts for 35% of total tonnes and 63% of total tonne-km (average haul length c290 km). Inter-island freight accounts for only 2% of total tonnes, but some 14% of total tonne-km (average haul length c1,245 km).

Transport task by mode. Road-only movements accounted for some 34% of total tonne-km (but 56% of total tonnage). Rail only movements accounted for 24% of tonne-km, and combined road/rail for 30%. Road is dominant for local movements, accounting for around 80% of tonnes up to 100 km. Road/rail combined accounted for 70% of tonnage between 500 km and 1,000 km, while longer distances were dominated by ship and combined road/rail/ship.

Factors affecting mode choice. For those segments currently carried by road only, respondents thought that rail or ship could not reasonably be used for about 80% of the total tonne-km. For those segments where rail or ship was considered as a reasonable option, the main reasons road was chosen varied by distance. For local movements, cost was considered as the dominant factor; for inter-regional movements cost, time, door-to-door service, reliability and frequency were given similar weightings; and for inter-island movements, reliability and time were the main factors.

Factors affecting carrier choice. The most important factors in respondents' choice of carrier (essentially relating to road movements) were reliability and price, followed closely by frequency and time factors. Safety was also seen as important, but not loss or damage. In terms of particular commodity groups, reliability was most important for groups 1 (general) and 2 (perishable exports); price and time for group 3 (other containerised exports), and frequency for group 4 (bulk exports).

7.2 General comments

Survey respondents were asked an open question at the end of the interview, inviting them to make any other comments that might be helpful to the understanding of willingness to pay for time savings and reliability improvements for freight. Of the 59 respondents, only six did not take this opportunity.

Time and reliability were seen as important, but reliability more so because it cannot be planned for. A regular and reliable service was more valuable to customers than a fast one (eg as long as it was delivered on the specified date). The value of reliability is already largely captured in current arrangements, and most respondents would be unwilling to pay more to get what they now already have (or to pay less for lower levels of service and reliability).

Resilience as a characteristic was not surveyed; but respondents still commented on resilience issues. These were mainly about maintaining the security of the network, keeping it open, especially where there were no alternatives (such as the inter-island route). It was also commented that poor road availability might influence plant location.

Safety was expressed as a 'key focus' and respondents were prepared to pay a premium to ensure safety (without being able to specify an amount). A specific instance was food chain safety, especially with exports: for example, if the approved food safety chain was broken, the product was not exportable and was largely worthless.

Further comments are provided in appendix F3.

8 Market survey - shipper willingness to pay analyses and results

8.1 Overall survey approach

The heart of the market survey was a set of questions designed to determine shippers' estimates of their WTP for increases (or WTA for decreases)[21] in expected travel times and in the reliability (variability) of travel times for their current freight movements.

This chapter outlines the methodology applied in this section of the survey and then sets out and comments on the WTP estimates derived from this section. It also compares these estimates, where possible, with previous estimates derived for the New Zealand freight market through the earlier work of Kim (2014).

A SP rather than revealed preference approach was chosen to estimate shipper willingness to pay for changes in (particularly) expected travel times and the reliability (variability) of travel time. Consideration was given to choosing one or other of the two most common SP approaches, ie contingent value methods and choice modelling methods.

We do not attempt to provide here a detailed description and comparative assessment of the two methods: a considerable literature is readily available on this topic.[22] For this project, the principal factors influencing our preference for adopting the contingent value methodology were:

- greater realism of survey questions (less hypothetical, closely based on current transport characteristics) and easier comprehension for respondents
- substantial interactions between variables of interest were not expected (allowing for simpler survey methods while still providing satisfactory results)
- less complex in terms of survey design and analysis methods
- more feasible to undertake through telephone-based interviews rather than requiring face-to-face delivery
- lower survey/analysis costs and shorter elapsed time.

8.2 Survey willingness to pay methodology

Box 8.1 sets out (in a slightly abbreviated form) the WTP questions relating to travel time and reliability.

For both travel time and reliability, respondents were asked for their maximum WTP, as a percentage of their current transport prices, for each of the three specified percentage changes (improvements) in expected journey time and in journey time reliability (ie 25%, 50%, 100%).

[21] These survey questions covered both maximum WTP for better services and minimum WTA compensation for worse services. Issues were encountered in interpreting the WTA questions and therefore the WTA results are not given here: some WTA results are given in appendix F and further discussion of the WTA issues is provided in appendix F4.

[22] A recent Waka Kotahi research project provides a useful description and assessment of the two methods: refer Denne et al (2018).

Potentially answers could have been provided for all the 143 commodity segments covered by the survey, with three answers for each segment (corresponding to the three levels of change in travel time and reliability specified), giving a potential total of 429 data points. In practice, the majority of respondents said that they were not willing to pay any significant additional amount for improved journey time or reliability – the implication being that in most cases current journey time and reliability performance is largely satisfactory for their needs.

Box 8.1 Willingness to pay questions re travel time and reliability

Travel time (expected)	Reliability (of travel time)
*What is your actual (expected) journey time, and is it fixed?	*Is variability in travel time enough to cause concern? *If yes, what % of journeys are affected and what is their average lateness?
* Where a potential trade-off between price and expected journey time, what is the **maximum extra price** willing to pay in return for a shorter journey time (10%/25%/50% shorter)?	*Where a potential trade-off between price and reliability, what is the **maximum extra price** willing to pay in return for a more reliable journey (late 25%/50%/100% less often)?

The WTP responses obtained were used to derive averaged WTP values for travel time and reliability improvements for each respondent for:

- each commodity segment for which a non-zero WTP previous response was given – for each of the three specified levels of travel time change (as specified in box 8.1), from which the average of the three levels was derived
- within each commodity group, unweighted average and weighted average of WTP values over all commodity segments having non-zero responses, with weightings proportional to the total tonnage for each segment
- weighted average (weightings within each commodity group in proportion to tonnage) for all segments surveyed, including those with zero WTP values for travel time and reliability improvements.

The key results are given in table 8.1. This table is split into two main sections, with the upper section (A) giving WTP results for travel time savings and the lower section (B) giving WTP results for reliability improvements. The top part of each section sets out key survey response statistics for both travel time and reliability, including the number of commodity segments covered in the survey and the number and proportion of these providing non-zero responses to the WTP questions.

Both sections provide separate results for commodity group 1 alone, for groups 2–5 combined, and for all groups in total.[23]

The final section (C) of the table compares the NFDS split of the market (tonne-km) between group 1 and groups 2–5 with the corresponding split from the survey data. It is seen that the splits for the two sources are very similar; therefore, no adjustment was considered necessary in terms of the relative weighting of the groups within the total freight task.

[23] Given the relatively small number of non-zero responses provided for commodity groups 2–5, the view was taken that these groups were best combined in presenting the results.

Table 8.1 Summary of WTP for travel time and reliability improvements[c]

	Commodity group 1	Commodity groups 2–5	Total commodity groups 1–5
A: TRAVEL TIME			
Response statistics:			
# firms	**21**	**42**	**55[a]**
# total segments	**45**	**98**	**143**
# segments with non-zero WTP values	**17**	**14**	**31**
% segments with non-zero WTP values	**38%**	**9%**	**18%**
% tonnes WTP values	**54%**	**10%**	**29%**
WTP values ($/tonne/hr):			
Non-zero segment responses (weighted)	**$10.98**	**$3.40**	**$5.45**
All segment responses (weighted)	**$1.13**	**$0.26**	**$0.45**
B: RELIABILITY			
Response statistics:			
# total segments	**45**	**98**	**143**
# segments with non-zero WTP values	7	2	9
% segments with non-zero WTP values	15.6%	2.0%	6.3%
% tonnes WTP values	31.5%	2.6%	8.9%
WTP values ($/tonne/hr SD):[b]			
Non-zero segment responses (weighted)	$28.44	$27.96	$28.33
All segment responses (weighted)	**$8.95**	**$0.57**	**$2.52**
C: SURVEY RELATIONSHIP TO TOTAL MARKET			
Proportion of total tonne-km (ex NFDS)	**38.3%**	**61.7%**	**100%**
Proportion of total tonne-km (ex survey)	**41.1%**	**58.9%**	**100%**

a) Eight firms had segments in both group 1 and groups 2–5

b) SD = standard deviation (of travel time distribution).

c) All prices in NZ$ (2017).

8.3 WTP for travel time and reliability – results and commentary

The bottom parts of sections A and B of table 8.1 (WTP values) show our estimates of WTP for travel time and reliability improvements per tonne, in the following units (values in NZ$ (2017):

- travel time – $/tonne/1-hour change in (expected) travel time
- reliability – $/tonne/1-hour change in SD of travel time[24].

[24] While different studies in this field use different measures for expressing changes in reliability, the measure adopted here is used frequently and is most consistent with the current treatment of reliability in EEM.

Two sets of results are provided for each of travel time and reliability values, with responses weighted by the relevant tonnages in each case:

- weighted average value for all segments for which respondents expressed non-zero values.
- weighted average value for all segments, including those for which respondents expressed zero values.

Notable features of these results include the following:

8.3.1 Travel time

- For group 1 segments, the weighted average WTP value for those expressing a non-zero value was approximately $11.00/tonne/hr, and over all segments averaged some $1.10/tonne/hr.
- For groups 2–5, the corresponding average values were in the order of only one-quarter of those for group 1 (ie much lower, as expected), at about $3.40/tonne/hr for non-zero values and about $0.25/tonne/hr averaged over all responses.
- Over all groups, the corresponding values were $5.45/tonne/hr for non-zero responses and $0.45/tonne/hr averaged over all responses.

8.3.2 Reliability

- For group 1 segments, the weighted average WTP value for those giving non-zero values was approximately $28.50/tonne/hr SD, and over all segments was about $9.00/tonne/hr SD.
- For groups 2–5, the corresponding values for those giving non-zero values were approximately the same ($$28.00/tonne/hr SD) as for group 1, and for all segments averaged about $0.60/tonne/hr SD. Relative to group 1, this overall much lower figure reflected the much lower proportion of segments expressing non-zero values for reliability (ie about 30% of all segments for group 1, less than 3% for groups 2-5).
- Over all groups, the weighted average value per segment was approximately $2.50/tonne/hr SD.

Further details of the analysis methodology adopted and the results are provided in appendix F4.

8.4 Service frequency and loss/damage results

The survey included questions about frequency of service and freight loss or damage, designed along similar lines to the questions about time and reliability, in order to elicit the WTP values that respondents placed on these attributes. However, responses to these questions did not yield enough quantitative data to warrant detailed analysis which could potentially derive generally applicable values for these two attributes. A large majority of respondents placed no or minimal value on improving frequency,[25] and nearly all of them placed no significant value on reducing damage or loss. These results reflected that shippers were generally satisfied with existing levels of both attributes: the prevailing position was that they already received the frequencies that met their business needs, and loss or damage was not a

[25] The relatively low WTP for improving service frequencies in the freight sector may be contrasted with the relatively much higher WTP values commonly found for improving service frequencies in the urban public transport sector. This difference, at least in part, reflects that the great majority of freight shippers have negotiated service frequency (and timing) levels that best meet their normal needs and their services are generally quite reliable; whereas public transport users are subject to the limitations of service timetables (not specially tailored to the needs of individual users), which may operate with greater or lesser reliability.

significant problem. Some respondents commented that what used to be a problem with loss and damage has essentially been solved in recent years and good service levels (tailored to their specific requirements) are now the norm.

Service frequency responses. Quantified trade-offs between price and service frequency were provided for only eight commodity segments. For four of these segments, respondents were prepared to pay more for improved frequency, and for the other four, respondents (all transporters) considered that their customers would accept some discount for reduced frequency. As transporters accounted for only about 20% of total segments, this gives some indication that transporters may think their customers value frequency changes more highly than the shippers actually do.

Freight loss/damage responses. While 9% of segments reported loss/damage as a concern, the actual amount of loss/damage currently experienced averaged only 1% or less of commodity values. As a quantified trade-off between price and loss/damage was provided for only one of these segments, it was not possible to derive any specific WTP values for loss/damage. Clearly damage is not important to the great majority of the survey respondents: this finding is consistent with the evidence that the current extent of loss or damage is very small (relative to the values of the goods transported).

8.5 Comparisons between this study's market research scope/methodology and Kim (2014)

Prior to this research project, the only substantive research undertaken in New Zealand relating to freight user valuations of journey attributes was Kim (2014). It was therefore seen as important for our research to examine Kim's research methods and findings on freight valuations – and, where possible, to compare his findings with those from this study.

The scope of Kim's research and this project's differed in four main respects:

1. *Freight sectors covered*. This project covered a sample of all domestic freight movements. Kim's research covered the general freight (retail and manufacturing) sector only (ie essentially our commodity group 1) on the basis that freight movements in that sector are expected to be the most sensitive to time and reliability aspects (many of the international freight studies have covered only this sector).
2. *Survey approach.* This study focused on: i) personal interviews with shippers (largely by phone); ii) obtaining very high response rates, accounting for a large proportion of the total New Zealand freight task; and iii) asking for details of actual sets of trips made and 'pivoting' around these trips to directly determine (maximum) willingness to pay for potential variations in attributes of the existing services. By contrast, Kim's study focused on: i) a mail-out/mail-back survey, covering a potentially large sample of shippers of manufactured goods; ii) obtaining only a low response rate of those approached; and iii) asking for preferences for hypothetical journeys (for full containers or less-than-container (LCL) payloads) according to the mode used (own truck, hire truck, truck and train) and the journey time, reliability and price involved.
3. *Analysis methodology*. Both this study and Kim's study used variants of SP methods, ie essentially analysis methods based on respondents' statements as to how they would behave under specified hypothetical travel conditions. Our study applied a 'contingent valuation methodology', whereas Kim applied a 'choice modelling or choice experiment set (CES) methodology'. Both methodologies are valid, with the choice between them being in part dependent on the survey outputs required (refer also discussion in section 8.1).

4 *Primary outputs.* This project focused on deriving shippers' willingness to pay for changes in travel time, reliability and other freight service attributes, with these results being able to be applied directly for economic evaluation purposes. However, the results cannot be used directly to develop a freight mode choice model. Kim's focus was on developing such a freight mode choice model, which could then be applied to estimate the effects of changes in freight service attributes on mode choice (principally between road and rail). Implicit in his model are WTP values for travel time, reliability and service frequency changes which can (to an extent) be compared with our WTP results.

8.6 Comparative results and conclusions

As Kim's research covered only our commodity group 1 (manufacturing and retail goods), comparisons between the results from the two studies were only possible for this group. The following provides summary comparisons for each of the service attributes addressed for this group:

- *Travel time.* For both studies, estimated values for travel time savings were derived in the same units, ie $ per tonne per hour reduction in travel time. For group 1, our study derived a best estimate of $1.13 (refer table 8.1). Kim's study derived four estimates, $0.55 for long haul FCL, $1.03 for short haul FCL, $2.76 for long haul LCL and $3.20 for short haul LCL[26]. As anticipated, the values per tonne are lower for long haul than short haul, and lower for FCL than for LCL. We expect that our estimate is most likely dominated by FCL movements, probably with more long haul than short haul, but with a mixture of all four of Kim's categories. On this basis, we consider that the correspondence between our group 1 value and Kim's four values is very satisfactory.
- *Reliability.* Our study derived values of reliability in units of $ per tonne per one-hour change in the SD of travel time. This measure, using SDs to reflect reliability, is used in some of the international research on reliability and is also used in the current EEM. Kim's study used a different measure, based on the percentage reduction in lateness. Therefore it has not been possible to compare results for the two different measures.
- *Frequency.* Our study was not able to place a value on WTP for frequency improvements, but all indications were that these were not a substantial concern for the great majority of freight movements (refer section 8.4), so any WTP value for frequency improvements would be relatively low. Kim derived a set of values based on WTP for one increased departure per day (in the context of relatively few departures currently).
- *Freight loss or damage.* Neither study was able to place a significant value on this aspect: this is consistent with the evidence that the extent of any loss/damage currently is very low.

[26] We note that Kim's analyses were undertaken primarily in terms of shipments and there is some uncertainty in converting these to tonnes (which was necessary for comparisons with our study).

9 Development of recommended EEM values of shipper time and reliability

9.1 Overview

This chapter summarises the process undertaken to derive a set of recommended unit values for freight shipper time and reliability improvements suitable for inclusion in EEM, based on the findings from the previous project tasks.

As noted earlier (section 6.1), at the outset of the project the intention was to derive values based on: i) the New Zealand market research undertaken by Kim (2014) for group 1 (general freight) movements; ii) findings from the international literature review undertaken as part of the project; and iii) potentially a limited survey of the New Zealand market to reconcile the evidence from Kim's research and the international review and to estimate values to fill in any remaining data gaps (eg for particular commodities). However, our review of the international literature found that it was inadequate for use in this way, particularly as any commodity-specific data was very sparse and generally inconsistent between studies.

Given this deficiency, it was judged to be necessary to undertake a more comprehensive survey of the New Zealand freight market, by interviews with a substantial sample of domestic freight shippers, with the results from the survey being the primary source of new values (refer sections 8.1 to 8.4). The values obtained from this market survey would then be compared with the evidence from Kim's research (sections 8.5, 8.6) and the international review (chapter 5), in order to identify and potentially address any major disparities.

These values and comparisons between the various sources are summarised as follows:

- *WTP values from study market research*. This is the primary source of values for shipper time and reliability that (with appropriate factoring, etc) would be appropriate for incorporating in the EEM. Table 9.1 (col 5) summarises the relevant values from the market survey in units of per tonne per hour change in travel time or reliability (figures given in NZ$ (2017). Figures are provided for group 1 (alone), groups 2–5 and all groups combined. Note that the market survey found that very few respondents were willing to pay significant amounts for improvements in service frequency or for reductions in loss/damage to freight in transit, so no WTP values for changes in these attributes could be estimated.
- *Comparisons with international literature values.* Chapter 5 outlines our international review, with the key findings being summarised in table 5.1 (travel time) and table 5.2 (reliability). For comparison purposes, our particular focus in the international review was on values of time that could be expressed in $/tonne/hr and values of reliability expressed in $/tonne/hr SD. Given the very wide ranges of values found in the international review, results have been summarised in terms of inter-quartile ranges, as show in table 9.1 (column 3). While the international review provided sufficient data points to derive estimates for most of our five commodity groups, these should be treated with some caution, as they are mostly based on only a few data points (which may relate to widely differing situations). For our group 1, where the best comparisons are possible, it is seen that the market survey value of time estimate lies within (but towards the bottom of) the inter-quartile range of the international values; while the market survey value of reliability is quite close to (less than 5% above) the one value available from the international review.

- *Comparisons with Kim's research.* Sections 8.5 and 8.6 compare Kim's New Zealand-based research, in terms of both methodology and results, with our market survey. These comparisons are summarised in table 9.1 (col 4). Kim's research covered essentially our group 1, but divided this into four sub-groups (according to haul length and LCL/FCL loads). Our group market 1 survey estimate ($1.13/tonne/hr) fits well within the range of Kim's four estimates; this correspondence is very satisfactory. It was not possible to compare our survey reliability values with those from Kim's research, as the units used were incompatible.

9.2 Conversion of market research values to truck/hour basis

All the current EEM values for travel time and reliability savings are based on a unit of per truck per hour, whereas all the study analyses up to this point were on a per tonne per hour basis. Therefore, estimates were required of average net tonnes per truck (per hour) to convert our results into the current EEM units.

This estimation process involved the following steps:

1 Additional questions to 30 of our market survey respondents as to their typical maximum loads carried on a 44 tonne curtain-side truck and trailer unit, on a 50 tonne 50MAX truck, and on larger high productivity motor vehicles (HPMVs).

2 Estimation of average load factors (by total km or hour operated), allowing for estimated levels of back-loading. These estimates were made for commodity group 1 and for groups 2–5 combined, leading to an all groups average figure (refer table 9.1, columns 6, 8). The resulting all groups' average load factor figure was 62%, which compares well with evidence from previous New Zealand studies.

3 Average factors to convert unit values of time savings from per tonne/hour to per truck/hour were thus derived for typical heavy vehicle types, ie 40 tonne gross (HCV2), 50 tonne gross, 50MAX (new HCV) and a 40:60 weighted average of these two types (table 9.1, cols 7, 9, 10).

   A similar process was followed for reliability figures per truck hour. The resultant recommended values from the shipper perspective for both travel time and reliability are given in the five right-hand columns of table 9.1. These weighted average values across all truck types are:

   a For travel time savings: about $8/truck hr for all groups combined, disaggregated into $22/truck hr for group 1, $4/truck hr for groups 2–5.

   b For reliability improvements, about $45/truck hr SD for all groups combined, disaggregated into $173/truck hr SD for group 1, $9/truck hr SD for groups 2–5.

9.3 Development of recommended values for the EEM

As just noted, the right-hand side of table 9.1 presents new values (based on our market survey) for (expected) travel time and for travel time reliability for heavy freight vehicles from the shipper perspective. These values are given in units of per truck per hour (and expressed in NZ$ (2017) prices).

Table 9.1 Derivation of recommended unit values for freight shipper travel time and reliability (NZ$ (2017) for inclusion in EEM

VFTR commodity gp	Current EEM	International (i/quart range)	Kim (2014)[b]	Study market survey	This study – recommended shipper values for EEM – by truck capacity				
	HCV2				HCV2		New HCV		Average
					44 tonne gross capacity		50 tonne gross capacity		40% 44 tonne, 60% 50 tonne
EXPECTED TRAVEL TIME (VoT)									
	Av load tonne	**Per tonne per hr**	**Per tonne per hr**	**Per tonne per hr**	**Av load tonne**	**Per truck per hr**	**Av load tonne**	**Per truck per hr**	**Per truck per hr**
Group 1		$1.03–$5.76	$0.55, $1.03 $2.76, $3.20	$1.13	17.40	$19.66	20.66	$23.35	**$21.87**
Groups 2-5		$0.42–$4.55		$0.26	14.85	$3.86	17.33	$4.50	**$4.24**
Groups 2,3,5		$0.42–$4.55							
Group 4		$0.34–$3.66							
All groups	$3.18[a]	$0.52–$5.91		$0.45	16.74	$7.53	18.91	$8.51	**$8.12**
RELIABILITY OF TRAVEL TIME (VoR)									
		Per tonne per hr (CPCS only)		**Per tonne per hr SD**	**Av load tonne**	**Per truck per hr SD**	**Av load tonne**	**Per truck per hr SD**	**Per truck per hr SD**
Group 1	na	$7.24		$8.95	17.40	$155.73	20.66	$184.93	**$173.25**
Groups 2–5		$3.36–$9.65		$0.57	14.85	$8.47	17.33	$9.88	**$9.32**
Groups 2,3,5		$4.76–$12.05							
Group 4		$3.72							
All groups	na	$3.72–$7.24		$2.52	16.74	$42.18	18.91	$47.65	**$45.46**
RELIABILITY RATIOS (VoR : VoT)									
Group 1		0.4–1.33		7.9	na	7.9		7.9	7.9
Groups 2–5		0.48–2.20		2.2		2.2		2.2	2.2
Groups 2,3,5		0.50–2.40							
Group 4		0.6–1.05							
All groups		0.4–2.13		5.6	na	5.6		5.6	5.6

[a] EEM 2002 number $2.16 *1.47 as per EEM July 2017 update (but based on freight stockholding costs: see sections 3.2 and 10.2 of this report).

[b] Kim order CES 1 (FCL interisland); CES 2 (FCL within island); CES 3 (LCL interisland); CES 4 (LCL within island).

For application of these new values for travel time in the EEM, it was necessary to:

- separate the current EEM figures between the freight (shipper) component (the smaller part) and the vehicle-related (transporter) component (the larger part)
- deflate the market survey values to NZ$ (2002), for consistency with all the benefit values in the current EEM
- adjust for any double counting between the benefit categories covered in the market survey and those already covered in the shipper component of the EEM values
- appropriately extrapolate from the shipper values of the market survey for heavy freight vehicles to also cover light and medium freight vehicle categories.

These processes for travel time are outlined in section 9.4, resulting in an amended version of the current EEM, table A4.2. The equivalent processes for reliability are somewhat simpler and are outlined in section 9.5.

9.4 Derivation of new EEM travel time values

It was noted earlier that current EEM resource values of time savings for freight vehicles already include a small component that relates to stockholding costs (calculated based on values of goods in transit and on time spent in transit) and expressed in units per truck hour. This component is $2.16 per truck hour (NZ$ (2002 prices)[27] for HCV2 vehicles and correspondingly lesser amounts for light and medium commercial vehicles.[28] Details are provided in chapter 2 and appendix A (table A.1).[29]

This $2.16 figure is essentially a shipper-related cost already covered in the market survey; it should therefore be replaced by the (considerably larger) market survey figure.

The amended numbers (including the shipper-related values with adjustment for double-counting) should be applied in the same way as those in the present EEM table, A4.2. Table 9.2 below gives the new set of EEM values (expressed in NZ$ (2002). The values in this table should be adjusted for subsequent years simply by applying the EEM relevant published uplift factors for values of time (refer EEM, appendix A12.3).

Table 9.2 uses the standard categorisation into light, medium and heavy commercial vehicles (LCV, MCV and HCV respectively), and the sub-division of heavy vehicles into two classes. We have added a category for 50MAX, and a 40:60 weighted average of HCV2 and 50MAX.

The current study focused on HCV2 and heavier vehicles. Figures for lighter vehicles are assessed using the shipper values per tonne per hour from the study ($0.45 for all groups; $1.13 for group 1, in 2017 dollars), together with estimates of the load capacity (gross weight less tare).[30] Similarly, as the EEM

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[27] This $2,16 (2002) figure equates to the $3.18 (2017) figure derived from the market survey (refer table 9.1, col 2).

[28] We note that the $2.16 figure is not separately identified in the current EEM table A4.2; it can be derived only from access to various Waka Kotahi file papers, which are now around 15 years old.

[29] The current EEM figure of $2.16 attributed to stockholding costs varies by size category of commercial vehicle but not according to the commodity group carried.

[30] Estimated gross weight LCV 12 tonne, no trailer (tare 5 t); MCV 20 tonne, including trailer (tare 10 tonne); HCV1 30 tonne, including trailer (tare 14 tonne). Gross weight based on *WIM annual report 2016* (NZ Transport Agency 2016b) for MCV and HCV1; assumed LCV is Waka Kotahi's vehicle equipment standards class. Note that HCV2 gross weight is the maximum pre-high productivity motor vehicles weight of 44 tonne. Gross load capacity derived by

does not have vehicle values for vehicles heavier than HCV2, equivalent vehicle values for these were scaled from the 44 tonne HCV2 value.[31]

Where there is sufficient information on traffic composition, the higher numbers for group 1 (general freight) could be used, or the weighting between general and other freight adjusted to better reflect the specific traffic composition. Similarly, we have used the heaviest class of vehicle to derive the numbers, as these handle most of the traffic. The new time values are based on a per tonne of freight per hour unit, so can be readily adjusted for different vehicles, different average loads, and different mixes of 44 tonne and heavier vehicles where the required traffic information is available. Where average loads are available for lower weight classes of vehicle, the shipper value can be calculated. For LCV and MCV the general freight number might be more applicable than the overall values.

Table 9.2 Values of time combined with current EEM vehicle values, in $NZ (2002) (per truck per hour)

$2002	LCV	MCV	HCV1	HCV2	50MAX	Weighted
Current EEM: Vehicle and freight (EEM)[a]	1.70	6.10	17.10	28.10		
Freight component[a]	0.13	0.50	0.92	2.16		
Net vehicle	1.57	5.60	16.18	25.94	29.47b	28.10
This study: This study – all groups [c]	1.33	1.90	3.03	5.12	5.79	5.52
This study – group 1[c]	3.90	5.57	8.91	13.37	15.88	14.88
Recommended EEM: Rec. vehicle and freight – all groups[d]	2.90	7.50	19.21	31.06	35.26	34.62
Rec. vehicle and freight – group 1[d]	5.47	11.17	25.09	39.31	45.35	42.98

[a] See appendix A, table A.1; EEM table A4.2

[b] 50 tonne is 44 tonne scaled by factor 50/44

[c] $ (July 2002); this study's values divided by Waka Kotahi uplift factor to July 2017 (1.47)

[d] Sum of 'net vehicle' and 'this study'.

9.5 Derivation of new EEM reliability values

The current EEM provides a generic methodology for estimating the benefits of any changes (positive or negative) in reliability for road traffic in general, and these include a different multiplier factor for freight movements relative to other traffic movements. In the case of freight movements, it is unclear in EEM whether the benefits calculated using this methodology are benefits to the transport operator (allowing for improved vehicle utilisation etc) or benefits to the freight shipper. Following discussions on this point with

using tare weights based on Isuzu trucks and truck rentals trailers. Load factors as for HCV2 (details given in appendix G.6).

[31] There would be merit in updating EEM on a more precise basis for these heavier trucks, perhaps as a new HCV3 class.

Waka Kotahi (steering group members and peer reviewers), we have taken the view that any reliability benefits calculated through the current EEM methodology are a proxy for benefits to the transport operator, not the shipper.

On this basis, the full reliability benefit values estimated in our market research (as given in table 9.1) should be treated as benefits to shippers additional to any reliability benefit figures currently in EEM. These shipper unit reliability benefit values by vehicle category are given (for all commodity groups and for group 1 only) in table 9.3, in NZ$ (2002).

These new reliability figures were derived on a per tonne basis (in 2017 dollars), based on $2.52 per tonne per hour SD for all groups, and $8.95 for group 1: they can be readily scaled to reflect specific vehicle sizes and traffic mix. Note that while the unit reliability benefit values are apparently large numbers (averaging $28.69 (NZ$ 2002) per truck per hour change in the SD of travel time for HCV2 trucks), a reliability improvement of this magnitude seems unlikely to be obtainable on most truck trips.

Table 9.3 Values of unit shipper reliability benefit values in $2002 (per truck per hour change in SD)

$2002	LCV	MCV	HCV1	HCV2	50MAX	weighted
All groups	7.44	10.63	17.01	28.69	32.41	30.93
Group 1	30.90	44.14	70.63	105.94	125.80	117.86

Notes (a) and (c) from table 9.2 also apply to this table.

9.6 Additional comments on application of shipper travel time and reliability benefit values

We provide the following additional comments relevant to application of the new shipper travel time and reliability unit values.

Mode independence of values. In principle, since the values in tables 9.2 and 9.3 represent shipper values of time and reliability, they are mode independent. However, one issue is that the traffic mix on rail tends to differ from that for the market as a whole, including less ‘general freight’ and more of the other commodity groups. To the extent that specific information is available, the appropriate commodity value or weighting should be used rather than the overall market figure.[32]

Non-linearities in valuations of travel time and reliability benefits. Normally in EEM applications, the benefits of transport system improvements are translated in linear fashion into economic benefits, ie assuming a given travel time or reliability change results in similar benefits in all situations. Clearly, this is only a convenient approximation to real-world circumstances:

- For many heavy freight movements (by whichever mode), the shipper’s main concern is commonly whether the freight arrives ‘just in time’ to meet its delivery target (‘time-gate’): any changes in travel time or reliability improvements such that freight arrives significantly before, or after, this target are likely to be of little value to the shipper.

[32] With further analysis of the market survey results, some conclusions may possibly be drawn on relative shipper valuations of reliability improvements for commodities currently carried by rail and those carried by road (but it would most likely be found that our sample contains too few rail movements for useful conclusions to be drawn).

- A 'time-gate' approach is difficult to apply in practice to multiple movements on a road or rail network. It might potentially be applied to examine the benefits to specific major traffic movements (by road or rail) of specific changes in network expected time and time reliability. In such an application, the benefits could be very large where a time-gate can be met where previously it was difficult to meet, but otherwise would most likely be very small or negligible. Further exploration of such approaches is beyond the scope of this project.

While these comments potentially apply to freight carried by both road and rail, the issue is perhaps of greater importance for rail freight, given rail's generally lower frequency of service and lower level of reliability than road freight in many situations.

10 Conclusions and recommendations

This research project investigated the willingness to pay of shippers of freight within New Zealand for improvements in expected journey time, reliability of journey times, frequency of freight services and loss/damage to freight in transit. It focused on a SP survey (using the contingent valuation methodology) of New Zealand freight shippers, covering some one-third of the New Zealand domestic freight task (measured in tonne-km). It included an extensive international literature review of evidence on the willingness to pay for journey attributes by freight shippers. The primary output was a set of travel time and reliability values for road and rail freight movements in New Zealand, for inclusion in the EEM used for the ex-ante economic appraisal of transport projects.

Our conclusions and recommendations resulting from this research project, and relating to each of the project objectives, are set out in table 10.1 (following).

Table 10.1 Project objectives, conclusions and recommendations

Project objectives[a]	Conclusions	Recommendations
1. Develop enhanced/updated unit mean values of travel time (savings) and of travel time reliability (savings) for freight transport movements in New Zealand – by building on previous New Zealand and international research and analysis methods.	• This objective has been fully achieved – refer executive summary and chapter 9 in particular.	• Refer item 2 below.
2. Provide the outputs in a form appropriate for incorporation in EEM.	• This objective has been fully achieved – refer chapter 9 (sections 9.4, 9.5) in particular.	• The new freight shipper values for travel time and reliability are recommended to be incorporated in the next update of EEM (principally in EEM table A4.2). • Refer also last recommendation below (under item 6).
3. Illustrate the application of the recommended methods and values through case studies.	• This objective was not achieved. Waka Kotahi was unable to provide any case study material relating to previous project evaluations with suitable form and content (appendix I summarises the work undertaken on case studies.)	• It is recommended that further work be undertaken to satisfy this objective. This would involve completion and presentation of selected case studies, either existing or planned, to illustrate the application of the recommended new EEM values. This would be dependent on Waka Kotahi being able to provide appropriate information from the evaluation of selected roading projects. • These case studies could be published as a separate document and/or included (maybe in summary version) in the updated EEM.
4. Provide a peer reviewed research report, consistent with the above and the specific deliverables listed in the Request for Proposals.	• This document is the peer-reviewed research report that addresses the specified objectives and deliverables. • A presentation (PowerPoint) has also been provided, as specified, summarising the main study tasks and their findings.	• This research report has been approved by the two peer reviewers and is recommended for publication. • Its recommendations should (as appropriate) be incorporated in the next update of EEM.
5. Develop proposals for dissemination and promotion of the research and its findings and recommendations.	• Dissemination and promotion of the research (while in progress) has already been achieved in part through presentations to the NZ Transport Knowledge Conferences in November 2017 and November 2018.	• It is recommended that further dissemination/ promotion be best undertaken as part of the wider process for disseminating/promoting the next EEM update (assuming that the project recommendations are to be incorporated in that update).
6.		• It is recommended that further work be carried out to restructure the sections of EEM covering operating cost and benefit parameters, in particular to better distinguish between transporter cost items and user (including shipper) benefit items (refer in particular section 2.2 and appendix D of this report).[b]

Notes: [a] The project objectives are as set out in the consultant proposal (refer chapter 1).

[b] This is an additional recommendation arising from the project work (but not covered in the original project objectives).

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Appendix A: Current EEM road freight procedures, values and issues (travel time, reliability, vehicle operating costs)

A1 Introduction

Valuing freight transport time and reliability involved researching:

- documentation of the current EEM procedures and values, and their methodological basis; followed by
- critical appraisal of the methodologies involved.

In the context of estimating the economic benefits of roading system improvements (that would potentially benefit both road freight and other road users), the EEM provides unit benefit values under three categories:

1 Travel time values (EEM, section A4)

2 Trip time reliability benefits (EEM, section A4.5).

3 Vehicle operating costs (EEM, section A5).

In all three categories, the unit benefit values provided relate largely to the costs experienced by the transport operator, rather than other perceived costs and benefits that may be of interest to the shipper (and which are the primary concern of this research project).

In order to separate out and assess the cost and benefit components of interest to the shipper, additional to the direct transport costs, this appendix analyses all the EEM cost components in the above three categories, in the following sections:

- time-related costs (EEM, section A2)
- reliability-related costs (EEM, section A3)
- vehicle operating costs (EEM, section A4)
- summary and commentary (EEM, section A5).

Note that all the cost and benefit values given in this appendix are resource costs, appropriate for application in economic valuation. These differ from behavioural costs and are after deduction of indirect taxation (principally GST). All values given, except where specifically noted, are in NZ$ (July 2002) (which is the price base used in EEM for all the items covered in this appendix).

A2 Time-related costs

This section summarises current EEM values of time for commercial vehicle (light/medium/heavy) travel in the course of work. It covers time-related costs for: i) vehicle occupants (driver, passenger where applicable); ii) the freight carried; and iii) the freight vehicles themselves.

Table A.1 provides a summary of the relevant EEM values. The following points should be noted in relation to this table:

- The top two (numerical) rows comprise behavioural values for commercial vehicle drivers and passengers. These are intended for use for behavioural/demand modelling rather than directly for economic appraisal (they are included here for completeness).
- The equivalent appraisal values are given in the third (numerical) row – using an 'equity' value for work travel across all modes, based on the EEM behavioural value derived for car drivers.
- The following row provides a composite value covering the freight carried and the freight vehicles themselves, as described below.
- The final row specifies the component of the row above that relates to the freight carried.
- The base occupants' values of time may be augmented to reflect congested conditions. The values given in the RH column reflect the maximum increment applicable for transport in congested conditions (details not given here – refer EEM, section A4.4).

Table A.1 EEM road freight – values of time summary (work travel) – $/hr [a,b,c]

Item	Freight vehicle category				CRV max increment[g]
	LCV	MCV	HCV1	HCV2	
Behavioural values[d]					
Driver	23.45	20.10	20.10	20.10	3.15
Passenger	21.70	20.10	20.10	20.10	2.35
Resource values					
All occupants[e]	23.85	23.85	23.85	23.85	3.15
Vehicle and freight [f]	1.70	6.10	17.10	28.10	--
Freight component [h]	*0.13*	*0.50*	*0.92*	*2.16*	

Notes:

a All data from EEM, section A4.

b All figures given in July 2002 prices. Price escalation factor to July 2017 is 1.47 (EEM, section A12.3).

c Figures relate to in-work travel only (EEM also gives separate figures for commercial vehicle travel for commuting and other non-work travel purposes).

d From EEM, table A4.1(a).

e From EEM, table A4.1(b).

f From EEM, table A4.2.

g Represents maximum incremental values for congestion (denoted as CRV), which are additional to the base travel time values.

h This row represents the component of the row above that relates to the value of the freight carried, accounting for 'reduction in stockholdings between the points of production and consumption and perishable cargo. . . being delivered in better condition, with higher market value' (ref Technical note: Vehicle and freight travel time savings in the *Project evaluation manual*, IH Bone, 22 April 1999 (draft)).

We note that the 'vehicle and freight' cost item in the last but one row of table A.1 includes a component for vehicle-related standing charges (incurred irrespective of use), although no further details are given in EEM (refer EEM, section A5.2 and further discussion in section A4 of this appendix). We understand this component to include vehicle depreciation related to elapsed time (rather than distance operated) and such vehicle 'fixed' costs as registration and possibly some components of vehicle insurance, depot-related expenses, etc.

In our view, vehicle-related standing charges such as these would normally be treated as a component of VOC, not of VoT (as they do not vary with the time that the vehicle is in use, like other VoT components).

This would also be consistent with the way in which such standing charges are categorised for passenger cars in EEM.

Therefore, in comparing any freight sector values of time from elsewhere with the EEM values, it will be important to ensure that comparisons are on a ‘like-for-like’ basis; typically, this would involve excluding such vehicle-related standing charges in both cases.

The earlier Waka Kotahi NZ Transport Agency research report (Bone et al 2013, section 3.2) contains further details on the New Zealand research and development of evaluation values of time for commercial vehicles and freight, for incorporation in EEM, since the early 1980s.

A3 Reliability-related costs

EEM, section A4.5 provides a set of procedures for estimating the benefits from improvements in trip time reliability (variability). While these procedures apply primarily to private road vehicle travel they may also be applied to commercial vehicle/freight movements.[33]

(Un)reliability represents the unpredictable variations in journey times which are experienced for a journey undertaken at broadly the same time every day. For road-based travel, the impact is related to the day-to-day variations in traffic congestion, typically as a result of day-to-day variations in traffic flow (this is distinct from the variations in individual journey times, which occur within a particular period).

Travel time variability in EEM (and often in other economic evaluation guidelines) is expressed in terms of the SD of travel time. EEM, section A4.5 states that the benefits to a commercial vehicle from a reduction in travel time variability (TTV) on the route used are to be calculated as the product of:

- reduction in TTV (calculated as the change in the travel time SD, expressed in minutes)
- relevant value of travel time savings (eg refer table A.1)
- 1.2 factor.[34]

Travel time reliability is in principle calculated for a complete journey, with the total network variability being the sum of the TTV for all journeys on the network. In practice, models may not represent the full length of journeys and this is accounted for in the EEM procedures.

The sources of variability are road sections and intersections: reduced variability arises from a reduction in congestion on links and at intersections along a route. The EEM procedures relate reliability and associated benefits in large measure to the volume: capacity (V/C) ratios on the links and intersections traversed.

The EEM procedures for estimating changes in TTV are relatively complex to apply, requiring the running of a detailed traffic model. Here, for illustrative purposes, we take a short-cut approach, based on experience from more detailed studies where the incremental value of reliability benefits has been derived as a proportion of the base travel time benefits. We were advised that, typically, the incremental reliability benefit is in the range 5%–8% of the base travel time benefit. However, this percentage figure is based on a typical urban traffic mix: for commercial vehicles, the figure would be around 25% higher (EEM, section

[33] Bone et al (2013) notes that ‘the EEM currently does not provide for the evaluation of reliability… for commercial vehicles and freight’*:* however, we think this statement is incorrect.

[34] EEM gives this factor as 0.9 for a typical urban traffic mix but notes that for commercial vehicles a factor of 1.2 should be used.

A4.5). This indicates that a typical travel time reliability benefit for commercial vehicle traffic would be around 8% of the base value of time savings for such vehicles.[35]

The EEM procedures note that the formula for estimating the SD of travel time applies to ‘normal’ variability experienced day-to-day in congested traffic conditions; it does not allow for ‘extreme’ variability resulting from traffic incidents or other causes. It is also notable that the procedures link reliability directly to levels of congestion (V/C ratios), so there is no basis for evaluating any interventions that may reduce TTV while the degree of saturation remains unchanged.

A4 Vehicle operating costs

This section summarises EEM information on VOC procedures and values, but only to the extent necessary to clarify how freight vehicle depreciation charges are treated between the travel time category (EEM, section A4) and the VOC category (EEM, section A5).

EEM, section A5.1 calculates VOC values in the following components:

- base running costs, varying by speed and gradient
- road roughness costs
- road surface texture costs
- pavement elastic deflection costs
- congestion costs
- bottleneck costs
- speed change cycle costs.

Except for the base running costs, all components are expressed as marginal (incremental) costs, reflecting the additional cost over the base level associated with that component.

The VOC base running costs comprise four main cost categories: fuel/oil, tyres, repairs and maintenance and use-related depreciation. The proportionate cost breakdown between these categories is set out in table A.2.

Table A.2 Breakdown of base VOC cost category[a]

Vehicle class	Percentage of total base VOC by cost category			
	Fuel and oil	Tyres	Repairs and maintenance	Depreciation
LCV	32.3	8.3	27.3	32.1
MCV	30.4	7.2	45.4	17.0
HCV1	34.7	10.5	44.3	10.5
HCV2	31.3	13.5	43.4	11.8

Notes: [a] From EEM, table A5.0(a).

EEM, section A5.2, states that ‘Standing charges, ie those incurred irrespective of use, are excluded from these costs. Such charges are included in the travel time costs for vehicle types’ (table A4.2)

[35] We note that this percentage appears to be low relative to most international analyses we have examined.

We understand that freight vehicle standing charges are currently included in the ‘vehicle and freight’ resource values in the last row but one of table A.1 (although in our view they would be better treated as a VOC component). However, the EEM does not appear to specify the values of those charges for each commercial vehicle category, nor the methodology used for their derivation.

A5 Findings and commentary

The present EEM is concerned primarily with unit cost (and benefit) values (of time, operating costs, reliability, etc) suitable for applying in economic (resource cost) appraisals of transport improvement projects. The values currently specified for road freight transport primarily reflect the (financial) costs of providing truck operations, but also contain some components relating to other economic costs associated with freight movements, not incurred by the trucking company: one example is the stock-holding costs associated with the time freight is in transit. However, the EEM does not clearly distinguish between those (financial) costs incurred by the transport operator and those other (perceived) costs experienced by the freight shipper.

Such a separation is significant in the context of the current research, where we are interested specifically in the economic costs (and benefits) perceived by the freight shipper, separately from the direct transport costs incurred. Appendix D2 of this report outlines a suggested approach to re-formulating the relevant sections of the EEM to make clear the distinction between the (financial) costs incurred by the transport operator and the other (perceived) costs and benefits to the freight shipper.

Consistent with the approach proposed in appendix D, table A.3 separates out (to the extent possible) those EEM cost components (unit values) that reflect direct financial costs to the transport operator from those additional components reflecting perceived costs and benefits to shippers.

For this project, the EEM coverage of the perceived shipper costs is most relevant, as shown in the lower half of table A.3. Our main findings in this regard are as follows:

- *Journey time related costs.* EEM values are understood to contain a component representing stock-holding costs for goods being transported. While this component is not separately identified in the EEM, estimates of this component have been made from earlier work.
- *Journey time variability costs*. The EEM includes methods to derive the incremental economic costs for travel: i) in congested conditions; and ii) in situations where travel time is unreliable (variable). For private vehicle travel, where travel time values are based on travellers’ WTP valuations, it is clear that the congestion/unreliability incremental costs reflect the dislike of travel in these conditions. For commercial/freight travel, where travel time values are based on transport labour costs (MPL basis), it is less clear whether congestion/unreliability incremental values reflect additional costs incurred by the transporter or cost penalties (inconvenience, etc) experienced by the shipper. Having discussed this issue with Waka Kotahi (steering group members and peer reviewers), we have assumed that any congestion/unreliability values (as per the EEM formulation) are a proxy for additional costs experienced by the transporter – rather than a component of shipper costs. They are therefore shown in section A (rather than section B) of table A.3.[36]

[36] This supposition was to be examined was to be examined as one output of the proposed market survey.

- *Service frequency costs*. As indicated in the table, the EEM does not include any value functions that reflect perceived benefits to shippers of having more frequent services available.[37] We anticipate that some freight shippers would perceive significant benefits from the availability of more frequent transport services – this is one aspect covered in the project's market survey.

In summary, our assessment of current EEM procedures and associated unit cost and benefit values relevant to road freight transport indicates that:

- In the context of this research project and more widely, there would be merits in the EEM providing a clearer separation between the financial costs of truck-based transport and the wider economic (WTP) costs perceived by freight shippers.
- These perceived shipper costs and benefits are not all valued, or are inadequately valued, through the current EEM procedures. This seems likely to be the case particularly in relation to journey time variability (reliability) costs. The only component of freight shipper costs included in the current EEM values is that relating to freight stockholding and perishability/ damage costs: it is unclear whether the current EEM values are a good representation of these costs.
- This reinforces the desirability of investigating the values that shippers place on all the various features of transporting their goods - which was investigated through the project's market survey.

[37] By comparison, the EEM does include functions that estimate benefits to public transport users from having more frequent public transport services available. However, unlike for public transport, decisions on freight service frequency are made in the private sector, largely independent of the state of the road network. Therefore, any frequency benefits are essentially independent of decisions on road investment and so are not included in CBA.

Table A.3 EEM current road freight-related unit values for economic evaluation

Cost or benefit category	Items covered	Base value[a]	Source/EEM ref[b]	Notes/comments
A. Transport operator (financial) costs				
1. Truck occupant time costs	Driver (and passenger) time	$23.85/veh hr	EEM, table A4.1(b) [table A.1]	• 'Equity' value applies to driver only (same values per work-related passenger). • Excludes any congestion increment (refer item A4a below in this table).
2. Fixed (elapsed time) vehicle and overhead costs	Vehicle-related and operator overhead costs	$25.94/veh hr (HCV2)	Table A4.2 [table A.1]	• Includes vehicle time-related depreciation and vehicle 'fixed' and overhead costs. • Excludes value of freight carried (refer item B.1 below in this table).
3. Variable distance-related truck operating costs	Vehicle use (distance)-related operating costs	$1.00/veh km (HCV2)	Table A5.0[a] [table A.2]	• Covers vehicle R&M, fuel/oil, use-related depreciation and tyres. Excludes all fixed and semi-fixed charges (refer item A.2 in this table). • Multiple adjustments apply to these 'base' costs to allow for a range of operating conditions (refer EEM A5.1 etc).
4. Journey time variability costs	a Congestion value of time (CRV) increment	$3.15/veh hr (HCV2–max)	Table A4.1(b), A4.4	• EEM (A4.4) notes that 'Road users value relief from congested traffic conditions over and above their value of travel time savings'. Consistent with this, we understand that the CRV incremental values reflect the incremental WTP of private car users to avoid congested conditions. But this argument does not clearly hold for business and commercial travel, where VoT values are based on the MPL approach. Following discussions with Waka Kotahi, we have taken the congestion increment as a proxy for any additional transport operator costs associated with congested conditions.
	b Journey time reliability increment	Typical value for truck traffic, c.8% of 'base' time benefits (ie items A.1, A.2 above in this table).	A4.5	• As for congestion (above), for commercial/freight travel, we take any incremental reliability costs and benefits as a proxy for any increases in transport operator costs associated with journey time unreliability (but noting that the distinction between congestion impacts and reliability impacts is somewhat artificial). We also note the EEM specifies that potential reliability benefits are to be estimated as a product of (among other factors) the SD of journey tine and a 'reliability ratio' factor for commercial vehicles of 1.2.

Cost or benefit category	Items covered	Base value[a]	Source/EEM ref[b]	Notes/comments
B. Freight shipper (perceived) costs				
1. Journey time-related costs	Freight stockholding and perishability/ damage costs	$2.16/veh hr (HCV2)	EEM, table A4.2 (component only) [table A.1, last row]	• This component relates to stockholding costs (related to freight value) and any perishability/damage costs. Refer table A.1. • Unclear whether current EEM figures are a reasonable estimate of these cost items as perceived by shippers.
2. Service frequency costs	Not covered	--	--	• No mention of freight service frequency costs and benefits. (By contrast, this by the public sector).

Note:

[a] All values given in July 2002 $ except where noted. (Update factor for travel times to July 2017 $ is 1.47 – EEM, table 12.2).

[b] References in [ ] relate to sections of this appendix; unbracketed references relate to sections in the EEM.

Appendix B: International literature review

B1 Introduction

This international (including New Zealand) literature review considered over 160 papers, reports and other material on the subject of valuing time, reliability, frequency and loss or damage. The focus of this review has been on the valuation of these attributes as it relates to the freight itself, rather than the operating costs of trucks or rail. That is, what do freight owners regard as the costs to them of their freight taking longer to arrive, or its arrival being unpredictable. It encompasses (Hirschman et al 2016, p41)[38] 'Cargo-related supply chain costs including cost of capital incurred from delays in getting intermediate products to production facilities, opportunity cost of delayed final sales, admin and management, insurance, product spoilage, reduced production efficiencies'. These are not called inventory costs by Hirschman because shippers rarely hold extra inventory to mitigate trip time uncertainty.

It does not include vehicle operating costs or driver costs from the perspective of the transport operator (together 'VOC'). These tend to be much larger than values associated with the freight itself. The EEM already has adequate values for VOC[39]: these values are nevertheless relevant when comparing options that the shipper may take, in the sense that the prices shippers face are likely to closely reflect operating costs. As a very simplified example, a shipper may be faced with a choice between two options, one costing it $100/tonne and taking 10 hours; and another costing $200/tonne and taking five hours. Both these numbers will include VOC. If the shipper values the quicker option enough for it to pay the extra cost, then we can say that it values the five-hour reduction at least at $100/tonne or $20/tonne/hour. In this case while the numbers have a foundation in operating costs, the choice made represents the value to the shipper. It appears however that some studies include the value of time from a carrier perspective, which will include VOC directly, and do not separate out these VOC from the values for freight, making them difficult to interpret.

Values of time are expressed in the studies as dollars (or other currency) per shipment per hour, or per truck per hour, or train per hour. For the purposes of EEM it is desirable to express the values as per tonne per hour, so without a key to tonnes per shipment a number of studies are less useful. Similar issues arise with reliability. Some studies have such a key, typically around 15–20 tonne per shipment, ie for a typical truckload of manufactured or retail goods: while it is tempting to use this as a rule of thumb, there is no evidence that that same relationship would apply to other studies. Nevertheless, Feo et al (2011) have used 15 tonne/shipment as a working hypothesis.

We are thus confined to a relatively small number of studies that have values per tonne. We have updated these values to current NZ$ (2017), as described in the next section. For completeness, we have separately included studies expressing values per shipment, despite the difficulties they raise.

Internationally, the studies tend to be focused on particular countries where researchers or government agencies have pursued the topic, principally Sweden, the Netherlands, Britain, the US, Australia and New Zealand. Tables are presented for travel time (section B2) and reliability (section B3), for which a reasonable amount of data exists, and also for frequency (section B4) and loss/damage (section B5), which are poorly researched. A commodity summary is also presented for time and reliability for those

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[38] Detailed references are given in the master reference list for the whole report

[39] EEM, section A4

studies that included commodity values. As Feo-Valero et al (2011) say, the results in various studies ‘vary enormously’. That verifies, they say, that VoT for freight ‘is highly dependent on factors such as the type of freight being transported, type of transport, and the origin of the shipment’. They caution about extrapolating results from one situation to another.

In the absence of quantified information, the classification of service attributes may be useful as an indicator of relativity between the key attributes studied for this report. Studies ordering attributes, both mode-neutral and for mode choice, are set out in section B5. To the extent that studies have taken a WTA approach, a comparison with willingness to pay is given in section B6.

B2 Time

B2.1 Overview

Values of time (savings) in the literature are denominated in a range of currencies, and naturally at different dates. To bring them to a comparable state, we have undertaken a two-step process. First, the values have been converted to NZ$ by using the OECD purchasing power parity indices for NZ$ and the relevant currency at the time of the study, which give an NZ$ equivalent at the currency date in the study (or failing that, date of the data, or in the last resort of the study). Secondly, we have scaled that NZ$ value to a 2017 value by use of GDP per capita data, for March in each year to 2017. GDP per capita better represents the income growth of the economy, and thus the willingness to pay for service attributes, than using prices adjusted using CPI as an inflator. The actual GDP per capita series used was the ‘expenditure measure’ series in the ‘SNE’ group, from Statistics New Zealand. This series is not available prior to 1992, as a result of a discontinuity on the population side, and so values in earlier studies are based on the SND series for GDP and an estimated correction to population,[40] or on conversions to another currency and date in later studies. All values in this paper are thus in NZ$ (2017).

The data below is presented in three ways. The first is a commodity-by-commodity analysis, for those studies that present it in that way. The second is an analysis by the nature of the transport – by mode, or container, or LCL/bulk, and similar variables. There is little consistency among the studies in this regard. The third looks at all other unclassified values given: it is probable that these relate to general manufacturing freight. In all cases the numbers may be reported as per tonne or per shipment (per hour) and this is reflected in the analysis.

This still leaves considerable variability in the numbers. Some of this may be due to the inclusion of vehicle operating costs in the figures, which is not always apparent. Other variation might be in the classification of the freight. A further source of variations is likely to be the methodology differences between studies. But it is possible to derive some patterns.

B2.2 Commodity view

As noted in the introduction, commodity classifications vary widely. We have attempted to match some of the definitions to reduce this variability, for example treating ‘other manufacturing’ as the same as ‘processed goods’, ‘distribution’ and ‘consumer goods’ as the same, and equating ‘food’ and ‘perishable goods’.

As described in appendix F, this study has adopted a grouping of five sets of commodities:

[40] Following discussions with and guidance from Statistics NZ

1 Retail, manufacturing, general freight
2 Perishable exports
3 Other containerised exports and precursors
4 Bulk exports
5 Other domestic commodities.

Ideally, we would match the international studies by commodity with these groupings. Unfortunately, on a commodity basis there are few studies for each commodity, even with the combinations noted in the previous paragraph. Moreover, some of our groupings are not represented very fully, or not at all. Many of the studies are testing methodologies, and naturally include commodity groupings where time is valuable for the commodity, and deal less with those with lower or nil time values.

Group 1: Retail, manufacturing, general freight

Most of the international studies concern commodities that we have classified into group 1. These are variously called electronic, consumer goods, technical goods, processed goods, semi-processed goods, and automotive parts. In NZ$ (2017), the values of time savings for these ranged from zero per tonne per hour to $10.61, and from $5.76 per shipment per hour to $429. The median values are $2.76 per tonne and $84.89 per shipment. Inter-quartile values, which exclude outliers, are $1.03–$5.76 and $39.41–$211 respectively. Fridstrom (1995) identified a value of zero for frozen goods, edible goods (other than refrigerated), and raw materials. De Jong et al (2000), however, estimated low-value raw materials and semi-processed goods at $6.83/tonne/hr.

Kurri et al (2000) identify ‘electronics industry’, ‘daily goods’ (interpreted by Feo et al (2011) as consumer goods), and ‘technical goods’, with road transport values per tonne per hour of NZ$ (2017) $9.45, $4.23, and $2.72 respectively. It is reasonable that final consumer products are valued the highest. They do not appear in the commodities covered by rail, probably because they are time sensitive. In fact, none of the group 1 products are in their rail list. Kurri’s figures appear to be a blend of willingness to pay and willingness to accept values.

De Jong et al (2014) identify the difference between ‘final products, loss of value’ and ‘final products, no loss of value’ as a value for time itself of $5.85 per shipment per hour, or $0.81 per tonne per hour.

In Australia a two-stage study examined inter-city and intra-urban movements on a pallet/hour basis. Stage 1 covered a range of manufacturing industries, including automotive parts, food and beverages, some building materials, and packaging. This is reported in Wigan et al (2000). The second stage study was confined to the automotive industry and is reported in Austroads (2003). Wigan values inter-city full truck loads (FTL) at $1.49/pallet/hour, and FTL urban at $2.94. less than truck load (LTL) urban (out of scope for this study) was higher. Austroads values inter-city FTL at $3.15 and urban FTL at $1.68.

In New Zealand, Kim’s (2014) study focused on this group. He presented four scenarios from his choice experiment sets: inter-island long haul FCL ($0.55 per tonne per hour), intra-island short haul FCL ($1.03); inter-island LCL ($2.76) and intra-island LCL ($3.20). Further details are given in appendix F.

Group 2: Perishable exports

There were no studies that identified values for the particular commodities in this group, which covered raw milk, meat, fish, and horticulture. The commodity mix of the studies naturally reflects the economy of the country studied, and with the predominant European/North American focus of these studies, it appears that this group is less important in their economies than in New Zealand’s. A recent Florida study

(CPCS 2017) did however identify an overall ‘perishable’: category, valued at NZ$ (2017) 1.04/tonne/hour. An earlier study (de Jong 2000) also identified a value for perishables of NZ$ (2017) $6.29/tonne/hour.

Group 3: Containerised exports

The sole study in this group is the Finnish forestry study by Kurri (noted above), which is a study of manufacturing and so includes manufactured forestry products like pulp. The values for road transport of NZ$ (2017) $0.82/tonne/hour is much lower than values for other commodities in the study, and suggests, reasonably, that forestry shippers do not value time highly. Kurri also includes values for rail transport, which are much lower than for road. The ‘chemical forest industry’ is valued at $0.44/tonne/hour, and the ‘mechanical forest industry’ as low as $0.14. No other studies were found that include group 3 commodities.

Group 4: Bulk exports

For convenience ‘metal’, which could fit in group 1 or 4, is included in group 4, along with coal and other bulk goods. Group 4 had inter-quartile values ranging from NZ$ (2017) 0.34/tonne/hr to $3.66, with a median of $1.66. The Kurri study valued it at $5.96 for road, and $0.32 for rail, which is suggestive of different products being carried, possibly only the rail component matching group 4. Values per shipment per hour for this group range widely, even on an inter-quartile basis, from $5.31 to $49.59, which suggests a definitional problem.

Group 5: Other domestic commodities

‘Chemicals and agricultural raw materials’, which could be in group 1 or group 5, are counted as in group 5. Again, values range widely from $0.21 to $7.11/tonne/hour and from $4.24 to $525/shipment/hour. The latter number is from Fowkes et al (2001) and measured the value of late arrival (ie lateness arising en-route), closer to WTA than WTP for time saved. The inter-quartile values narrow the range somewhat, from $2.35 to $3.79 and $118.63 to $179.10 respectively, but there is still considerable variability.

Studies with several commodities

A few studies considered several commodities. In general, these studies support a hypothesis that time values tend to increase as the value of the goods increases. For example, in the Kurri study, the rank order for road from lowest value was forestry, technical goods, consumer goods, metal, and electronics. The range from lowest to highest was $0.82 to $9.45/tonne/hour. Fowkes and Whiteing (2006) expressed their results as per hour per 20 tonne truck, first in terms of delay en route. The rank order for them on a truckload basis was ‘other bulk’ ($0.32), coal, petroleum and chemicals, ‘finished goods’, automotive and ‘express’ ($10.61). On a per tonne basis, at their assumption of 20 tonne truck, these numbers are very low. In terms of a value of lateness the order is similar, coal, other bulk, chemicals and automotive. In Fowkes et al (2001) the order for value of a delay (en route) was ‘not distribution’, food, automotive, ‘distribution’ and chemicals, and similarly for a value of late departure, not distribution, food, chemicals, and distribution.

Fowkes (2007), reporting on the same study as Fowkes and Whiteing (2006), had a comprehensive list for Britain, and CPCS (2017) for the US, as in table B.1.

Table B.1 Commodity values of time savings

Commodity	Britain	US
	WTP values NZ$ (2017)/tonne/hr	
Agriculture and food		$2.48
Metals	$0.11	
Heavy manufacturing		$2.89
Aggregates	$0.21	
Paper, chemicals, non-durable mfg		$4.55
Oil and chemicals	$0.21	
Petroleum and minerals		$7.11
Other bulk commodities	$0.32	
Coal	$0.42	
All bulk commodities	$0.42	
Finished goods	$2.12	
Express	$10.61	
Automotive	$4.24	
All freight	$1.06	$2.53

Source: Fowkes (2007), table 3, p14; CPCS (2017) table 6–2, p52.

Overall values for those studies which differentiated by commodity group range in inter-quartile values from $0.61/per tonne per hour (NZ$ 2017) to $5.46, with a median of $2.60; and from $13.80 to $179.10/shipment/hour, with a median of $44.37. Table B.9 gives the detail. Group 2 is represented by the US CPCS (2017) study's 'perishable' category, which may not be strictly comparable to the New Zealand commodities in the group.

B2.3 By nature of the freight

There is considerable variability in the way authors have characterised the nature of freight. It can be by mode, or own account/third party for road, by container, by LCL or combined transport. Naturally enough this diversity limits the comparability of the studies.

Significance et al (2012) and its summary in de Jong et al (2014) is the leading European study. It provides (table C2.2) values that include VOC, but gives a guide as to how important the VOC and freight values respectively are in the mix. Overall, VOC is 80% of their values of time, and cargo value is 20%. For road they give a range of 15%–22% for value of cargo. However, for rail and sea they give a range of 10%–60% for value of cargo, which is not very useful. Table B.5 summarises the values, in NZ$ (2017). The 'cargo' columns are based on the midpoints of the freight proportion ranges, 18.5% for road and 35% for rail and sea. It is only appropriate to use this average on overall figures, as higher values for say LCL will reflect higher cargo values, and essentially constant VOC.

Table B.2 Values of time savings for cargo component (identified by de Jong)

	Road		Rail		Sea	
NZ$ (2017)	**VOC and cargo**	**Cargo**	**VOC and cargo**	**Cargo**	**VOC and cargo**	**Cargo**
Overall	$11.77/tonne/hr	$3.42	$2.83/tonne/hr	$0.99		
2–40 tonne truck	$89.49/veh/hr	$16.56				
Ship/full train			$2,590/train/hr	$907	$1,954/ship/hr	$676
Container	$139.94/veh/hr		$272/train/hr		$1,789.75/ship/hr	
LCL 2–15 tonne	$54.16/veh/hr					
LCL 15–44 tonne	$103.62/veh/hr					
LCL average	$87.13/veh/hr					
Bulk			$2,873/train/hr;			
Wagonload			$2,590/train/hr			
All non-container			$1,955/train/hr			

Source: de Jong (2014, table 5), no pagination

There is no indication of the weight of the cargo on a train or ship, so the measures for these modes are not that useful either. The per-tonne difference between road and rail probably arises from the nature of the cargoes carried.

Most other studies give values for road, sometimes with a split between own account and third party, as shown in table B.3.

Table B.3 Road values of time including own account/third party

Reference	Country	Overall	Own account	Third party
NZ$ (2017)		Per tonne per hour		
Bergkvist (2001b)	SE		$6.56	$13.87
De Jong et al (2001)	FR			$14.75–$32.17
Vellay and de Jong (2003)	FR			$97.00 ('subcontracted')
Masiero and Hensher (2012)	CH	$5.66 (short/ medium distance) $21.64 (long)		
Russo and Chila (2007)	IT	$42.80		
De Jong (2000a)	GB		$18.70 (LGV) 6.24 (HGV),	$23.38 (LGV), $8.31 (HGV)
Fowkes et al (2004)	GB	$3.41	$5.38	
Fowkes et al (2001) (delay en route)	GB	$3.41	$5.38	$1.31–$4.93
Fowkes et al (2001) (late departure)	GB	$2.09	$4.01	$1.00–$5.33

Reference	Country	Overall	Own account	Third party
Abdelwahab (1992)	US	$0.86		
CPCS (2017)	US	$2.53	$1.65 (Shippers with transportation)	$38.01 (Shippers without transportation)
Per shipment per hour*				
Transek (1990)	SE	$9.0		
Transek (1992)	SE	$12.61		
INREGIA (2001)	SE	$0–$104.1		
Halse and Ramjerdi (2012)	NO		$67.52	$11.89
De Jong et al (1992)	NL	$75.62–$99.26		
De Jong et al (2000)	UK		LGV tolled $103.63, untolled $60.45 HGV $103.63 and $97.87	HGV $138.17 tolled, 60.45 untolled
CPCS (2017)	US	$61.16	$36.37	$457.89

*Some studies have values per truck or other vehicle. In most cases here, the values can be presented per tonne avoiding the problems identified by Massiani (2014), that an assumption that a truckload is the same as a shipment may not be valid. The only values it affects in this appendix are those in table B.7, relating to per wagon values for rail. Massiani's main concern appears to be a truckload may contain several shipments (ie LTL). We believe this to be unlikely for rail (although we have no information on the opposite case, that a shipment may take up several wagons).

Some studies focus on rail and combined transport (table B.4).

Table B.4 Rail and combined transport values of time

Reference	Country	Rail	Combined
NZ$ (2017)	**Per tonne per hour**		
Kurri et al (2000)	FI	0.27	
De Jong et al (1992)	NL	$1.18	
De Jong et al (2001)	FR	$5.02–21.55	$5.31–$8.26
Russo and Chila (2007)	IT	$0.35 door to door	$12.24
Viera (1992)	US	$1.70	
Brooks et al (2012)	AU	ML model $1.48	
Per shipment/vehicle per hour			
Transek (1990)	SE	$2.7/wagon	
INREGIA (2001)	SE	$0.00	
De Jong (2000)	NL	$2160.02; full wagon $86.30	

B2.4 Undifferentiated values

As noted, a number of studies do not appear to differentiate values by commodity or other characteristics. Most of these are likely to relate to road transport, and to manufactured or general freight. A summary is given in table B.5.

Table B.5 Values of time where commodity/mode not specified

Reference	Country	Values per tonne/hr	Per shipment/hr
NZ$ (2017)			
Beuthe and Bouffioux (2008)	BE	$7.71	
Bolis and Maggi (2003)			
Bolis and Maggi (1999)	CH		$21.88
IRE et al (2005)	CH	$2.82	$20.49
Danielis et al (2005)	IT		$18.94
Feo et al (2010)	ES excl Murcia Murcia	$1.10 $2.07	$16.34 $31.17
Fowkes et al (1991)	UK	$0.33–$4.68	
Small et al (1999)	US		$475–$637
Kim (2014)	NZ	ML model: Inter-island (long haul) FCL $0.55 Intra-island (short haul) FCL $1.02 Inter-island LCL $2.72 Intra-island LCL $3.16	

B2.5 Summary of values of time

As summarised in table B.6, values of time by commodity range from zero to NZ$ (2017) $10.61 per tonne per hour; and from $0.03 to $525.40/shipment/hour. To reduce this range, we have focused on the inter-quartile ranges, which are $0.62 to $5.46 and $13.80 to $179.10 respectively, with median values of $2.60 and $44.37.

In terms of commodity, commodities that are likely to have higher values per tonne have a higher median value of time, which is as expected. The highest value is for perishables, and then general manufacturing. The single value for containerised exports and precursors represents a lower end of that market and is perhaps anomalous. Group 4 includes coal and heavy metal industries, and the low value for group 5 probably reflects the inclusion of aggregates, as well as higher value petroleum and chemicals. The overall commodity median of $2.60 is weighted heavily by group 1. However, the weight of that group is much less within the overall total, which includes modal classifications and those studies that did not make any differentiation by commodity or mode, and the overall median is almost the same as for group 1. The median value of freight by rail is less than 40% of that for road, which is probably a reflection of a different mix of cargo.

Many studies give an overall value of time, sometimes subdivided by transport type or mode. Putting them all together we get an inter-quartile range of $3.41 to $13.65 per tonne per hour (road or unspecified) and $0.83 to $2.53 for rail. However, the respective median values of $3.42 and $1.33 suggest that lower values are more typical. Also of note is that road is considerably higher than rail on average. Overall values for studies that give a commodity breakdown are not included in these numbers, to avoid double-counting.

In terms of values per shipment per hour, the road inter-quartile range is $9.90 to $93.35, with a median of $44.12. There are only three rail values, with a very wide range, and further analysis would be problematic.

Table B.6 Summary of values of time

	By commodity group						Road	Rail	Undiffer-entiated	All data
	Group 1	Group 2	Group 3	Group 4	Group 5	All groups				
	NZ$ (2017)/tonne/hour									
Range	$0.00–$10.61	$1.04–$6.29	$0.82	$0.11–$5.96	$0.21-$7.11	$0.00–$10.61	$0.86–$42.8	$0.27–$21.55	$0.33–$7.71	$0–$42.8
Mean	$3.80	$3.67		$2.35	$2.35	$3.21	$11.60	$4.07	$2.98	$4.62
1st quartile	$1.03	$2.35		$0.34	$0.35	$0.62	$3.41	$0.83	$1.59	$0.86
Median	$2.76	$3.67		$1.66	$0.96	$2.60	$3.42	$1.33	$2.17	$2.72
3rd quartile	$5.76	$4.98		$3.66	$3.79	$5.46	$13.65	$2.53	$3.75	$5.66
Count	17	2	1	4	6	30	7	8	7	49[a]
	NZ$ (2017)/shipment/hour									
Range	$5.85–$429.3	$46.28	-	$2.12–$49.59	$4.24–$525.40	$2.12–$525.40	$0–$104.1	$0–$86.3	$16.34–$637	$0–$637
Mean	$145.94			$20.07	$143.89	$118.63	$50.1	$29.67	$174.40	$110.89
1st quartile	$39.41			$5.31	$18.04	$13.80	$9.90	$1.35	$19.72	$9.00
Median	$84.89			$8.49	$34.71	$44.37	$44.12	$2.7	$21.88	$34.71
3rd quartile	$211.37			$49.59	$23.41	$179.10	$93.35	$44.5	$253.09	$99.26
Count	7	1	0	3	7	18	6	3	7	33[b]

Note:

[a] Rail wagons assumed to be same as a shipment. Applies to only a few cases.

[b] Do not add across because 3 per tonne and 1 per shipment data points have been deleted from 'All data' to avoid double counting commodity and mode views.

B3 Reliability

B3.1 Definitions of reliability

Reliability is, in broad terms, a measure of the consistency in achieving the expected travel value. It is essentially a cargo-related cost, and so is a pure shipper value. Carriers have very low values (see below) and these are related to the opportunity cost of the vehicle (de Jong et al 2014), so are most appropriately treated as a component of vehicle operating costs.

However, there are many definitions of reliability in the studies. They range from the simple – such as 'improvement in on-time performance' (Fries et al 2009), arrival within three hours of schedule (Brooks et al 2012), the random variation in travel time (Li and Hensher 2012) or failure to comply with stipulated delivery times and conditions (Feo et al 2010) – to the more complex formulae of probability of arrival within a given transport time (Kim 2014) and the SD of transport time (Significance et al 2012).

B3.2 Values of reliability

A number of studies provide a monetary value for reliability, such as a value per 1% reduction (or improvement) in reliability or the willingness to pay for a 1% increase in the probability of reliable delivery. For example, Fries et al (2009) gives values for a 1% increase in 'on-time reliability', as shown in table B.7.

Table B.7 Reliability values by commodity: Switzerland

Commodity	NZ$ (2017) per tonne per % point increase
Building materials	0.23
Food	1.12
Iron and metal	1.50
Chemicals and agricultural raw materials	3.67
Manufactured goods	8.19
Overall	2.57

Source: Fries et al (2009) table 2, p6.

In New Zealand, Kim adopts a similar approach to presenting the data to Fries. Kim presents values per shipment (convertible to tonnes) in $ per shipment per (1% point) increase. Converting to tonnes and NZ$ (2017), the values of reliability for his four experiment sets, are shown in table B.8. Each of the sets involves comparing rail and road (and in one case also sea) but separate VOR values are not given by mode.

Table B.8 Reliability values in New Zealand

Choice experiment set	Value of reliability, per tonne, per % point increase, NZ$ (2017)
1. Inter-island (long haul) FCL	$1.18
2. Intra-island (short haul) FCL	$3.43
3. Inter-island LCL	$2.44
4. Intra-island LCL	$2.44

Source**:** Kim (2014), table 7.1, p178. This data is from the mixed logit (ML) model. 2012 base data.

CPCS (2017) gives values for the US (Florida) per shipment-hour and per tonne, as shown in Table B.9. Neither that study nor the one its data is taken from (Jin and Shams 2016) offer any explanation for the differences between per tonne values and per shipment values. They claim their study is comparable with other studies but they do not specify reliability in terms of per 1% point increase.

Table B.9 Values of reliability improvements by commodity: US (Florida)

Commodity	NZ$ (2017) per shipment hour	NZ$ (2017) per tonne hour
Agriculture and food	$110.95	$7.24
Heavy manufacturing	$37.48	$3.72
Paper, chemicals & non-durable manufacturing	$25.49	$2.28
Petroleum and minerals	$35.98	$16.86
Overall	$82.46	$6.30
Perishable	118.44	7.24
Non-perishable	83.96	5.19

Source: CPCS (2017) table 6–2, p52; Jin and Shams (2016) table 7–5, p110

Wigan et al (2000) classified reliability values by the type of transport: intercity FTL (NZ$ (2017) $5.79 per pallet per 1% reduction), urban FTL ($2.83) and urban LTL ($4.45). Their commodity set included automotive parts, some building materials, food and beverages, and packaging, though they did not specify their results at that level. Austroads (2003), in a second stage of the same project, but limited to the automotive sector, found a willingness to pay for 1% increase in the probability of reliable delivery per pallet of NZ$ (2017) $21.01 for intercity FTL, under $6.30 for metro FTL and under $4.20 for metro LTL.

Fowkes et al (2001) analysed reliability in terms of arrival time spread in pence per minute. 'Arrival time spread' is defined as the difference between the earliest arrival time and the time at which 98% of the deliveries could be expected to be made, a similar concept to the SD methodology above. The order of the values, highest to lowest, for this was distribution goods, chemicals, other commodities, the overall value, food, and 'not distribution', a somewhat different ordering to the values in table B.7.

Fowkes (2007) also provides a 'spread' analysis (value of 98% arrival time minus earliest arrival time), as in table B.10. This is a similar, though not precisely the same, order, and shows a general relationship between increasing value of the commodity and increasing value of reliability.

Hirschmann et al (2016, p61) identified the characteristics that meant shippers aimed for very high on-time performance, ie expedited shipments, cargo transfers to other modes, high value shipments, and perishable products.

Table B.10 Value by commodity using 'spread ratio'

Commodity	'Spread' value, NZD2017 (cents/min/tonne)
Metal	0.35
Coal	0.71
Automotive	0.71
Aggregates	1.41
Other bulk	1.41
All bulk	1.41
Oil and chemicals	2.48
Containers	10.61
All non-bulk	12.73
Finished goods	3.54
Express	35.37
Overall	3.54

Source: Fowkes (2007), table 4, p15

B3.3 Reliability ratio

A useful measure related to reliability is the reliability ratio, 'RR': this is the ratio of the value of a minute change in the SD of the journey time to the value of a minute change in the scheduled or expected journey time (Fowkes and Whiteing 2006). A number of studies have calculated this ratio, with results that are both greater than 1 and less than 1. That is, some studies believe that unit changes in reliability (defined in terms of the change in the SD of arrival time) are more highly valued than a unit change in mean travel time, and some less. For instance, Fowkes and Whiteing (2006) calculate the overall RR at 0.8, and NZIER (2008) at 1.2 (quoting the Netherlands). Peer et al (2012) also give a value of 0.8.

Halse et al (2010) gives an overall value of 1.1 (distinguishing between shippers 1.2 and carriers 0) and Significance (2013) 0.37 overall (shippers 0.9 and carriers 0.28), (sourced from De Jong and Bliemer 2015). It is unsurprising that carriers place a lower value on reliability than their clients, as it is the clients that bear the brunt of poor reliability. Significance et al (2012) attributes that to people in transport being used to thinking in transport times, not variability, and they build in buffers to cover unreliability. For this study, there is a case for ignoring the carrier value; the two values presumably represent the values placed on the same trip by the two parties, at least conceptually, and it is the shipper value we are concerned with here. For these we have the values above, of 0.9 and 1.2.

The Fowkes and Whiteing study (2006) also sets out RR estimates for a number of commodities, for freight users, as given in table B.11.

Table B.11 Reliability ratio by commodity: UK

Commodity	RR
Metal	0.35
Coal	0.71
Automotive	0.71
Aggregates	1.41
Other bulk	1.41
All bulk	1.41
Oil and chemicals	2.48
Containers	10.61
All non-bulk	12.73
Finished goods	3.54
Express	35.37
Overall	3.54

Source: Fowkes and Whiteing (2006) table 3, no pagination

The commodity breakdown helps us understand the overall 0.8 value (above), and perhaps adds to its credibility. However, the high RR values for very basic commodities such as aggregates are perhaps surprising: and probably reflect very low value of time for these commodities.

CPCS (2017) also give reliability ratios, as in table B.12, again differentiated into per shipment and per tonne data.

Table B.12 Reliability ratios by commodity: US (Florida)

Commodity	RR: based on shipment	RR: Based on tonnage
Agriculture and food	3.4	2.9
Heavy manufacturing	0.8	1.3
Paper, chemicals & non-durable manufacturing	0.4	0.5
Petroleum and minerals	1.1	2.4
Overall	1.5	2.5
Perishable	2.8	7.0
Non-perishable	2.4	2.2

Source: CPCS (2017) table 6–2, p52

B3.4 Summary of values of reliability

On the basis of the international evidence, we can assess a range of values of reliability and of reliability ratios, as summarised in tables B.13 and B.14. In some cases, only one study provided usable information. No study covered our commodity groups 2 and 3, although CPCS did give RR for "perishable goods' which can serve as a proxy. Overall, 0.8 is a typical figure, (excluding carrier values) in the UK context; but the US values are on the whole higher, with the perishable value per tonne for example suggesting a reliability ratio of around 7.0.

Table B.13 Reliability values summary

	By commodity group					
	Group 1	Group 2	Group 3	Group 4	Group 5	All groups
VOR $/tonne/% pt incr	$0.23-$8.19			$1.50	$3.67	$0.23-$8.19
Mean	$2.72					$2.69
1st quartile	$1.15					$1.18
Median	$2.44					$2.44
3rd quartile	$2.94					$3.43
Count	7	0	0	1	1	9
$/tonne/hr (CPCS)	$7.24	$7.24	--	$3.72	$2,28–$16.86	$2.28–$6.86
Mean					$9.57	$6.48
1st quartile					$5.93	$2.28
Median					$9.57	$3.72
3rd quartile					$13.22	$7.24
Count	1	1	0	1	2	5

Table B.14 Reliability ratio values summary

	Group 1	Group 2	Group 3	Group 4	Group 5	All comm groups	Overall values
RR (incl CPCS)	0.4-2.9	7.0		0.4-1.3	0.4-2.4	0.4-7.0	0.8-2.5
Mean	1.13			0.83	1.17	1.53	1.23
1st quartile	0.4			0.6	0.4	0.4	0.83
Median	0.6			0.8	0.5	0.8	1.05
3rd quartile	1.33			1.05	2.13	2.13	1.2
Count	4	1	0	3	5	13	6

B4 Frequency

Frequency (along with loss and damage) are less studied than time and reliability, probably because people value them less highly than these other attributes (see section B6).

A reduction in frequency from daily to tri-weekly attracted a high 30% discount (WTA) for exports in Shinghal and Fowkes' (2002) study of the Indian market. A slightly lower price discount (25%) applied to forwarders, and even lower for chemicals and electrical. Autoparts and food were indifferent. Feo et al (2011) were concerned with short sea traffic and found an increase of one sailing a week was worth NZ$ (2017) $61.37 per shipment. Puckett et al (2011) reported a significant value for frequency gains, again for sea, of $2350 per departure per week. This suggests that frequency may increase in value with distance and load size: in reality the distinctions are probably related to existing frequencies being greater in metro and LTL than in long distance and FTL, making improving frequency for short haul/LTL relatively less attractive.

Zamparini et al (2011), in a study on Tanzanian transport, show that there is a large range in valuation according to commodity, with printing and publishing having the highest value for a 10% improvement (approximately NZ$ (2017) $0.08/tonne-km). A small number of firms, eg pharmaceuticals, had a value of around $0.02–0.05 per tonne-km, but most had negligible values. The use of tonne-km is unhelpful, as most studies do not include a distance component. For the printing and publishing case the distance involved was 200 km, so the value per tonne was $16, a relatively high number, which may relate to the transport conditions in Tanzania.

In New Zealand, Kim (2014) measured values of frequency for four ‘choice experiment sets’, in terms of dollars per shipment per departure per day, increasing, ie the value of an additional departure. Journeys involving rail were assigned a frequency of two to four times per day, and sea five or seven times per week. These were compared with the current road-only frequency as a default value, which was not stated but was always more frequent (Kim 2014, p86). The values obtained per shipment can be converted to tonnes, using Kim’s assumptions of 16 tonne per FCL container, and 4 tonne per LCL shipment, as given in table B.18.

Table B.15 Frequency values (WTP) from New Zealand

Choice experiment set	Value per tonne of 1 extra departure/day (NZ$ 2017)
1. Inter-island (long haul) FCL	$7.21
2. Intra-island (short haul) FCL	$3.61
3. Inter-island LCL	$1.00
4.Intra-island LCL	$1.06

Source: Kim (2014), table 7.1, p178. Data from the mixed logit (ML) model.

B5 Damage

Masiero and Hensher (2012), writing about Switzerland, found a willingness to pay of just over NZ$ (2017) $86 overall to decrease the annual probability of damage by 1%; again there was a distinction between short/medium and long distances $78.56 and $266.12, possibly because of the greater exposure on longer distances. Wigan (2000) found a similar relationship in Australia, with inter-capital FTL willing to pay NZ$ (2017) $112.38 per 1% reduction in damage, urban FTL $41.36 and urban LTL $61.19 per pallet. Austroads (2003) found a value of $162 per pallet for 1% improvement in the probability of damage for full truck loads on inter-city routes, while the equivalent in metro areas was $78.

It is in many cases unclear if the authors’ reporting of a ‘1% reduction’ meant 1% or 1 percentage point.

A series of studies in Sweden expressed willingness to pay for damage in very fine terms, for a reduction of 0.1%. Here, the values are multiplied by 10 for consistency to give values per 1% reduction. Transek (1992) valued them at NZ$ (2017) $1,135 per 1% per shipment. Bergkvist and Westin’s (2000) figure was a much lower $84 per shipment. In INREGIA (2001) the valuation was limited to rail and air, NZ$ (2017) $7,086 and $3,630 to $13,051 respectively per 1% change. Danielis et al (2005) found that NZ$ (2017) $10.98 compensated for a risk of damage of 5% of shipment value (not the same as a 5% risk of damage).

In a study on Tanzania, Zamparini et al (2011) found that loss or damage was the second most important attribute after time, even though actual losses were low. The highest value for a 10% reduction in loss or damage was NZ$ (2017) $0.43 per tonne-km (also printing and publishing, so $87 per tonne) although most sectors valued it at $0.02 or less per tonne-km.

B6 Rank order of service attributes

A number of studies identify the important service attributes in rank order. In the absence of direct quantification of values, these importance rankings can assist in our understanding of the attributes we are concerned with. Some of the studies classify the attributes as factors influencing mode choice, and others just as factors influencing choice of transport generally, presumably including operator and mode. We have not kept this distinction: for our purposes we believe them to be interchangeable.

Table B.16 provides a summary of the rankings in the studies. Reliability is most often (but not always) ranked first. Below it, it is harder to discern patterns, although cost (price) is often second. Transit time is not always important. Beyond that it is difficult to see any patterns.

Table B.16 Ranking of freight service attributes[a]

Reference: Attribute	Fowkes (2007)*	Grue and Ludvigsen (2006)		Moschovou and Giannopoulos (2012)		Moschovou and Giannopoulos (2010)	Kim et al (2014); Kim and Nicholson (2013)
		Road	Rail	Road cf rail	Logistics, forwarding		
	Rank						
Reliability	1	1	3		1	1 (incl quality)	1 'timeliness' (time and reliability)
(Scheduled) transit time	2	6	9				
Flexibility in departure time	3						
Control/tracking	4					9	
Frequency					4	8	
Security	5						
Ease of (un)loading	6			4			
Environment	7						
Damage	8	3		2		3	6
Processing claims			4				
(Equipment) availability, freight handling	9	5		3		10	4
(Door–door) costs		2	2			2	2
Service availability at origin/customer		4	1			4	3

Reference: Attribute	Fowkes (2007)*	Grue and Ludvigsen (2006)		Moschovou and Giannopoulos (2012)		Moschovou and Giannopoulos (2010)	Kim et al (2014); Kim and Nicholson (2013)
quality							
Shipment/ cargo life				1		6	
Value of load					2	7	
Size of load					3	5	

[a] Sourced from NERA et al (1997)

B7 Comparison of willingness to pay and willingness to accept values

Most work in this field has focused on WTP for improvements in services (eg reduced travel time, better reliability, increased service frequency). As summarised here, only a few studies have also addressed WTA compensation for reductions in service quality and quantity. The market survey in this study aimed to obtain both WTP and WTA values, which could then potentially be compared.

The analysis in Kurri et al (2000) reports higher WTA values than WTP. That is, people expect a higher discount for reduced service than they would pay for enhanced service. In other words, there is a higher value on avoiding going backwards than on gaining further improvements.

The values in Kurri for road are NZ$ (2017) WTP $2.86 and WTA $6.57. Valuing on a WTA basis is thus about 2.3 times a WTP valuation. For rail their values are $0.19 and $0.49, still showing WTA values as higher, with a ratio of 2.6. Rail customers are even more averse to reduced service.

Shinghal and Fowkes (2002) include an analysis akin to a WTA approach. They assessed reductions in frequency and the discounts that would have be given to make the reductions attractive. A reduction in service to tri-weekly would require a 30% discount for exporters, 24% for forwarders, 13% for chemicals and 9% for electrical. Autoparts and food were essentially indifferent to the reduction. Reducing further to weekly services was viewed much more adversely, eg a 60% discount would be required for exporters. Unfortunately, the study did not give WTP values for improving frequency, so the WTA: WTP relationship cannot be assessed.

Zamparini et al (2011) assessed both WTA and WTP in the situation of risk aversion for all attributes. WTA values consistently were higher than WTP. Over the 24 sectors, the ratio of the WTA and WTP values (for time, frequency, damage and reliability together) was 2.17 (with a median of 1.73). The values for WTA and WTP were the same in the risk neutral situation.

Understanding this difference between WTP and WTA will be an important issue for future work. It has also been examined in this study's market survey.

Appendix C: Review of international economic evaluation procedures

C1 Introduction

This appendix summarises the structures and (where possible) sources for freight values of time (VoT) and values of reliability (VoR) used for economic evaluation purposes in selected (developed) countries and generally incorporated in the (national or regional/state) transport evaluation manuals of those countries. In some cases, current/recent unit values have also been obtained, but there has been less emphasis on this aspect.

Investigations were carried out for seven countries which are generally regarded as among the leading countries internationally in economic evaluation (appraisal) for the land transport sector:

- New Zealand
- Australia (federal level)
- England
- Netherlands
- Sweden
- Germany
- USA (federal level).

New Zealand is included here mainly for comparative purposes: appendix A covers current New Zealand procedures and values in more detail.

The emphasis of this appendix (as for the broader study) is on aspects of costs and benefits as experienced by the shipper (consignor or consignee of goods) rather than by the transport operator; transport operator costs are already well established in the EEM and their review was outside the scope of this project. However, we note that there is a lack of clarity (and possibly confusion) in much of the literature as to the division between transport operator costs (VOC) and other costs and benefits perceived by shippers.[41] In determining shipper costs, it has therefore been necessary in some cases to first clarify this division to ensure that costs are being split on a constant basis.

Another issue encountered, in reviewing international evaluation practices and the research behind them, is the freight modes to which they relate. In some countries, the market research from which values are derived and the manuals in which they are contained are specific to one mode, almost always road (truck) freight. Examples include New Zealand, Australia, England and USA. In other countries, such as the Netherlands, market research has also covered other land transport modes and the relevant manual usually provides specific values by mode.

Following this introduction, the appendix is structured into two main sections: section C2 covers freight time-related values; section C3 covers freight reliability-related values.

[41] We note that this lack of clarity also applies in the EEM (refer appendix B of this report for further details).

C2 Travel time-related costs

C2.1 Overview

Table C.1 sets out our summary on the inclusion and basis for travel time-related costs in economic evaluation in the seven countries.

Time-related costs have been sub-divided into three categories:

1. Driver time – essentially driver (and any other vehicle crew)-related wages and on-costs.
2. Vehicle-related time – covers other costs incurred by the transport operator that are related to the time involved in the transport task, which would typically include some proportion of vehicle capital charges.
3. Freight commodity costs – these are costs experienced by the shipper rather than the transport operator, which relate principally to:
   - stockholding costs (relate to the opportunity costs of the goods associated with time delays)
   - perishability costs (relate to loss of market value of goods to seller, or decline in value to potential buyer, as a result of time in transit)
   - time value of early/late receipt of goods (end-user cost relating to timing of availability of goods).

Categories 1 and 2 are components of the transport operator costs and are only included in the table for completeness. In relation to these categories, we note that:

- All seven countries include driver time costs (category 1) in their evaluation procedures (as part of VOC).
- All seven countries also include (in principle) vehicle time-related costs (category 2) in their procedures (again as part of VOC). However, we note that the current Australian procedures do not appear to include any costs within this category but assume that all vehicle-related costs are either fixed (ie independent of use) or are distance related.

The focus of the remainder of this summary is on the freight commodity-related costs, which are experienced by the shipper (ie category 3). In regard to these costs, the seven countries may be divided into two groups:

- Four countries include figures for the value of time relating to the freight (cargo) itself – New Zealand, Australia, Netherlands, Sweden.
- Three of the seven countries do not have any allowance for costs in this category – England (WebTAG), Germany and USA.

Table C.1 Coverage of freight travel time-related costs in economic evaluation – summary of international practices

Country	Transport carrier (‘factor’) costs		Shipper costs	References	Notes
	Driver time etc	Vehicle time-related (incl capital charges)	Freight stockholding, perishability, etc		
New Zealand	Yes	Yes	Yes – related to interest on value of goods in transit.	EEM (sections A4, A5) Appendix A of this report (covers road freight mode only).	‘Vehicle and freight’ costs per hour given in EEM (table A4.2) are understood to include vehicle-related standing charges and a component relating to the freight itself (stockholding, perishability, etc) costs, but the full breakdown of these costs is not available.
Australia (Federal)	Yes	No (refer Notes column)	Yes – set of ratios for freight (per vehicle hour), by urban/non-urban and by vehicle combination: values understood to be based on Austroads (2003) after various adjustments and allowance for cost indexation (full details not available). Previous values (Austroads 1997) were taken arbitrarily as 25% of hourly operating costs.	Transport & Infrastructure Council Australia (PV2, table 3.4, 2015)	Relates to road freight only (no values given for rail freight). No vehicle time-related costs are apparent: it appears that vehicle capital is treated as a lump sum, not allocated to VOC or time-related costs. Austroads (2003) (E) undertook a pilot study of travel time savings for freight in transit, with SP surveys undertaken in 1998 and 2000. The surveys estimated values for time savings, delay savings (reliability) and damage/loss. The survey results provide the basis for the current TIC shipper values. A recent TIC scoping study for further research into the value of travel time savings (VTTS) suggested further SP-based research for the road freight (and person travel) sectors, but the freight sector work has not proceeded to date.

Country	Transport carrier ('factor') costs		Shipper costs	References	Notes
	Driver time etc	Vehicle time-related (incl capital charges)	Freight stockholding, perishability, etc		
England	Yes	Yes	No – not included	Department for Transport (UK) 2014; WebTAG (Unit A1.3, Jan 2014); de Jong (ICTAP Annex 3, 2013)	
Netherlands	Yes	Yes	Yes – related to interest on value of goods in transit	Significance et al (VOTVOR project) 2012; de Jong (ICTAP 2013)	New VoT, VoR structure and values adopted (2013?) resulting from Significance et al (2012) SP etc study. Further values of time combined (by mode) based on SP interviews with shippers and carriers with the sector costs data for operator cost items (result is one single value for freight time savings). Table 3.1 gives further information on methodology. Results summary: road (per truck) VoT = €38/hr; rail (per full train) = €1,100/hr.
Sweden	Yes	Yes	Yes – related to interest on value of goods in transit. Also allow for damage to goods in transit (per km value)	Odgaard et al (HEATCO Deliverable 1, 2005) De Jong (2013)	
Germany	Yes	Yes	No	De Jong (2013)	
USA (Federal)	Yes	Yes	No (under research)	DOT (2012)	Update of original 1997 document

C2.2 Countries excluding freight values

C2.2.1 England

For England, the only time-related component of (road) freight evaluation values relates to driver wage costs, and we have seen no mention of any British research on the topic or intention to include a freight-related component in future. This is somewhat unexpected.

C2.2.2 Germany

For Germany, a review of practice by Vierth (2013) simply states that no allowance is made in evaluation procedures for freight commodity costs.

C2.2.3 USA

For USA, the latest Federal guidance document relating to travel time savings in economic evaluation (DOT 2012) states that 'Although we are not yet prepared to offer guidance on this issue (ie the value of freight time to shippers), we are conducting research, and hope the additional information will permit concrete recommendations in the future'.

C2.3 Countries including freight values

These four countries do include figures for the value of time relating to the freight itself, based principally on the interest on the value of the goods in transit. Specific comments on practices in each of these countries follow.

C2.3.1 New Zealand

The current EEM contains a time-related cost component for (road) freight values, which is used to account *for '…*reduction in stockholdings between the points of production and consumption and perishable cargo. . . being delivered in better condition, with higher market value' (Significance et al 2012). However, the EEM does not specify this component separately but includes it within an overall freight vehicle time-related resource cost total, which mostly relates to vehicle occupant time (wage costs): the freight component accounts for only 5%–10% of this total. Further details are provided in appendix A (table A.1 of this report).

C2.3.2 Australia

The recent ATAP/Australian National Guidelines update (Transport and Infrastructure Council, Australia, 2015) includes a set of values for road freight 'payload' time savings (additional to the time savings for vehicle occupants). We understand that these values are based on results from an earlier pilot SP survey of shippers (Austroads 2003). This gave A$1.50/hour of delay per pallet for interstate capital full truck loads and A$0.80/hour for intra-city freight. For less than full loads intra-city, a value of A$2.20 was obtained, over a variety of goods types. This study forms the basis for parameter values included in the Austroads (2008) guidance, which gives values of freight time on a vehicle type basis for urban and non-urban travel. The values incorporate conversion from per pallet to per truck (using unreported conversion and load factors) (Bone et al 2013). The NGTSM rates vary with the type of truck involved (articulated by number of axles, various types of combination vehicles) and are further sub-divided between urban and non-urban operations (with urban values being approximately twice non-urban values).

The range of values provided is an order-of-magnitude greater than the current EEM values (eg up to around $60/hour for the heaviest vehicles in non-urban operation, compared with just over $2/hour for freight HCV2 vehicles in EEM). Further investigation of this disparity may be warranted. The NGTSM paper notes that 'Austroads has identified the specific needs for such a study (ie a more detailed study into the value of travel time for freight) in the near future*'.* However, we understand that the

NGTSM/Austroads ‘mega-study’ into improved VTTS is focusing on person travel and is not (at this stage) to cover freight transport.

C2.3.3 Netherlands

What is probably the most detailed (and highest quality) research internationally on freight transport values of time and reliability was undertaken in the Netherlands in 2011/12 (Significance et al 2012 and various other publications). The research involved some 800 interviews (using SP methods) with both shippers and carriers (transport operators) and covered all significant freight transport modes – road, rail, sea, inland waterways and air.

Values were estimated separately for containerised and non-containerised freight, initially per shipment, then converted to per vehicle or vessel (but not per tonne), for VoT and VoR by mode. All values were sub-divided into the transport cost component and the cargo (freight) component. For VoT it was found that the transport cost component was considerably larger than the cargo component, whereas for VoR the cargo component was small but positive and the transport cost component generally not significantly different from zero. Estimates of the reliability ratios were between 0.1 and 0.4, which were said to be ‘in line with recent empirical studies abroad, but lower than in earlier assessments’.

The Significance et al (2012) study results generally combine carrier costs and shipper costs, and combined values appear to be specified for use in economic evaluation. This is unfortunate as separating these components might be achievable (but would probably be challenging), most likely most likely by going back to those responsible for the original research.

C2.3.4 Sweden

Full details are not available on the methodology adopted in Sweden for evaluation purposes. From the summary information available the treatment of freight user benefits and costs has three components (Odgaard et al 2005):

1. Cost allowance for goods while in transit based on value of the goods at an interest rate (time-related)
2. Delays in transit (time-related)
3. Damage to goods and other ‘quality’ factors (distance-related).

The values adopted are said to be ‘based on a survey of the international literature’ (De Jong 2013).

C3. Reliability-related costs

C3.1 Overview

Table C.2 summarises the inclusion and basis for TTV costs in economic evaluation in the seven countries.

In terms of their TTV treatment, the countries may be divided into three groups:

1. TTV excluded from evaluations – USA
2. TTV partially included (or uncertain) in evaluations – Australia, England
3. TTV fully included in evaluations – New Zealand, Netherlands, Sweden.

The following outlines key features of the TTV treatment in each country, within these three groups.

C3.2 Countries excluding TTV

C3.2.1 USA

The only country in this category. While several US research/review studies have been undertaken (eg Concas and Kolpakov 2009), reliability values and procedures have not to date been included in Federal evaluation guidelines.

C3.3 Countries partially including TTV (or uncertain)

C3.3.1 Australia

Key developments in Australia on this topic over the last 15 years have been:

- Austroads SP surveys (Austroads 2003) included estimates of TTV, along with travel time, for some commodity groups – but these have not to date been incorporated into evaluation procedures.
- Austroads subsequent advice (Austroads 2005) was that TTV should be included as a user cost in the assessment framework, but only at a qualitative level.
- Austroads 2011 report addressed the inclusion of TTV in project evaluation but indicated that high priority needed to be given to further research on the topic to derive appropriate values.
- Further research on the topic was again identified as a priority by Austroads in 2015 (TIC 2015). However, no research relating to freight transport valuations now appears to be included within the current major market research project on the valuation of time savings for project evaluation.

C3.3.2 England

The current English provisions (WebTAG) specify that reliability benefits are not to be quantified for inclusion in NPV or BCR estimates; but should be included (qualitatively?) in the appraisal summary table and thus taken into account in the overall VFM assessment.

Table C.2 Coverage of freight reliability-related costs in economic evaluation – summary of international practices

Country	Inclusion of reliability	Comments on treatment, methods, research	References	Notes
New Zealand	Yes	Methodology provided for road freight (in EEM). Key component is the estimation of any change in TTV, expressed as the change in the travel time SD over the total trip. This change is then multiplied by the relevant commercial vehicle VTTS and a VoR/VoT factor (1.2) to give the economic benefits of any variability changes.	EEM (section A4.5) This report – appendix A4	Unclear at this stage how any reliability benefit estimates from applying the EEM methods would compare with estimates from applying 'best practice' methods used internationally (eg Netherlands): further investigation would be required to answer this question.
Australia (Federal)	Partially – but see comments in Notes column	Travel time reliability (variability) and its role in project evaluation are addressed in detail in Austroads 2011. It is noted there, and elsewhere, that further research on freight TTV was identified as a priority aspect for further work by Austroads (TIC 2015). However, no further research on this topic for freight appears to be envisaged within the proposed major market research into VTTS for project appraisal (TIC 2014).	Austroads 2003, Austroads 2005, Austroads 2011; Transport and Infrastructure Council (TIC) 2015; TIC 2014.	Austroads (2005) advice on economic evaluation of road projects is that TTV should be included as a user cost in the assessment framework, but no economic values are provided. It is included only qualitatively in MCA in evaluation guidelines for incident management projects. It is notable that the Austroads SP surveys (Austroads 2003) estimated values for reliability (for some commodity types) as well as travel time, but these reliability values have not been brought into standard evaluation practices.
England	Partially – but see comments in Notes column.	Travel time variability (reliability) is defined as the variation in journey times that travellers are unable to predict (ie variations from the expected value). Measure adopted for TT variability is the SD of the travel time distribution. Reliability ratio (RR) useful concept, being the ratio value of SD: value of travel time. WebTAG adopts an RR value for all types of traffic of 0.8 (based on Netherlands research). Main focus in analysis is to estimate the SD: WebTAG addresses this in some detail, distinguishing between main inter-urban roads, urban roads and other roads. Major issues that arise are the degree of congestion on the roads concerned and the availability of alternative routes.	WebTAG Unit A1.3, section 6/App B, Jan 2014)	The English provisions specify that reliability benefits are not to be included in the NPV and BCR estimates; but should be included in the appraisal summary table and thus taken into account in the overall VfM assessment (WebTAG A1.3, section 6.2).

Country	Inclusion of reliability	Comments on treatment, methods, research	References	Notes
Netherlands	Yes	New (2013) values of VoT and VoR derived from SP surveys of shippers and carriers. SP alternatives described in terms of (expected) travel time, reliability and travel costs: survey presents reliability in terms of equally likely travel times, with responses converted into travel time SD (used as the reliability measure for analysis purposes). Results: road (per truck) VoR (SD) = €14/hour (RR = 0.37); rail (per full train) VoR (SD) = €220/hr (RR = 0.20).	Significance et al 2012) Besseling et al (2004)	Prior to 2013, based on a literature review (Besseling et al 2004), reliability benefits were taken (somewhat arbitrarily) as 25% of (expected) time-related benefits.
Sweden	Yes (but not specific to freight)	Road traffic generally (taken to apply to freight): Measure is SD of travel time RR (VoR/VoT) = 0.9. For long unexpected delays: • measure is length of delay • unit value = 3.5 * VoT.	Eliasson (2004) summarised in Eliasson (ICTAP 2013)	
Germany	Uncertain	Research undertaken by Significance et al (2012) for BVWP (2015) – details not investigated		
USA (Federal)	No	Values for freight reliability do not appear to be included in any of the evaluation documents examined. However, US research gives the following recommendations, but these are not specific to freight (Concas and Kolpakov): • Appropriate reliability measure is (95th–50th) percentile range of travel time distribution, or (80th–50th) where data is sparse. • On this definition, RR is taken as 0.8–1.0 generally, but may be up to 3.0 in case of non-flexible arrival/departure constraints (eg fixed work schedules).	Concas and Kolpakov (2009)	Values not provided in any of evaluation manuals examined. Range percentile (95th–50th) of travel time distribution, corresponds approx. to 2.0 SD.

Additional notes: a) The 2001 New Zealand survey report originally proposed a reliability function expressed in expected delay (minutes), with the report stating that (BCHF et al 2002, section 1.3.6): 'The results suggest a high weighting on expected delay minutes, valued at around the same as normal minutes, despite occurring only in 1/10 or 1/5 trips. This suggests a stronger aversion to delay risk among commercial vehicle operators than among work commuters and other non-work trip purposes.'

'The recommended model has values of delay minutes $1.30/minute for 1/5 probability of delay and $1.06/minute for 1/10 probability of delay.'

'Note that, after discussion with Transfund NZ and the 2001 study working group it was decided for that round of PEM revisions to adopt overseas (UK) findings for reliability based on SD of travel time, rather than probability of delay minutes, with an added value of 1.2 minutes of in-vehicle time per 1.0-minute reduction in the SD of travel time.'

The main reliability (TT variability) measure adopted in WebTAG is the SD of the travel time distribution (commonly referred to as the value of reliability, VoR). WebTAG provides procedures for estimating the TT variability for the main different road types. For valuing changes in reliability, it adopts a RR value (ie VoR/VoT) of 0.8 for all types of traffic (based on Netherlands research).

C3.3.3 Germany

We are uncertain of the current situation re German project evaluation. Literature available refers to a ‘recent research project for Significance for BVWP (2015)’. It is not clear whether the results from that research have now been incorporated into the relevant German evaluation manual(s).

C3.4 Countries including TTV

C3.4.1 New Zealand

For *road traffic* (person and freight movements), EEM (section A4.5) sets out procedures for estimating the economic benefits of changes in TTV. These procedures are summarised in appendix A of this report. Key features are that the economic benefits for freight vehicles (trucks) are derived as the product of:

- reduction in TTV, calculated as the change in the travel time SD (expressed in minutes)
- relevant value of travel time savings
- reliability ratio (RR) factor, of 1.2.[42]

Application of these procedures requires the running of a detailed traffic model to estimate changes in TTV, with the extent of such changes being closely related to the level of congestion on the network (related to the V/C ratios on links and intersections). We understand that, typically, the incremental reliability benefit is in the range 5%–8% of the base travel time benefit, based on a typical urban traffic mix: for commercial vehicles, the figure would be around 25% higher (EEM, section A4.5). This indicates that a typical travel time reliability benefit for commercial vehicle traffic would be around 8% of the base value of time savings for such vehicles.[43]

For *rail (or sea) freight traffic,* no standard procedures currently exist in New Zealand for estimating economic benefits of changes in rail (or sea) freight service reliability.

C3.4.2 Netherlands

Prior to 2013, the Netherlands evaluation procedures assumed that reliability benefits for road traffic were 25% of any time-related benefits: this percentage was somewhat arbitrary but based indicatively on a literature review.

A major market research project was undertaken in 2011/12, using SP methods and interviews with both transport carriers and freight shippers (consignors/consignees) (Significance et al 2012). It covered values for both time and reliability, for both person and freight transport; for freight, all transport modes were covered ie road/truck, rail, inland waterways, sea and air. Emphasis was given in the market research to separation of the ‘factor cost’ values for transport carriers (vehicle operating costs etc) from the ‘benefit’ values to shippers. Separate values were also estimated for containerised and sub-containerised freight.

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[42] EEM gives this factor as 0.9 for a typical urban traffic mix, but notes that for commercial vehicles a factor of 1.2 should be used.

[43] We note that this percentage appears to be low relative to most international analyses we have examined, this may warrant further investigation.

For use in economic evaluation in the Netherlands, it appears that the research results for 'factor costs' (VOC) and shipper benefits have been combined into a single set of values, so obscuring the interpretation of the research findings. Further comment on these findings is provided in appendix C.

C3.4.3 Sweden

Sweden is said to be: 'the only (EU) country that calculates freight user benefits, which include the costs of goods whilst in transit, plus a time-related cost per hour for delays and distance-related cost to include risk of damage to goods' (Odgaard et al 2005). Our understanding is that road freight (and other traffic) TTV are estimated based on the SD of travel time and applying a reliability ratio (ie VoR/VoT) of 0.9 (ie very similar in principle to the New Zealand methodology).

Appendix D: Potential EEM restructuring – separation of transport operator cost and shipper benefit categories

D1 Introduction

Early in the project we had to resolve which aspects of the costs and benefits associated with the movement of (land-based) freight were within the scope of the project for investigation and which aspects were outside the project scope.

The original intention when the project was developed by Waka Kotahi was that, in broad terms, costs incurred by the transporter of the freight (carrier, transport operator), often loosely called 'operating costs' were out of scope; but costs and benefits as experienced by the freight shipper (end user, consignor or consignee) were within scope. However, this distinction was not clearly specified in the original terms of reference, nor were its implications in terms of study scope and methodology set out. It was also found that the present EEM structure did not provide a clear distinction between 'operating costs' (incurred by the transport operator) and costs and benefits experienced by the freight shipper.

In the light of the initial study investigations, this appendix provides some comments and suggestions on possible restructuring of the present EEM sections so as to be more consistent with the distinction between the transport operator cost categories and transport user benefit categories. This distinction could usefully be made in the EEM in a consistent manner across both person and freight travel by all (motorised) modes, covering principally the travel time and the vehicle operating cost material.

D2 Possible land transport benefits and costs typology

This annex follows on from work in the early stages of the project to specify the cost and benefit categories that were within scope and out-of-scope for this project (refer section D2.1), This section extends the proposed categorisation structure for freight transport developed in the earlier phase of the study to also cover person transport, to check whether this structure would be realistic/ helpful in this wider context, and to note any implications of this categorisation scheme for the current EEM structure for travel time and vehicle operating cost items.

Table D.1 summarises how the proposed categorisation could apply across both freight and person transport. The categorisation is shown separately for work-related travel purposes and other travel purposes (it has been assumed, for simplicity in this table, that all freight transport is work related).

Key features of the categorisation worth highlighting are:

- The table has separate columns for the costs to the transport supplier ('operator' or 'carrier') of providing the transport services; and the user (beneficiary) benefits and costs resulting from the transport of the person or freight involved. (In some cases, the transport supplier and the user/beneficiary may be the same, as for most private car travel; in other cases, they will differ.)
- Typically, the transport supplier costs may be sub-divided into operating costs, vehicle (ownership) costs and 'crew' costs. The crew costs apply to freight transport and person public transport travel only: for car and active travel, the 'crew' and the end user are generally the same.
- The transport supplier costs are very largely based on market prices, and so are (in principle) readily determined. (This determination is outside the scope of the present project.)
- The user/beneficiary economic costs (including benefits) resulting from the transport services may be sub-divided into the financial costs associated with the transport task and the other economic

cost components, which are essentially time related. In general, the financial cost component paid by the user to the supplier equates to the supplier's transport costs involved (including contributions to joint/overhead costs and profit margins etc). One main exception to this relates to public transport, where in many cases services are provided on a subsidised rather than commercial basis, with the user paying only a proportion of the costs (but note that (eg) taxi services operate on a commercial basis).

- The other economic cost components relate to time, convenience and comfort factors as perceived and valued by the end user. These include expected travel time, travel time uncertainty/ unreliability, frequency convenience (principally relating to scheduled rather than on-demand services) and other quality and convenience factors. In general, these are 'non-market' factors, and so their valuation has to be determined through willingness to pay evidence (typically derived from SP surveys, which investigate respondents' trade-offs between the various time-related etc components and financial costs).

D3 Potential implications for EEM

If a categorisation of economic costs and benefits along the lines set out in table D.1 were to be adopted, then this would suggest that changes to the EEM structure and content relating to the transport costs and user benefits covered in this note would be advantageous, along the following lines:

- Clearly distinguish between 'transport supplier/operator costs (col 3) and 'user benefits' (col 4), as in table D.1[44].
- Cover all 'transport supplier costs' within a single section of the manual, ie including 'crew' costs (for freight and PT travel) along with other supplier costs. This section should also include the material on bus operating costs currently in EEM, section A15.
- Cover all user time-related benefit items in a single section (but maybe separating user time costs for in-work-related travel, which are established on a MPL rather than WTP basis). This would cover much of the material currently in EEM, section A4, plus other time-related material from section A18.

Table D.1 Land transport benefits and costs – potential typology

Transport type/mode	Purpose	Transport supplier costs (market prices)	User (beneficiary) benefits and costs (non-market/WTP valuation)
Freight transport (truck, train)	Work-related	• Operating costs • Vehicle costs • Crew costs	• Transport charge (= total TS costs) • Time (stockholding) costs (VoT) • Reliability costs (VoR) • Frequency/convenience costs (VoF) • 'Perishability' costs • Urgency costs.
Person transport (car, active, PT)	Work-related	• Operating costs • Vehicle costs • Crew costs (PT only)	• Transport charge (= total TS costs, except PT fares). • User time costs (MPL basis).

[44] This will have some particular issues for the current EEM, table A4.2, which includes some elements of operator costs and some of user benefits within a single number

Transport type/mode	Purpose	Transport supplier costs (market prices)	User (beneficiary) benefits and costs (non-market/WTP valuation)
Person transport (car, active, PT)	Other purposes	• Operating costs • Vehicle costs • Crew costs (PT only)	• Transport charge (= total T.S costs, except PT fares) • User time costs (VoT) • Reliability costs (VoR) • Frequency/convenience costs (VoF).

Notes: a) PT = public transport; WTP = willingness to pay; TS = transport supplier; VoT = value of time; VoR = value of reliability; VoF = value of frequency benefits; MPL = marginal productivity of labour.

Appendix E: Market segmentation

E1 Introduction

This appendix summarises the ways other researchers dealing with valuing freight time and reliability have segmented the freight market, both internationally and in New Zealand. It then details the segmentation adopted for this study.

Because the aim of the research was to provide values in the EEM for time and reliability to be used for evaluation of transport projects, it was important to identify a segmentation that related to the whole freight movement sector in New Zealand, not just those freight owners who might place greater value on those attributes.

For that reason, we chose a segmentation that could be related back to the NFDS. In principle, values derived for the major segments could be related to the volumes derived in the NFDS, for the country and by region, and potentially by route, and weighted appropriately for the mix of traffic.

We have also attempted to group commodities by the expected common nature of their sensitivity to time and reliability, and by dominant mode.

E2 International segmentation practices

Most of the international literature does not openly segment the market at all. It focuses on deriving values per shipment, and it is likely that the market is general freight, manufactured and retail, since the authors were seeking to establish how time and reliability are valued, and it is that sector that is likely to value those attributes most highly.

Where the market is broken down into segments, there is a great variety in the segments chosen. The choice appears to be determined either by the nature of the economy in the country concerned (principally in Western Europe), or by the ready availability of standardly classified national statistics. Thus, for example, we have found no studies that have a segment for livestock or dairy products, both of some significance in New Zealand. Nor are there many that have a segment for aggregates, although they are likely to be as important in Europe as in New Zealand. They are, however, of low value as a commodity and might be expected not to exhibit high values for time or reliability savings.

On the other hand, a number of international studies had a chemical industry segment, not of particular importance in New Zealand. Others dealt with the automotive industry. Transport of cars in New Zealand only accounts for 0.2% of tonne-km, as they are typically imported to the nearest port. Textiles, identified in another study, have only a tiny counterpart in New Zealand.

Another classification is related to full/part loads, and intra-city/inter-city traffic (eg Tsolakis et al 2011); Austroads (2003); Wigan et al (1998); all re Australia), which is also likely to be manufacturing and retail.

De Jong et al (2014), re the Netherlands, use a container/non-container split, again not very useful in relation to commodities. Similarly, Fowkes and Whiteing (2006), re the UK, offer container and 'express' segments, but alongside a commodity split of coal, petroleum and chemicals, other bulk, automotive and finished (general) goods. Fowkes (2001), also re the UK, includes 'distribution' or not, and own account/third party haulier classifications, as well as a commodity split between chemical products, and paint, food and grocery, and 'other commodities'. Fowkes (2007) (UK) has a similar classification into bulk (coal, oil, automotive being the only ones with significant time values), containers, and finished goods.

Fridstrom and Madslien (1995), re Norway, segment the market into edible refrigerated goods, frozen goods, raw materials, processed goods, and semi-processed goods.

Shinghal and Fowkes (2002), re India, use chemicals, forwarders, exporters, automotive parts, food and electrical. Austroads (2003), re Australia, use food, auto parts, building materials and packaging. Garcia Menedez et al (2004), re Spain, use wood, manufacturing, furniture, ceramics, textiles, agro industry.

Fries et al (2009), re Switzerland, use a more comprehensive split, with some values per tonne at a commodity level: food, including animal food, chemicals and agricultural raw materials, iron and metal, building materials, and manufactured goods. This split could be usable in New Zealand, but still not fully reflect the New Zealand economy. See also Fries et al (2008).

De Jong (2014), re the Netherlands, has the most comprehensive commodity split, apparently based on a national statistical grouping: agriculture, food, mining, ores, basic metals, construction, fertilisers, chemicals and miscellaneous. However, these are used for value of time inputs to his model and outputs in the form of values of time and reliability are not given. While this list is comprehensive, it still would not reflect the nature of the transport task in New Zealand.

E3 Kim and other New Zealand examples

There are few New Zealand studies relating to the value of freight time and reliability, and fewer with a commodity split. Bone et al (2013, p71) suggests a segmentation showing captive to road, and road or rail, plus two coastal shipping options not relevant to this study. As noted in the next section, we have approximated Bone et al's road/rail segmentation in the way we have chosen the commodity groups for this project.

They also suggested a segmentation based on distance: inter-regional, regional, and intra-urban. We have chosen slightly different categories to the same end. They also suggest international air and sea, and linkages on land. The international leg of journeys is outside our scope, but we have achieved much the same end in terms of land-side linkages by our commodity classification, which Bone et al did not cover.

Bone et al further suggested a consignment size classification, covering large multi-container/bulk shipments, full container/truck loads, and LCL. We have not used this dimension, though it informed our choice of commodity groupings. The same comments are true for the vehicle type/freight form classification suggested by Bone et al.

Auckland Transport (2016) used international values for broad commodities like bulk goods and perishable goods.

Kim (2014) and the papers based on it, Kim et al (2013, 2014, 2017, 2018), focused on the 'non-bulk products which could be carried by non-specialised transport modes or equipment [and were] limited to general cargoes, such as basic manufactured products, consumer goods and others … commonly loaded and transported on pallets or on containers' (Kim 2014, p72). This is reflected in his 'choice experiment sets' which were four variations on a 'shipment': two sets use a 16 tonne, 20 ft container ('FCL'), and another two sets comprise five pallets totalling four tonnes ('LCL'). Each pair of sets is further classified by distance, intra/inter-island, ie <250 km, >250 km.

One of our segments matches this group of commodities, so we can compare our results with Kim's and potentially extrapolate his work over the full set of commodities.

E4 Our principal commodity groupings

We chose the NFDS as the basis for the principal and detailed groups, in order to make sure the values we derived reflect the totality of the New Zealand market, and can be related to the more detailed data on freight flows in the NFDS. The groupings also try to segment the market by mode (road and rail), so that some groups represent typical rail commodities, others typical road commodities, and some both. This is so that separate values of time and reliability might be derived for road and rail. Clearly, however, the groups are not exclusively road or rail. We were not directly concerned with coastal shipping in this study.

Details of the commodity split and the division between road and rail are given in table E.1. Our first commodity group relates directly to the commodity types studied by Kim. This is made up of retail and manufacturing, and general freight, including domestic food. It is the largest group, representing 39% of NFDS total tonne-km. It is dominated by road transport (84%), although the proportion it makes up of total rail tonne-km (35%) is not far below the comparable proportion for road (40%).

The second group is perishable exports – raw milk, meat, fish and horticulture. This makes up 12% of total tonne-km, and is again dominated by road (87%): it accounts for significantly more of road's total than of rail's, in terms of the proportion of each mode's tonne-km.

The third group is other containerised exports and their precursors, and similar commodities – manufactured dairy, logs (including those exported in bulk), sawn timber, panels, pulp and paper, grain, wool, other agricultural products (includes imports), other minerals, and livestock. This group makes up 32% of total tonne-km and is dominated by road (84%). It is, however, similar to group 1 in its relatively even importance to road and rail.

The fourth group is bulk exports – coal, iron and steel. This is 6% of the total tonne-km and is dominated by rail (84%). It accounts for over a quarter of rail's tonne-km, but a negligible portion of road's total tonne-km.

The fifth group is other domestic traffic – petroleum, lime/cement/fertiliser, waste, concrete and aggregate. These commodities typically travel short distances, and hardly any of this goes by rail, with road having 97% of the market. It is 13% of road's tonne-km but only a small fraction of rail's total tonne-km.

Road thus dominates all groups except 'bulk exports' which was defined as a principally rail mode to see if time and reliability values could be specified separately for rail.

Table E.1 Principal commodity groups and road/rail shares[a]

Commodity group	Rail tonne-km (bn)	Road tonne-km (bn)	Total tonne-km (bn)	Rail tonne-km (%)	Road tonne-km (%)	Total tonne-km (%)	Road: total km (%)
1. Retail, manufacturing, general freight	1.47	7.46	8.93	34.9	40.3	39.3	84
2. Perishable exports	0.35	2.30	2.65	8.3	12.4	11.7	87
3. Other containerised exports, + precursors	1.17	6.07	7.24	27.8	32.8	31.8	84
4. Bulk exports	1.15	0.22	1.37	27.3	1.2	6.0	16
5. Other domestic	0.07	2.47	2.54	1.7	13.3	11.2	97
Total	4.21	18.52	22.73	100.0	100.0	100.0	81

Source: Deloitte (2014)

[a]. Note that this table excludes coastal shipping as out of scope.

These groupings were agreed with Waka Kotahi at an early stage in the project.

We have also classified the movements geographically (within each commodity) into intra-regional, inter-regional (within one or both islands), and inter-island. This should avoid the bias towards manufacturing and retail inherent in any intra/inter-city classifications.

E5 Our detailed commodity groupings

Table E.2 lists the five principal commodity groupings and their corresponding detailed commodity classifications in the NFDS. In our market research we asked the respondents to classify their four principal freight flows into one of these commodity classifications. In addition, we enabled respondents to write in a commodity if they thought their commodity was not covered: this was later reclassified by the researchers, as the detailed classifications are meant to be exhaustive.

Table E.2 Detailed commodity groupings

Commodity group	Detailed group
1 Manufacturing, retail	No further subdivision
2 Perishable exports	2a Raw milk
	2b Export meat and fish
	2c Export horticulture products
3 Containerised exports	3a Manufactured dairy for export
	3b Logs and timber
	3c Pulp and paper
	3d Livestock
	3e Grain, wool, and other agricultural products
4 Bulk exports	4a Coal
	4b Iron and steel
5 Other domestic	5a Liquid fuels
	5b Lime, cement, and fertiliser
	5c Waste, recycling
	5d Concrete
	5e Aggregate, rock etc
	5f Other minerals, eg pumice, gold, china clay

Provided there are sufficient respondents at the detailed grouping level, it would be possible to create values at this fine detail, but the sample size and respondents were not selected with that in mind. To do that for all commodity classifications would have required a much larger survey than was undertaken, well beyond the budget of this study.

Appendix F: Market survey

F1 Introduction

The centrepiece of the research project was a SP survey of a sample of shippers of domestic freight in New Zealand, in order in particular to establish their willingness to pay for improvements in freight journey time and in the reliability (variability) of these times, The survey and the results of this form the focus of chapters 6, 7 and 9 of the main report.

This appendix provides additional details of this survey, in the following main sections:

- F2 Survey development and delivery methodology
- F3 Survey analysis and results – market characteristics
- F4.1–F4.4 Survey analysis and results – WTP findings
- F4.5 Survey analysis and results – comparisons with survey results from previous New Zealand work (Kim 2014).

Sections F2 and F3 primarily supplement chapter 7; and section F4 supplements chapter 8.

F2 Survey development and delivery

F2.1 Market research approach

The original concept for the research was to take the Canterbury PhD thesis by Kim (2014) as a benchmark for our commodity group 1, retail and manufacturing, and scale from there for other groups. This was to be based on their share of the transport task, and the international literature on the values of time and reliability for similar commodities.[45]

This proved not to be possible, for several reasons, as follows. First, we had to compare our methodology with Kim (2014), so we needed to review group 1 anyway. Second, the assumption that international literature would provide adequate commodity information to extrapolate from group 1 proved wrong. The literature was sparse in terms of commodities other than those in group 1. Most studies dealt with group 1 or equivalent commodities, which is understandable because it is those commodities which would be expected to value time and reliability most highly.

Third, the structure of the New Zealand economy is different from that of European or North American countries, which are the regions where most of the studies originate. For example, primary industries for export, especially perishable and containerised primary exports, are likely to be more important (relatively) in New Zealand.

Most importantly, we wanted to make sure that the results represented the whole market, even commodities that were unlikely to place significant values on time and reliability. Since the output was to be a value or set of values for EEM, then those values should reflect the average of all freight users of the roads, or all users in particular groups. As some view of the value of time and reliability for those commodities hauled by rail was requested, it was also desirable to create a group which was dominated by rail.

[45] See appendix E: Market segmentation, for the definition of commodity groups.

Given that the original concept for the market research would not be adequate, it was decided to proceed with a fuller market research approach, using SP methods. Two main types of SP methods are generally recognised in the survey literature: i) contingent value methods; and ii) choice modelling methods (which are sometimes referred to as choice experiment sets – CES). We adopted the contingent value methodology, on the basis that i) it involved a simpler survey and would be less demanding in terms of its sample size requirements; ii) it would focus directly on variations around each respondent's current freight transport characteristics (eg currently experienced travel time, and extent of lateness, etc), rather than on a range of hypothetical transport journey attributes, and therefore would be expected to provide more realistic responses; iii) the survey analysis would be simpler; and given these characteristics; iv) it would be more affordable within the limited project budget[46].

Our approach therefore involved the development and application of a questionnaire survey for shippers and transporters, with a key component being a series of questions directly on willingness to pay for changes in travel times and reliability.

F2.2 Questionnaire development and contents

The questionnaire comprised six groups of questions, as follows[47]:

1. *Contextual questions* – contact details, nature of the firm (including distinguishing between transporters and shippers), use of third-party logistics, transport and logistics employee numbers, transport spend, and tonnage moved.

2. *Commodity and freight flow information***.** This introduced the concepts of 'commodity groups' and 'commodity segments'. The commodity groups comprised groupings of the more detailed commodities used in NFDS, with the intention of grouping together commodity movements which were expected to give similar importance to travel time and reliability; further details of these commodity groups are given in section 3.1 and in appendix E: 'Market segmentation'. The 'commodity segments' were commodity movements within a specific O-D category: the three categories were within a region, between regions intra-island, and inter-island.

   We asked respondents for the top four segments, in terms of the percentage of the total tonnes moved. A single respondent could have commodity segments in four different commodity groups; or three different segments in the same commodity group; or maybe only one segment in a single commodity group (eg local haulage of logs).

   We also asked, by commodity segment, for the detailed origin and destination, the average haul distance (from which we derived tonne-km) and the value of the commodity segment (per tonne). Information was also sought on whether the firm stockpiled freight, on the freight rate, and a description of the supply chain and the firm's position in it.

3. *Modal information (by segment).* This included the current mode used for each segment, whether a commodity currently carried by road could be carried by rail or coastal shipping, and if so the main reasons it was currently on road.

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[46] For further information on the characteristics and relative merits of alternative SP methods, reference may be made to a recent Waka Kotahi NZ Transport Agency research report: Denne et al (2018).

[47] All answers to the questionnaire were confidential, and respondents have not been identified in any of the survey analyses.

4 *Service factors (by segment)* determining the choice of carrier – how important were price, fast journey time, reliability of delivery time, frequency, and loss/damage.

5 *Willingness to pay questions (by segment)*. The valuation (WTP) questions were essentially designed to measure WTP for changes in journey attributes from the status quo, a forward-looking perspective. This was in keeping with the aim of the whole project, ie what value to place on these attributes for evaluation of future transport system improvements. In practice, many respondents were found to place no significant value on change from the status quo, that is, they were happy with their current service attributes.

WTP questions for each segment were asked for four journey attributes, as follows:

a *Journey time,* including whether a fixed delivery time was expected. This included the key question on the trade-off between price and expected journey time. If there was a potential trade-off, then respondents were asked for the maximum they were willing to pay for a shorter journey time, as in the following table:

Change in expected journey time	Maximum extra price (%) willing to pay for shorter journey time (please write in the %)			
10% shorter				
25% shorter				
50% shorter				

The possibility of trading-off a lower price for a longer journey time was also canvassed, asking for the minimum price discount the respondent was willing to accept for a longer time:

Change in expected journey time	Minimum price discount (%) willing to accept for longer journey time (please write in the %)			
10% longer				
25% longer				
50% longer				

b *Reliability*. The initial question was whether the current journey time varied enough to cause concern, and if so how early or late, and how often. This was followed by a question about any trade-off between price and reliability, followed by similar WTP and WTA tables to those for journey time (as above). For reliability the WTP choices were late 25% and 50% less often, or never late. For WTA the choices were late 25% and 50% more often, and twice as often.

c *Frequency*. The questions here were similar to those for reliability, but focused on potential changes in service frequency. For frequency trade-offs, the WTP choices were 10%, 20%, 50% and 100% more frequent, and WTA were 10%, 20%, and 50% less frequent.

d *Loss or damage*. This addressed whether there was loss/damage enough to cause concern, how much there was, and again trade-off questions with similar tables to those above. For loss and damage, WTP choices were 25%, 50% and 100% reduction in the amount of loss/damage, and WTA 25%, 50% and 100% increase in loss/damage.

6 *Other comments*. We also asked an open question about the respondent's experience in completing the questionnaire.

F2.3 Sample selection

Our approach to recruiting candidates for interview was to use an ‘opportunity sample’ derived from a set of interviewees from the researcher’s own knowledge and enquiries, supplemented by Yellow Pages listings and referrals from other interviewees. The aim was to cover a high proportion of all domestic freight movements, as measured by the NFDS. Attempts to use local business organisations’ databases were unsuccessful.

Shippers were firms producing or managing the freight required to be moved. Most interviewees were shippers. A small number of transporters were also interviewed; these were firms that transported the freight on behalf of shippers. Further details are in section F2.5. Our approach resulted in coverage of about one-quarter of the total annual New Zealand tonnes and one third of annual tonne-km, as measured by the NFDS (details in section F3.2).

The survey covered only domestic (ie within New Zealand) transport movements but did include the domestic ‘legs’ of import/export movements.

The project was primarily concerned with domestic movements by road (truck) and rail, not specifically with coastal shipping: however, limited information on coastal shipping movements (along with associated land ‘legs’) was collected through the survey and has been included in the relevant survey analyses.

F2.4 Delivery method and issues

The questionnaire was originally emailed as a pilot to eight respondents. Only three responded, most after follow-up, and a further two responded via an interview by phone. The experience with the pilot was a slow and arduous process, and we quickly concluded that the questionnaire was too daunting for people to complete unassisted. This suggested that the best approach to respondents would be by personal interview, with the questionnaire being completed by the interviewer.

Those personal interviews took place by phone, by one of the principal researchers. The interviewees were in general emailed first (though for a number of referrals the contact was directly by phone), followed by a call to book a time, and another phone call to complete the interview. The initial email covered the scope of the survey, and why it was being undertaken. A letter of support from Waka Kotahi was included.

The phone interviews were ultimately successful. In many cases difficulties were experienced in tracking down the right person to talk to, and repeated reminders were required. The success of this effort is illustrated by the mere three outright refusals.

Some respondents were based in Australia, as part of multi-national firms which looked after New Zealand transport and logistics from there.

The phone survey took from 20 to 60 minutes to complete, depending on the complexity of the respondent’s business. A simple single-segment business was relatively quick, whereas a business with four segments and different commodities in each took the longest.

Some questions required a follow-up email to get specific data that was not to hand on the day. Some respondents were most helpful with this, others required reminding, and some did not answer despite reminders. Not all questions were answered by all respondents, in some cases on the grounds of confidentiality.

F2.5 Responses and respondents

Of the 76 firms approached, only three refused outright and another 18 agreed in principle to help but were unable to (due to time constraints, etc), giving 55 respondent firms, an overall response rate of 72% of those approached. The 24% who were sympathetic, but in the end unwilling despite repeated contact, is perhaps a symptom of the complexity of the subject matter and sensitivity of some of its content. A further four respondents were people in the same firm as other respondents, looking after a different region or part of the business, eg raw milk is typically separate from dairy output in its management. This gave a total set of 59 responses covering 143 segments.

Ten responses were received from transporters, and the rest from shippers. We included transporters principally to access industries with multiple and dispersed firms; transporters could represent an aggregate response for particular industries. The same questionnaire was used for both, but with the transporter version asking for information about shipper preferences, whereas the shipper one asked these questions directly.

The inclusion of transporters and shippers resulted in some double counting of segments. Significant instances were identified and taken into account in the analysis.

These 59 responses accounted for an annual total of some 65 million freight tonnes (net of double counting). Fifty-four million tonnes of this amount (accounting for some 9,000 million tonne-km, average haul distance c170 km) was covered in the commodity segments analysed in detail.

F2.6 Response issues

The definition (and concept) of segments caused some difficulty, which meant the researcher had to assist in categorising the respondent’s freight. In this regard the use of an interviewer knowledgeable about the industry was very helpful. The problem largely arose because of the combination of commodity and origin-destination (O-D) classification in one question.

Some respondents did not know the value of the commodity or the distances travelled, and the researcher filled in these from other sources (value) and the detailed origin and destination information provided (distance).

The questions on trade-offs, WTP and WTA also required explanation and discussion with the researcher. Also, the repetition of four separate but similar questions on this topic was difficult for some respondents. In the event, the questions on frequency and loss/damage were largely answered in the negative, and arguably (with hindsight) could have been omitted.

F3 Survey analyses – market characteristics

This section provides additional material on key characteristics of the New Zealand domestic freight market, based on analyses of the study’s market survey. This material supports the more summarised material provided in chapter 7 of this report.

F3.1 Respondent characteristics

F3.1.1 Share of freight volume and task by commodity group

As can be seen from table F.1, the largest commodity group in terms of tonnes was group 3, other containerised exports, followed by other domestic commodities and general freight (manufacturing and retail). In terms of tonne-km, general freight was the most important, reflecting its longer than average haul distances (see table F.2). This was followed by other containerised exports and other domestic commodities.

Table F.1 Respondent shares of total tonnes, tonne-km by commodity group

Commodity group	Typical commodities	Share of survey tonnes (%)	Share of survey tonne-km (%)
1: Manufacturing and retail	Retail, groceries, drink, cars, tyres, rubber, machinery, manufacturing	24.2	41.1
2: Perishable exports	Fruit, meet, fish, raw milk, grape juice, bulk wine, squash	7.2	3.6
3: Other containerised exports	Dairy products, logs, grain, livestock, timber, stock food, pulp, honey	37.0	25.0
4: Bulk exports	Coal, steel	6.5	11.6
5: Other domestic commodities	Aggregate, cement, lime, minerals, liquid fuels, fertiliser, concrete, waste	25.1	18.8
Total		100.00	100.00

Note: Derived from table F.2

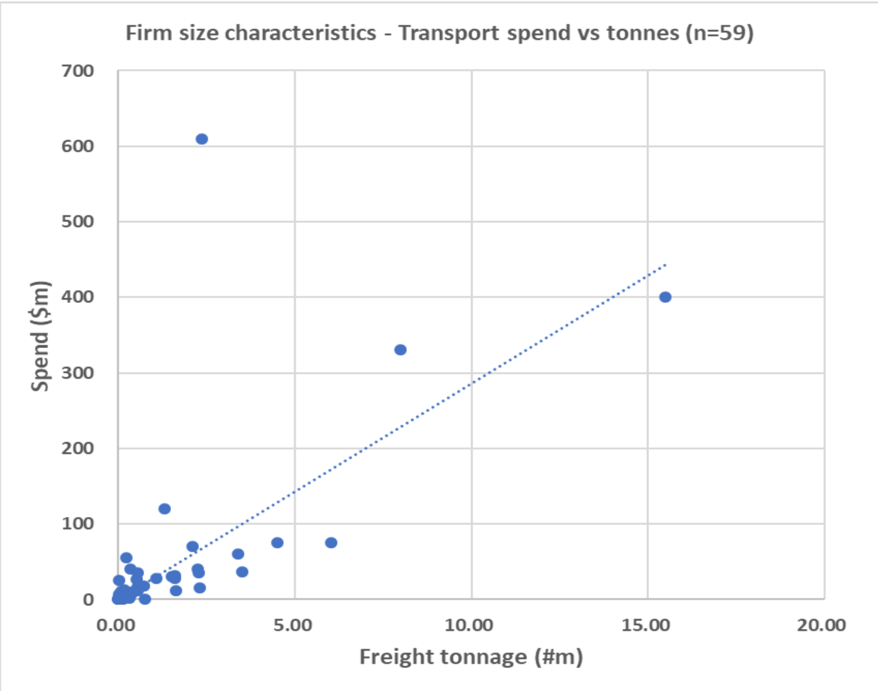
F3.1.2 Transport spend related to tonnage shipped

As an indication of the size of the firms surveyed, we asked for data on their annual freight tonnage and transport spend. The annual transport expenditure of the companies surveyed ranged between $50,000 and around $600 million (median $12m). The highest three were transporters, with expenditures between $330 and $609 million. The highest expenditure for a producer (shipper) was $120 million.

As expected, there was a relationship between the company's annual transport spend and its freight transport tonnage. On average, company transport spend was about $33 million per million tonnes of freight.

This relationship is illustrated in figure F.1.

Figure F.1 Firm size characteristics – transport spend and freight tonnages



F3.1.3 Logistics chains

We asked respondents to describe the logistics chain they were part of and their position in it (in italics below). The most common were:

- *Produce*–-transporter–client and its variants, such as: *Producer*–forwarder–client; *Producer*–transporter–port; and Port–*transporter*–client.
- Sometimes the producer was defined, or a similar function given, eg: *Mine*–transporter–*processing-plant; Distribution centre*–transporter–retail stores.
- More complex chains included: Importer–*transporter*–forwarder–transporter–client; Farm–*packhouse*–transporter–port; Farm–store–transporter–*producer. All*.

This aspect was not core to the research but could be related to all the other data in the survey as a potential area for future research.

F3.2 Comparisons of response statistics by commodity group with NFDS

The annual freight task represented in the survey was compared with estimates of the 2012 New Zealand total annual domestic freight task made in the NFDS (Deloitte 2014). The survey responses in total (after adjustments for double counting) accounted for approximately 23% of total annual tonnes and 34% of total tonne-km estimated in the NFDS. In terms of tonne-km, the highest proportion of the NFDS (2012) total was for group 5, bulk exports, where the survey returns accounted for 77% of the total available freight (as estimated for 2012), followed by retail, manufacturing and general freight at 38%.

These results are shown in table F.2, with further details given in annex FA.

Table F.2 Survey freight volumes (2017) compared with NFDS estimates (2012) – by commodity group

Group	Coverage	Surveyed segments #	Survey tonnes (m)	% of NFDS tonnes	Survey tonne-km	% of NFDS tonne-km	Survey ave haul-km
1	Retail, manufacturing, general freight	45	13.0	15.6	3,699	38.3	284
2	Perishable exports	17	3.9	13.9	325	12.2	83
3	Other containerised exports (and precursors)	41	19.9	35.5	2,247	31.1	108
4	Bulk exports	10	3.5	41.2	1,041	77.1	260
5	Other domestic commodities	30	13.5	22.4	1,693	31.1	115
Total		143	53.8	22.8	9,005	34.3	161

If allowance is made for the underlying growth in the New Zealand domestic freight task over the period 2012–2017, which is estimated at approximately 8% overall[48], then the survey data would account in aggregate for approximately 21% of the 2017 freight tonnage and 32% of the 2017 freight tonne-km.

[48] This 8% estimated growth figure (2012–2017) was provided by Richard Paling (pers comm, 31 Oct 2018)

F3.3 Commodity segment characteristics

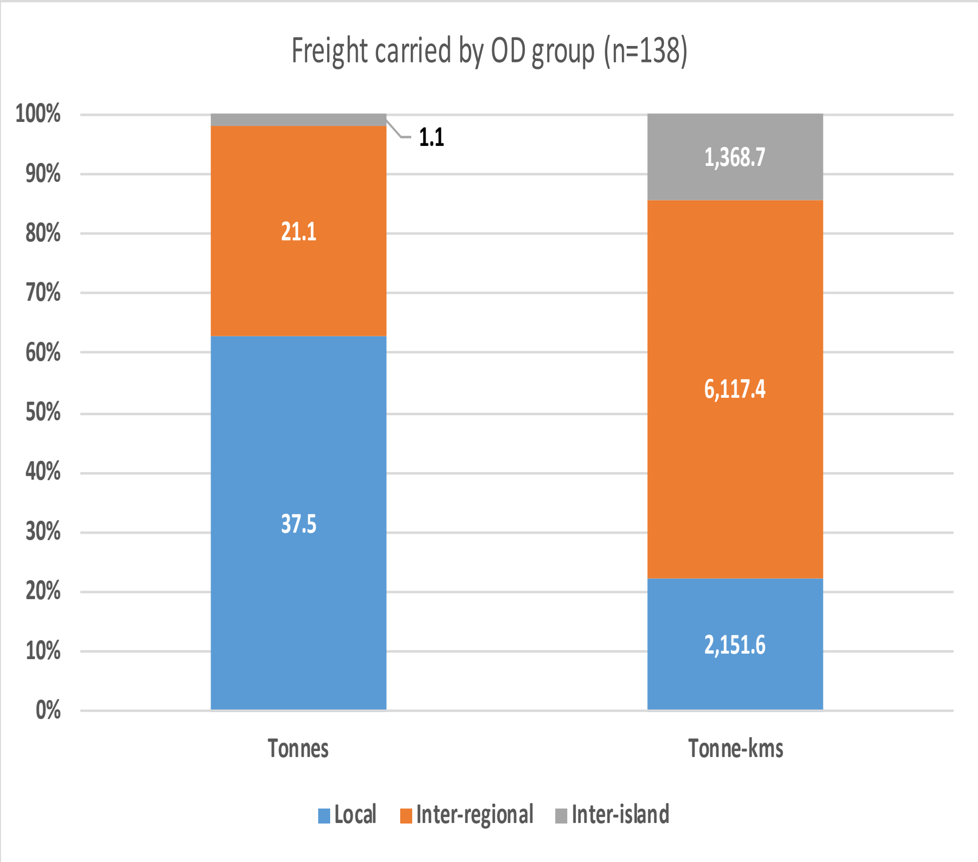
F3.3.1 Freight task by origin-destination category

Figure F.2 provides a summary of the freight task by O-D category. In terms of those categories, the 'local' category accounts for some 62% of total surveyed tonnes, but only 22% of tonne-km (average haul length c57 km).

The inter-regional (within island) category accounts for 35% of total tonnes, and the majority (63%) of total tonne-km (average haul length c290 km).

The inter-island category accounts for only 2% of total tonnes, but some 14% of total tonne-km (average haul length c1,245 km).

Figure F.2 Freight task by origin-destination category



F3.3.2 Transport price per tonne and tonne-km vs distance

As might be expected, transport prices per tonne increase with distance, following a broadly parabolic curve, ie the incremental price per kilometre gradually decreases as the distance increases, but with lots of scatter in the data. The following graphs (figures F.3, F.4) show the prices per tonne and per tonne-km against distance (using log-log scales to give a clearer picture of variability).

For a given distance, prices per tonne tend to be:

- lower than average for commodity group 2 (eg raw milk, meat, fish), group 3 (eg logs) and group 4 (eg iron, steel, coal)

- higher than average for group 1 (retail, manufacturing, other higher value commodities) and group 5 (mostly liquid fuels).

Figure F.3 Transport price per tonne vs haul length by commodity group – log scales

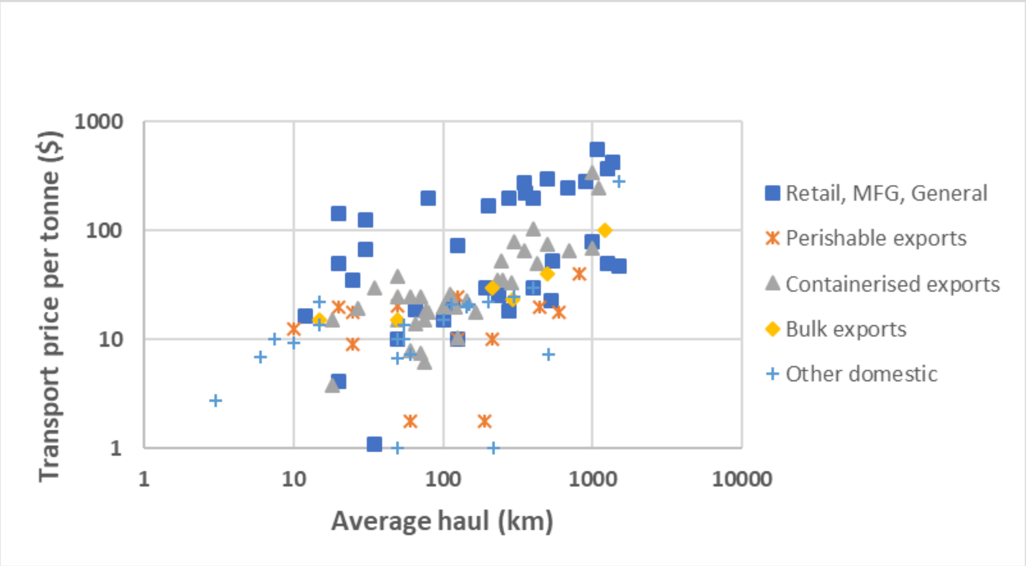
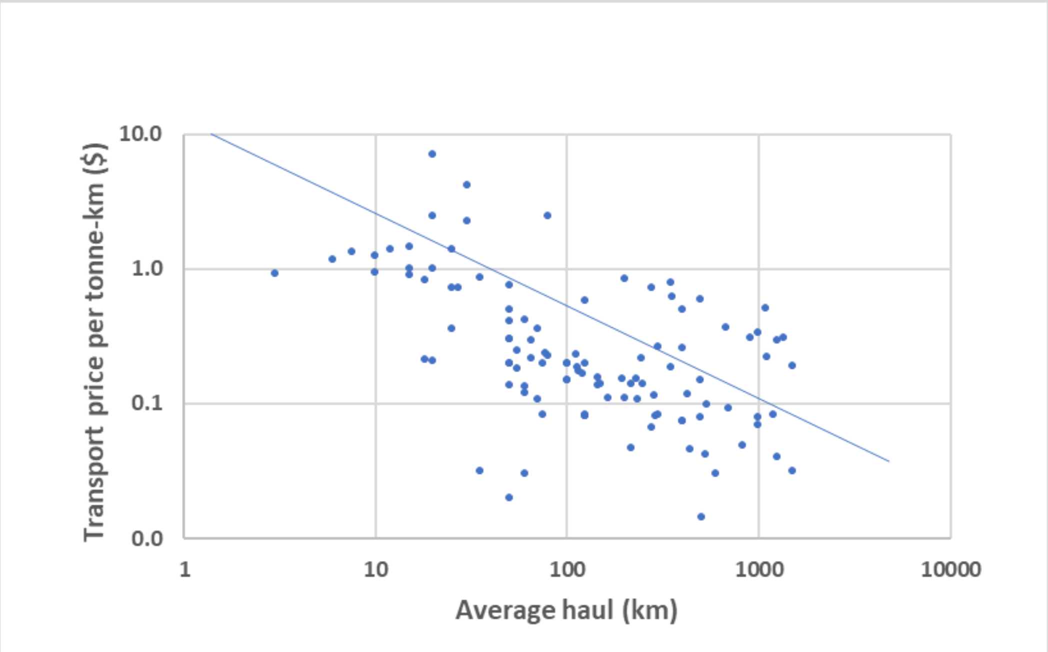


Figure F.4 Transport price per tonne-km vs haul length – log scales

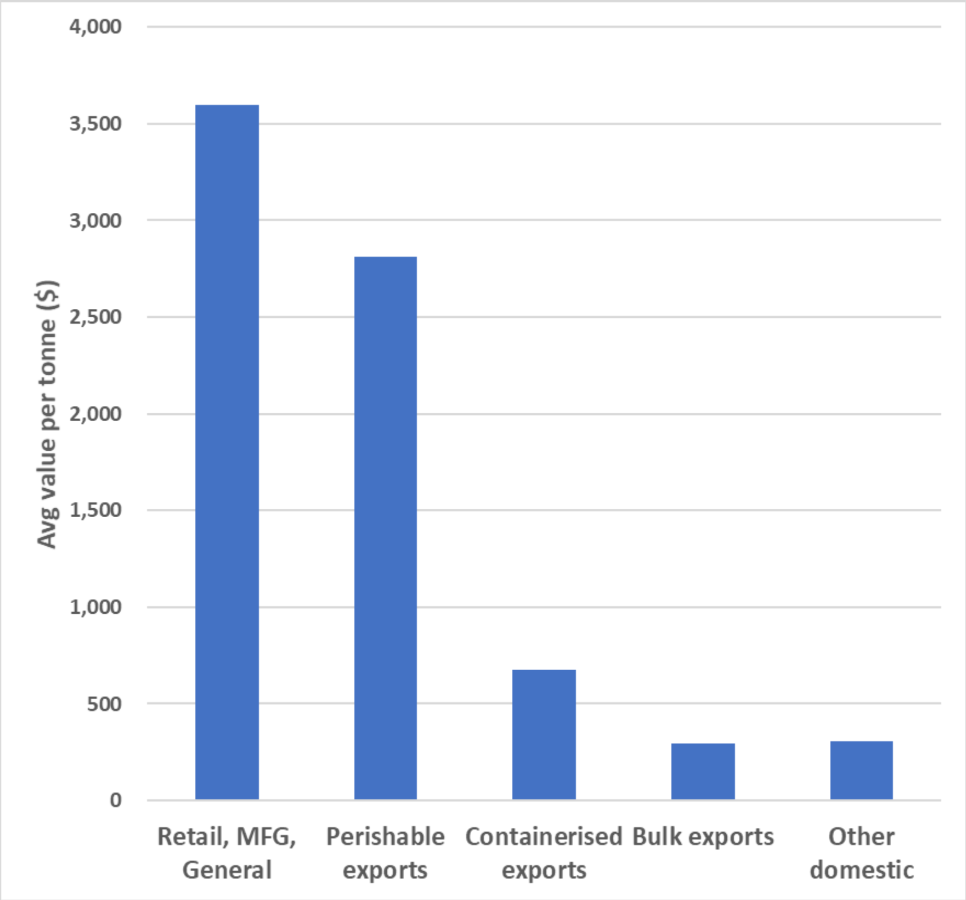


F3.3.3 Values of freight by commodity

Respondents provided estimates of the 'value density' (ie value per tonne) for each commodity segment surveyed. For the survey overall, the total value was some $79 billion for about 60 million tonnes, an average of some $1,300 per tonne.

As shown in figure F.5, average values varied markedly by commodity group, from about $3,600/ tonne for group 1 (retail, manufacturing, general) to $300/tonne for groups 4 and 5 (bulk exports, other domestic).

Figure F.5 Values of freight by commodity group



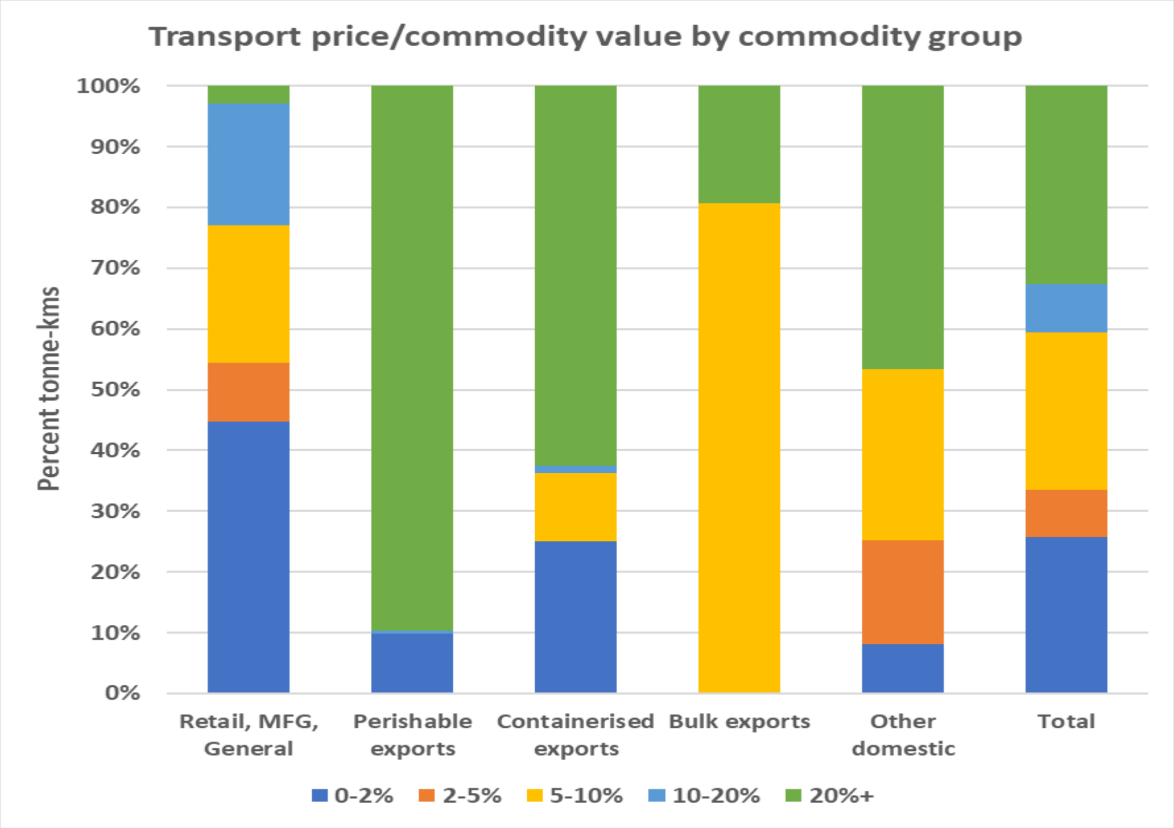
F3.3.4 Transport prices relative to commodity value

These commodity values were compared with transport prices (costs), for each movement (domestic only), with the results then aggregated by commodity group.

Over all commodities, the ratio transport price: commodity value is 0–2% for around 25% of tonne-km, 2%–20% for a further 45%, and over 20% for the remaining 30% of tonne-km: further details are given in figure F.6.

By commodity group, the highest transport prices (relative to the commodity values) are for group 2 (perishable exports), with prices exceeding 20% of the commodity values for around 90% of tonne-km. The lowest relative transport prices are for group 1 (retail, manufactured goods etc), with prices being less than 5% of the commodity values for over half the tonne-km.

Figure F.6 Transport prices relative to commodity values



F3.4 Mode and carrier choice aspects

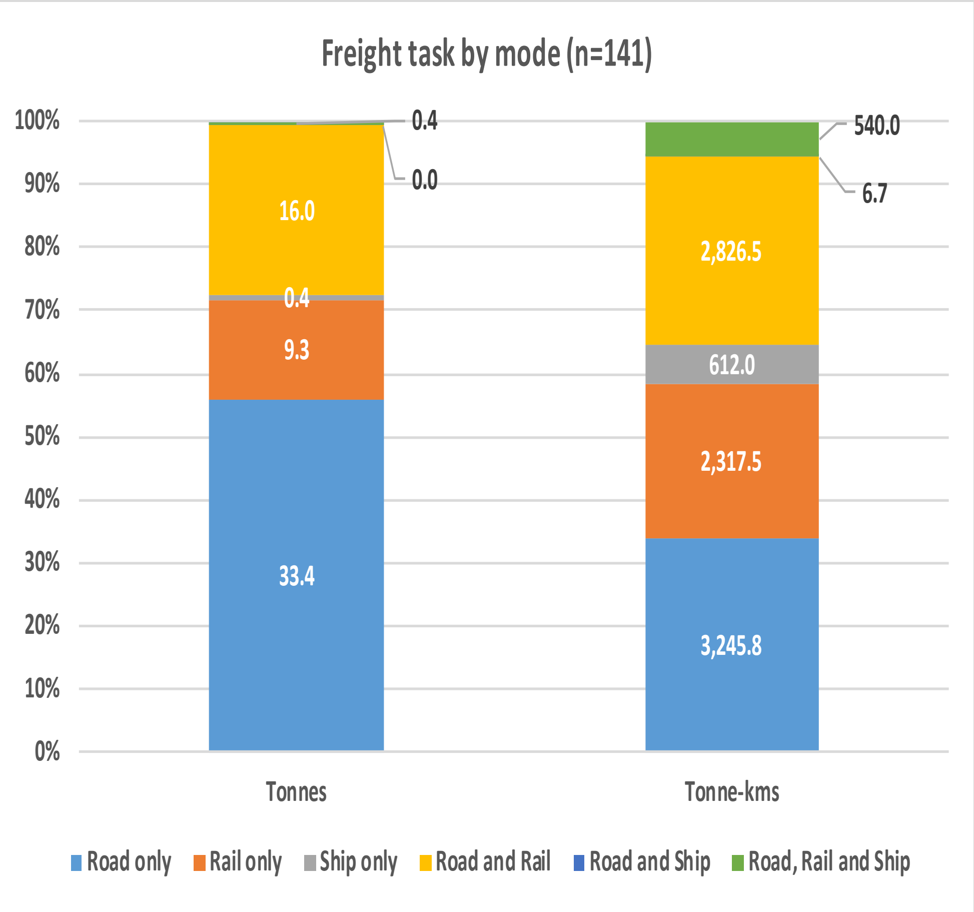
F3.4.1 Freight task by mode

The survey also provided a substantial amount of information about use and choice of mode,

The surveyed freight movements were categorised by transport modes used, recognising that a substantial proportion of movements involved two or more modes (road/truck, rail, ship – refer figure F.7). Movements using the Cook Strait ferry were treated as either road or rail (not ship), as appropriate.

Road-only movements accounted for some 56% of total tonnage, but only around 34% of tonne-km. The other major contributors in terms of total tonne-km were road/rail (30% of total) and rail only (24% of total).

Figure F.7 Freight task by mode

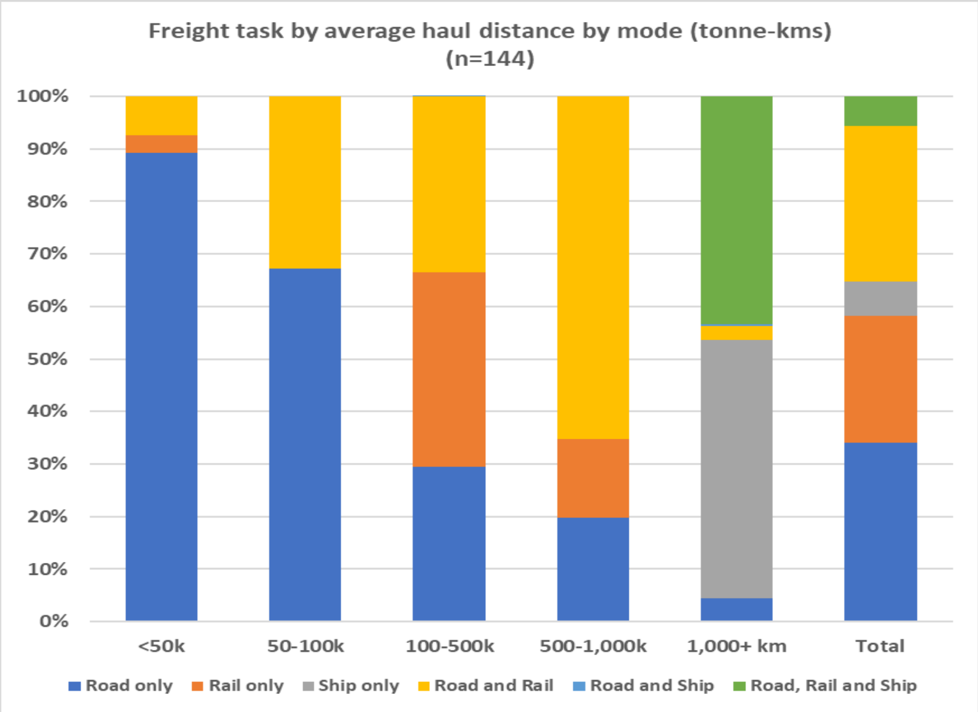


F3.4.2 Freight task by mode by haul distance

The mode used was analysed by haul distance, as shown in figure F.8. As anticipated, the market shares by mode show a strong pattern of variation with haul distance:

- Road only is heavily dominant for local movements: road accounts for around 80% of tonnage for distances up to around 100 km.
- For inter-regional movements, road/rail is dominant, accounting for around 70% of tonnage over distances between 500 km and 1,000 km.
- For longer distances (mostly inter-island traffic), ship only and road/rail/ship are the dominant modes.

Figure F.8 Freight task by mode by haul distance



F3.4.3 Importance of factors in choice of carrier

Respondents were asked about the most important factors in choice of carrier for each of their commodity segments. Five factors were specified, to be rated as very important (score 10, for analysis purposes), important (score 5) or not important (score 0).

Within each commodity group, the weighted score for all responses for each of the five factors was derived (weightings proportional to tonnages), as shown in table F.3.

For all commodity groups combined, reliability and price factors were the most important, followed quite closely by frequency and time factors. Safety (not included in the question) was also given as a significant factor, while loss/damage was seen as relatively unimportant.

The relative importance of the various factors differed markedly across the five commodity groups:

- Reliability was the most important factor for group 1 (retail, manufacturing etc) and group 2 (perishable exports)
- Price and time were the most important for group 3 (other containerised exports)
- Frequency was the most important for group 4 (bulk exports).

Table F.3 Relative importance of factors by commodity group (responses weighted by tonnes)

Factors	Very important					
	Commodity group					
	Retail, MFG, general	Perishable exports	Containerised exports	Bulk exports	Other domestic	Total
Price	8.8	6.8	8.5	7.0	7.5	8.1
Time	6.5	6.8	8.5	7.0	7.5	7.6
Reliability	9.7	10.0	7.8	6.7	7.9	8.3
Frequency	8.1	6.6	7.3	9.8	7.5	7.7
Loss	4.4	6.1	3.6	0.0	4.5	3.8
Other factors identified as important include safety (13% of tonnes)						

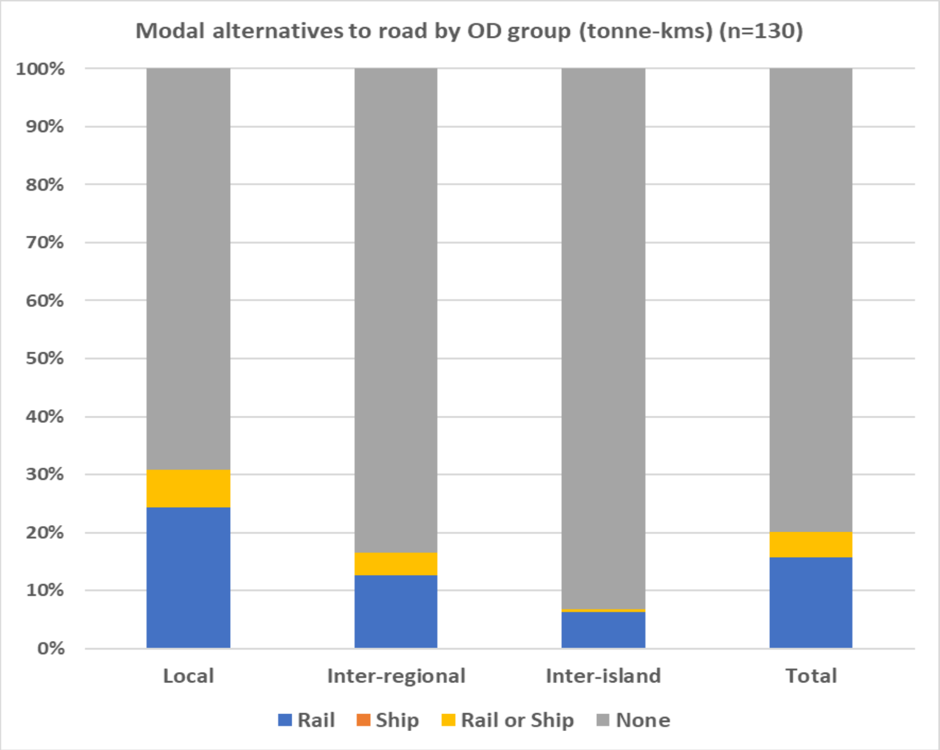
F3.4.4 Modal alternatives to road by origin-destination category

For commodity segments currently carried by road (only), respondents were asked whether rail or ship could reasonably be used for all or a major part of the journey. Overall, responses saying that rail or ship could not reasonably be used accounted for 80% of total tonne-km, as shown in figure F.9.

This proportion was somewhat lower (around 70%) for local movements, and higher (over 90%) for inter-island movements. In cases where rail or ship could reasonably be used, the dominant choice was rail.

These results are likely to reflect that a substantial proportion of longer-distance movements are already carried by rail and/or ship, and the existing road movements are likely to be captive to road for a range of reasons.

Figure F.9 Modal alternatives to road/truck by O-D category

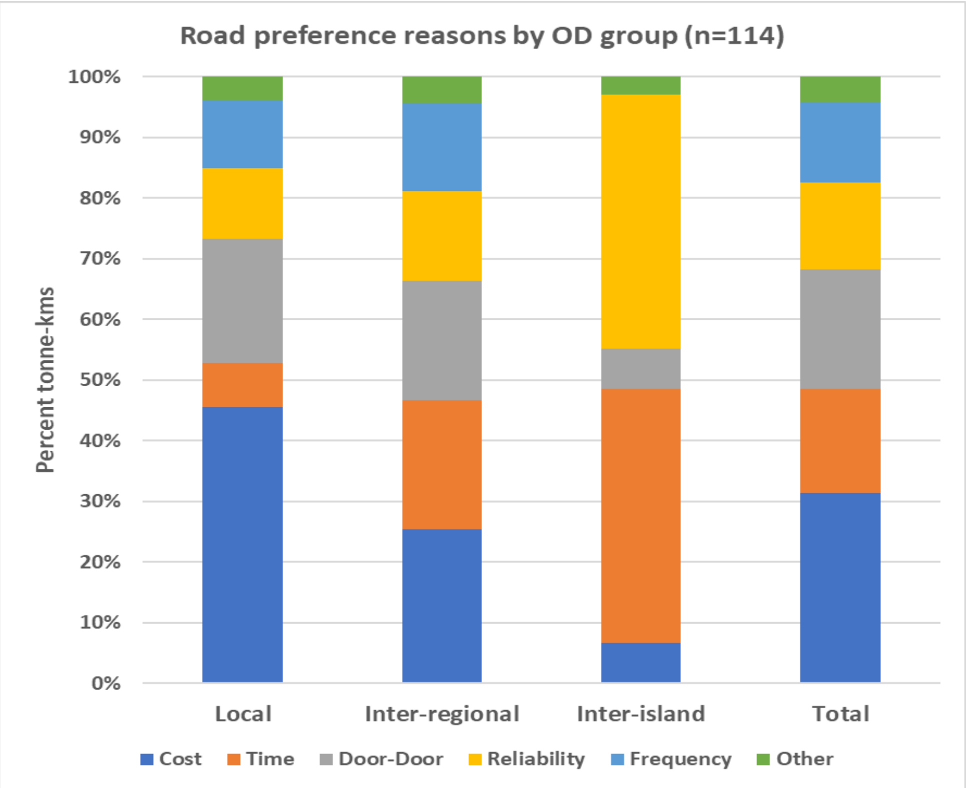


F3.4.5 Reasons for preference for road, by origin-destination category

For commodity segments currently carried by road (only) that could reasonably be carried by rail or ship, respondents were then asked about their main reasons for choosing road (figure F.10). These reasons differed considerably between the three O-D categories:

- For local movements, cost was the dominant factor (given for about 45% of local tonne-km), followed by door-to-door service requirements.
- For inter-regional movements, five factors were rated as of broadly similar importance: cost, time, door-to-door service, reliability and frequency.
- For inter-island movements, two factors were dominant: reliability and time.
- For all movements, loss or damage was seen as of relatively low importance.

Figure F.10 Road preference reasons by O-D category



F3.5 Respondent general comments and feedback

F3.5.1 Overview

Survey respondents were asked an open question at the end of the interview, inviting them to make any other comments that might be helpful to the understanding of WTP for time savings and reliability improvements for freight. Of the 59 respondents, only six did not take this opportunity. The question was, however, often interpreted broadly, and a number of the answers concerned productivity improvements, the state of the roads, vehicle operating costs and other topics not directly related to the time and reliability aspects. The answers from the 53 who did respond are summarised below, arranged thematically. Of note is that many of these comments relate to the operating and capital costs of running a truck, and were given even if the product had no reported time and reliability values.

F3.5.2 Reliability

Time and reliability were seen as important, but reliability more so because it cannot be planned for. A regular, reliable service was more valuable to customers than a fast one (eg as long as it was delivered on the specified date or to meet the specified time-gate). One producer was trying to model what customers would pay for costs outside of such a baseline reliable service. Retail stores held minimal stock, and so reliability in terms of delivery on time, in full, without damage was important. In some cases, stores might source locally in competition with the centrally organised suppliers if their service was not up to scratch. Customer contracts had such 'difotis' clauses (ie delivery in full, on time, in spec) calling for 95%–100% performance. Thus the value of reliability is already captured in current arrangements, and people would not be willing to pay more to get what they already have (or to pay less for lower levels of service and reliability). High service was normal, said one producer, and not capable of further premium pricing. A carrier estimated that a 5%–10% price component for reliability was already included in their current rate. A producer thought there was no willingness to pay extra – the current suppliers already had a 'fair deal'. A forest owner valued regularity in trucks arriving at the forest, but that was encompassed in the freight rate.

One respondent, a bulk liquids producer, felt that road and sea were very reliable and resilient, with alternatives available for adverse events. They were reluctant to pay for time and reliability savings as the system was complex and events were outside their control, meaning an investment in reliability would not have an effective return.

An importer, manufacturer and distributor of a bulk product noted that there was a significant difference between the time pressure on domestic goods relative to imported materials, where 60 days freight on board was the norm.

F3.5.3 Resilience

Resilience as a characteristic was not surveyed; reliability was assessed by the researchers in terms of the deviations around everyday performance, whereas resilience was about reaction to abnormal events, such as the Kaikoura earthquake. Nevertheless, respondents commented on resilience issues. These were mainly about maintaining the security of the network, keeping it open, especially where there were no alternatives (such as for the inter-island route). One said it was a challenge to get more involved with coastal shipping.

F3.5.4 Safety

In the list of attributes that people considered important in choosing a carrier, there was an 'other' option. One common attribute specified in this was safety, and this was reflected in the open comments. Safety was expressed as a 'key focus' and respondents paid a premium to ensure safety (without being able to specify an amount). A specific instance was food chain safety, especially with exports, needing to use only carriers with Ministry for Primary Industries (MPI) certification, and managing the supply chain so that export food safety was not compromised, for example by using a subcontractor without the certification. If the approved food safety chain was broken the product was not exportable and was largely worthless.

F3.5.5 HPMV

A number of correspondents pointed out the substantial gains in productivity from the introduction of higher weight and longer length limits with high productivity motor vehicles (HPMV). One bulk liquids producer cited an improvement of some 10,000 litres per load, at 35,000 compared with 25,000 10 years ago. The tonnage improvement is approximately 8 tonnes, some 31%. Another in the same industry reported a 50% productivity improvement since 2011. A different industry reported a 4% saving with 50MAX trucks. The entire quarter million tonne plus annual output of one factory is now carried to the nearby port in just two 60 tonne HPMV. Savings in loading time and organisation in agriculture were also noted from the bigger vehicles.

On the other hand, there were some criticisms of the HPMV arrangements. One respondent sought more reliability and comprehensiveness with respect to HPMV rules, for example flexibility with RUC for lighter loads, and expanding the network to include detours that, for example, could be used to avoid congestion. A log producer sought the ability to carry more on the network generally.

F3.5.6 Congestion

Congestion was a recurring theme, especially in the Auckland region, but also elsewhere (Tauranga and Hawke's Bay). Cartage rates were asserted as needing to rise, and move from tonnage and distance to time-based rates. One respondent produced a commodity with tight time and reliability requirements, which were impacted directly by congestion. Others pointed out that rate increases brought about by congestion did impact on the commodity in the sense of lowering its net worth (or raising its price). One solution suggested was to allow trucks to use bus lanes, which in some cases had taken away roading capacity from freight movements.

One respondent thought the problem resulted from a focus on private vehicles in roading investment. Provision of infrastructure had not kept pace with population. and the impact on productivity was of concern for freight owners.

Introducing night deliveries is a common reaction, mainly in Auckland but also in Tauranga. One carrier thought a discount in transport prices of 10% would be expected for such deliveries.

On-port congestion was also raised. One importer thought the difficulties in getting containers out of ports in Australia were reflected in its New Zealand operation. Others noted that turn-round at particular ports had worsened, and that bunching of trucks at the port was having impacts on the whole supply chain for that commodity. The problem was that trucks had to go through city traffic to reach the port and faced delays in doing so. Productivity could rise 30% if bunching problems at ports could be solved. But it had been a problem for 30 years so the respondent was not hopeful of a solution.

F3.5.7 Poor roads

A respondent in Gisborne considered that the quality of the roading network in and out of the region was a critical factor, and investment was needed. The reliability of the roads was a factor in considering establishing a plant elsewhere to provide greater resilience. This respondent had a short shelf-life product; another in the same region with a long-life product thought the infrastructure was adequate. A couple of other respondents had or were considering production in the South Island as well as the North to give resilience against failure of road and rail links north of Christchurch. A forest industry respondent said the sector was aggrieved that central government did not return taxes to local government for regional roads. As well, district councils could do better with regard to dust on roads.

F3.5.8 Use of rail and coastal shipping

A number of respondents would make more use of rail if its reliability/ service performance /poor arrival times improved, or if it became more available (eg access to loading facilities, rolling stock), or simply 'if it could be made to work'. A similar comment was made about coastal shipping, in relation to a bulk product. Coastal shipping could reduce transport costs, but would be a challenge. Rail was price competitive but from a South Island perspective its reliability suffers from maintenance issues, an old locomotive fleet, and few wagons. Rail's location constraints meant it was difficult to use for some commodity movements. Some thought more bulk materials like coal, grain, and fertiliser could move by rail or coastal ship, to free up road space for commodities with a greater 'just in time' need.

A couple of respondents commented favourably on inland ports: one saw aggregation at such places as involving multiple producers collaborating for collective savings. Another had identified that an inland port was cheaper than moving their containers directly to the current port, even though both the delivery to the inland port and the rail haul from it to the actual port were relatively short distances.

F3.5.9 Views on road transport

A number of respondents were complimentary about the service provided by road transport. Freight operators were good and infrastructure adequate. Road was very reliable but relatively expensive. Better roads and vehicles meant livestock spent less time in transit than previously. Carriers' gear was up to scratch, they were responsive to farmers' needs, and drivers were knowledgeable about stock. Those that did not meet the standards did not get more business, and 'bad operators stood out', whereas the good ones did not – they were the norm.

On the other hand, issues were raised about driver shortages, competition for trucks between similar bulk products, better utilisation of trucks, and reduction of empty running with collaboration and smarter techniques.

F3.5.10 Other

Some commodities that at first glance would be regarded as time-sensitive were not: raw milk was fine as long as it was delivered within a day. On the other hand a quarry-based bulk product, an input to construction, was surprisingly time critical: if it was late the construction project was held up.

A forestry company raised the issue of short sections of public road at the end of a long haul on private roads, which meant the whole haul had to be dimensioned for the public section, increasing costs. They would like to see a mechanism for use of short public sections at off-highway loading limits, with benefits to both them and highway authorities – off-highway roads unclutter the public highways generally. This firm also stressed the importance of maintaining highway/private road crossings.

A producer that transported its own product noted they were more about selling their product than its transport; own account haulage made them conscious of quality.

Damage was not generally raised as an issue in the survey; the norm was minimal damage and that was incorporated in existing rates. One respondent hypothesised that an additional payment of $1–$2 per tonne would be considered in return for a 50% reduction in damage.

F4 Survey analyses – willingness to pay analysis and findings

This section provides additional material on the analyses and findings of the WTP aspects of the study's market survey. It also contains a sub-section that compares the methodology and findings from the only previous broadly comparable study in New Zealand (Kim 2014) with this research study. The material in this section supports the more summarised material provided in chapter 8 of this report.

F4.1 Willingness to pay analysis – journey time

F4.1.1 Data and analysis methodology

Analysis of the market survey questionnaire results provided a set of best estimates for the willingness to pay (or accept) of freight shippers etc for reductions (or increases) in expected (typical) journey times for their freight movements. This sub-section sets out and comments on the summary findings from this part of the market survey.

The survey questionnaire (Q12) asked the following questions (paraphrased) in relation to each commodity segment:

Q12.1: Expected journey time?

Q12.2: Expectation of a fixed delivery time?

Q12.3 Any potential for trade-off between price and expected journey time?

Q12.4 If a potential trade-off, what is the ***maximum extra price*** *willing to pay in return for a shorter journey time (10%/25%/50% shorter)*

Q12.5 If a potential trade-off, what is the ***minimum price discount*** *willing to accept in compensation for a longer journey time (10%/25%/50% longer)?*

The 59 survey respondents provided details for a total of 143 separate market 'segments' (ie commodity movements * O-D category). For each of these segments, three responses were required for the WTP question (ie Q12.4 above) and similarly three for the WTA question (ie Q12.5 above). In total, over the 143 segments, 143 * 6 = 858 total responses could potentially be provided.

In practice, the number of responses was very much less than this:

- For the majority of commodity segments, a large proportion of respondents said, in relation to Q12.3 above, that there was no potential for trade-off between price and expected journey time.
- Of those respondents who indicated there was trade-off potential, some did not provide any information on WTP/WTA in relation to items Q12.4 and Q12.5 above. Twenty-six completed segment responses on trade-off potential were received (18% of the 143 commodity segments), accounting for 8.5% of total tonnes.
- For WTP, 21 respondent segments (63 responses) gave price vs journey time trade-offs for each of the offered journey time reductions (ie 10%, 25%, 50% shorter). These responses accounted for 51% of tonne-km (10% TT reduction), 27% of tonne-km (25% reduction) and 30% of tonne-km (50% reduction).
- For WTA, five respondent segments, (15 responses) gave price vs trade-offs for each of the offered journey time increases (ie 10%, 25%, 50% longer journey time). These responses accounted for 64% of tonne-km (10% increase), 40% of tonne-km (25% increase) and 40% of tonne-km (50% increase).

F4.1.2 Overall WTP/WTA results

The WTP/WTA results are summarised (for all commodity groups together) in table F.4. All values given are in terms of WTP/WTA for changes in (expected) journey time, expressed in $/tonne per one-hour time change. The first block (cols 2,3) in the table gives results for those respondents who expressed trade-off values, in the top half for WTP for journey time reductions, in the bottom half for WTA for journey time increases. Twenty-one responses (respondent segments) were received for each of the three WTP levels, five responses for each of the three WTA levels.

The first block gives an average 'unweighted' WTP value of $6.79/tonne per hour saved over the three levels of journey time savings (with the results indicating greater WTP per hour for the 25% journey time reduction than the 10% or 50% reductions). When these results are weighted by tonnes, the average reduces to $5.45/tonne/hr. The WTA values (bottom section of table) are rather lower than the WTP values, with $5.38/tonne/hr unweighted, $2.16/tonne/hr when weighted by tonnes.[49]

The WTP survey questions were probed in such a way that it can reasonably be assumed that respondents who did not answer these questions would have no interest (and place no value) on trading-off journey time against price. Therefore, the WTP results for those who responded can be factored down to represent averages over all survey respondents, on two bases:

1 Using a factor representing the number of responses to these questions relative to the total number of segments covered in the survey – this factor was 0.147 (about one-seventh) for the WTP responses.

2 Using a factor representing the tonnage accounted for by the responses to these questions relative to the total tonnage accounted for in the survey – this factor was 0.083 (about one-twelfth) for the WTP responses.

These factored results for WTP are given in the RHS of table F.4. For WTP, the average values are $0.56 unweighted, $0.45 weighted. These 'factored' values may be on the low side, as they assume that all survey respondents who did not respond to these travel time trade-off questions would place zero value on time savings. In our view this assumption is not unreasonable for the WTP questions, given the way the interviews were conducted, but it could be on the low side to an unknown but probably small extent.

Table F.4 WTP/WTA vs change in journey time

Change in journey time (%)	Change in $/tonne/hr (where journey time trade-off made)		Change in $/tonne/hr (weighted for total market)	
	Unweighted	Weighted by tonnes	Unweighted	Weighted by tonnes
- 50%	$5.77	$4.54	$0.48	$0.37
- 25%	$11.11	$7.68	$0.92	$0.63
- 10%	$3.51	$4.13	$0.29	$0.34
<0% (WTP)	**$6.79**	**$5.45**	**$0.56**	**$0.45**
+10%	[$9.14}	[$3.67]	n.a	n.a
+25%	[$3.90]	[$1.77]	n.a	n.a
+50%	[$3,09]	[$1,04]	n.a	n.a
>0% (WTA)	**[$5.38]**	**[$2.16]**	**n.a**	**n.a**

The WTP average values given in table F.4 may be compared with the typical transport price paid per tonne per hour across all the survey respondents: This was in the order of $10/tonne/hr (unweighted average).

For the WTA survey questions, only a small proportion of respondents provided values for the minimum price reduction that would be required in compensation for the slower travel times; these values related to 3.5% of the total survey segments and 8.3% of the total survey tonnage. Of the remaining WTA respondents, in general it appeared that they had little, if any, interest in being prepared to accept slower travel times, almost irrespective of the level of compensation offered, ie they would require very high (if not infinite) compensation in return for any slower travel times. As these high compensation levels were not able to be quantified, it has not been possible to derive total market estimates for the WTA questions.

49 Note that the WTA values relate to only five respondents, so the uncertainty about these values is considerably greater than for the WTA values (21 respondents).

Therefore, the relevant 'total market' WTA cells in table F.4 have been marked as 'na'. Similarly, for those respondents who did give values on the WTA question, the averages for these values are shown in [ ] in the LHS of table F.4, but these are unlikely to be representative (probably too low) of all segments likely to have significant WTA values. This issue is discussed further in section F.3.

F4.1.3 Findings by commodity group

Table F.4 results (discussed above) relate to the 26 out of the 143 segments (18.2%) covered in the survey which were WTP for journey time improvements. Table F.5 provides combined data (by commodity group) for those which were willing to make WTP or WTA trade-offs involving either faster or slower journey times: these covered 31 responses, of which 17 (55%) related to group 1 commodities.

Table F.5 Respondent statistics on WTP/WTA re journey time changes, by commodity group

Commodity group	Number of segments (WTP/WTA)		% segments responding	% tonnes responding
	Yes	Total		
1. Retail, manufacturing, general	17	45	38%	*54%*
2. Perishable exports	14	98	9%	*<1%*
3. Containerised exports				*20%*
4. Bulk exports				*4%*
5. Other domestic				*13%*
Total	**31**	**143**	**18%**	***29%***

Table F.6 summarises WTP/WTA estimates for group 1 alone, for groups 2–5 combined and for all groups together. The most relevant comparative results for the different groups relate to the WTP measure (given that the WTA samples are very small and the values unreliable) as follows:

- For WTP respondents alone, the average WTP is $7.53 (unweighted) and $10.98 (weighted by tonnes) for group 1 as compared with $5.32 (unweighted) and $3.40 (weighted) for groups 2–5 average, ie the ratio of values group 1: groups 2–5 is 1.42 (unweighted) and 3.23 (weighted). These weighted values can be taken as more representative of the overall market response than the unweighted values.
- When averaged over all 143 segments covered by the survey, the ratios of WTP values for group 1: groups 2–5 are somewhat higher, at 1.88 (unweighted) and 4.35 (weighted).[50]

[50] The increased ratios for all survey respondents relative to those for the WTP responses only reflects that group 1 respondents are more likely than others to respond to the WTP/WTA questions (as would be expected given their greater concern for time savings).

Table F.6 WTP/WTA for change in journey time – by commodity group (values in $/tonne/hr JT change)

Commodity group		WTP/WTA respondents		Total survey respondents	
		Unweighted	Wtd by tonnes	Unweighted	Wtd by tonnes
Group 1	WTP ave WTA ave	$7.53 [$7.95]	$10.98 [$2.18]	$0.77 na	$1.13 na
Group 2–5	WTP ave WTA ave	$5.32 [$1.51]	$3.40 [$1.62]	$0.41 na	$0.26 na
All groups	WTP ave WTA ave	$6.79 [$5.38]	$5.45 [$2.16]	$0.56 na	$0.45 na
Ratios grp1: grp (2–5)	WTP ave	1.42	3.23	1.88	4.35

Our conclusions from this segment analysis are that, for the market overall, the commodity group 1 WTP for time savings is about 4.3 times the average value for the other commodity groups (2–5). While noting the modest sample sizes in these analyses, we are confident that this relatively large ratio is significantly greater than 1.0 (but without being confident as to the precise level of this ratio).

F4.2 Willingness to pay analysis – reliability

This sub-section provides an analysis of the market survey questionnaire responses relating to the WTP of freight shippers for improvements in the reliability (reductions in the variability) of travel time for their freight movements. Similar to the analyses and findings on expected travel time in section F4.1, this sub-section sets out and comments on the survey findings on WTP for improved travel time reliability.

F4.2.1 Data and analysis methodology

The survey questionnaire (Q13) asked the following reliability-related questions (paraphrased) in relation to each commodity segment:

> *Q13.1: Does the actual journey time vary enough for you to be concerned? (Y – early; Y – late; N)*
>
> *Q12.2 (a): If Y-late, what % of your total journeys does this apply to; and on average how late are they? (b): If Y-early, what % of your total journeys does this apply to; and on average how early are they?*
>
> *Q12.3: In decision-making, is there any potential for trade-off between price and reliability? (Y/N)*
>
> *Q12.4 (a): If a potential trade-off, what is the **maximum extra price** willing to pay in return for a more reliable journey (late 25%/50%/100% less often)?*
>
> *Q12.4 (b): If a potential trade-off, what is the **minimum price discount** willing to accept in compensation for a less reliable journey (late 25%/50%/100% more often)?*

The 59 survey respondents provided details for a total of 143 separate market 'segments' (ie commodity movements * O-D category). For each of these segments, (up to) three responses were required for the WTP question (ie Q12.4a above) and similarly three for the WTA question (ie Q12.4b above). In total over the 143 segments, 143 * 6 = 858 total responses could potentially be provided.

In practice, the number of responses received was very much less than this:

- The majority of respondents (ie 41 ex 59) said, in relation to Q12.3 above, that there was no potential for trade-off between price and reliability for any of their commodity segments. Responses were that this potential only applied to 28 of the 143 segments (ie 20%).
- Only one respondent expressed any concerns about services arriving early; and this was the only respondent who was willing to accept a price discount for a less reliable service. Given this, our analyses have focused on WTP for improved reliability, and not addressed WTA relating to less reliable services.
- For those respondents who did provide WTP information, in many cases the information given was for only one or two of the three reliability improvement levels specified (ie 25%/50%/100% reductions in lateness): in most of these cases, our interviewer was able to ascertain from the respondent what their WTP would be for the other improvement levels.[51]
- For WTP, responses were provided on price vs reliability trade-offs for nine commodity segments, with each response covering all three of the offered levels of changes in reliability. These responses accounted for 6.3% of the total of 143 segments and for 8.9% of the total tonnage covered in the survey.

F4.2.2 WTP results – aggregated and by commodity group

Table F.7 summarises the reliability WTP results for the nine commodity segments which responded on this topic (ie with 9 * 3 responses across the three reliability levels specified):

- Seven of the respondent segments related to group 1, the remaining two responses to group 5 (no responses were received for the other three groups).
- The respondent segments accounted for 31.5% of the total survey tonnage for group 1, 2.6% of tonnage for groups 2–5 (8.9% of total tonnage for all groups combined). These proportions reflect that respondents in group 1 in particular are more likely to be concerned with reliability issues than those in other groups.
- The lower section of table F.7 provides our estimates of WTP for reliability improvements. This WTP is measured in terms of the average $/tonne that respondents stated they would be willing to pay for improved reliability, measured in terms of a reduction in the SD (spread) of travel times of one hour (per journey).
- Section F4.2.3 (following) provides a worked example to illustrate how the unit WTP values for TT reliability may be applied to estimate the shipper economic benefits of any reliability improvements for domestic freight movements.
- Four estimates of WTP are given in the lower section of table F.7 for improvements in journey time reliability (as in table F.6 for expected journey time). The first two estimates relate to those segments for which respondents gave their estimates of WTP: the first estimate (unweighted) is simply the average of the values provided by the respondents (expressed in terms of WTP in $/tonne for a reduction of one hour in the SD of travel time).[52] The second estimate ('weighted by group tonnes') is the average of the values in the first estimate adjusted to allow for the different tonnages in the

[51] In practice, in almost all cases, the uncompleted WTP for lesser levels of improvement than those completed was zero; and the uncompleted WTP for greater levels of improvement was equal to that for the completed level.

[52] For all WTP estimates given in table F.7, each respondent's results are averaged over the three specified levels of reliability change (ie 25%, 50%, 100%).

segments to which the estimates apply. The last two estimates are based on the first two, but expanded to represent averages for all survey responses (including those that did not respond to the reliability question) relating to commodity segments 1 and 5: again, the first of the two averages is based on the proportion of respondents in each of the two segments who responded to the reliability questions; the second average is after allowing for the proportion of total tonnage for each segment represented in these responses.

Table F.7 WTP for improvements in journey time reliability (by commodity group) [(a)]

	Commodity group 1	Commodity groups 2–5	Total commodity groups 1–5
Reliability response statistics			
Respondent segments	7	2	9
% all group segments	15.6%	2.0%	6.3%
Respondent mill tonnes pa % all group tonnes	4.1 31.5%	1.2 2.6%	5.3 8.9%
Reliability WTP estimates – $/tonne/SD hr			
Reliability responses:			
Unweighted (segments) Weighted by group tonnes	$252.79 $28.44	$26.20 $27.96	$202.44 $28.33
Total market averages:			
Unweighted (segments) Weighted by group tonnes	$79.58 $8.95	$0.53 $0.57	$18.01 $2.52

Notes: [(a)] Only commodity groups 1 and 5 provided responses to the reliability questions

The key results for WTP for reliability improvements are those in the last row of table F.7. These show that:

- Overall, the commodity group 1 segments covered in the survey (not just those responding to the reliability questions), the average WTP (weighted by tonnages) for reliability improvements was approximately $9/tonne for a one-hour reduction in the SD of journey times. This estimate is derived from the responses of those answering the reliability questions, which averages (weighted by tonnages) some $28/tonne, factored by the proportion of total group 1 tonnage carried by those who answered the reliability questions (31.5%).
- Similarly, for commodity group 2, the average WTP for reliability improvements across the whole group was approximately $0.60/tonne. This estimate is derived from the response of those answering the reliability questions, again (coincidentally) averaging some $28/tonne, factored by the portion of the total group 5 tonnage carried by those who answered the reliability questions (2.6%).
- For all groups combined (weighted by the total survey tonnes for each group) the average WTP was about $2.50/tonne per one-hour reduction in journey time SD.

These results highlight that:

- A much larger proportion of the group 1 respondents (15.6%) are concerned about and value reliability than the proportion for groups 2–5 (2.0%). These relative proportions are generally consistent with our prior expectations and our results for travel time savings.
- For those respondents (in groups 1 and 2–5) who were concerned enough about reliability to respond to the relevant questions, the unit values they are willing to pay for improved reliability (after weighting by tonnes) are very similar (at about $28/tonne per 1-hour charge in the SD of travel time in both cases).

- The overall result is that, on average over all respondents (weighted by tonnes), group 2–5 respondents value improvements in travel time reliability (per 1-hour change in travel time SD) at around 6% of the values of group 1 respondents.

F4.2.3 Reliability improvements – worked example

Box F.1 provides a worked example to show how the benefits of any reliability improvements may be applied in practice. Such application is dependent on having input assumptions on the following aspects of the commodity movement for analysis:

- Current expected travel time.
- Current reliability performance, in terms of:
  - proportions of current trips that are late
  - average lateness for those trips.
- Target reliability performance improvement (relative to current performance).
- Appropriate unit benefit values for reliability improvements:
  - expressed in $/tonne/one-hour change in travel time SD, with unit values depending on the commodity group (eg taken from table F.7).

Box F.1 Worked example – benefits of reliability improvements

A Assumptions

- **Traffic:** Group 1 commodity
- **Current expected travel time:** 6 hours.
- **Current reliability performance:** Late on 20% of trips by 50% of expected travel time (ie 3 hours late).
- **Benefits to be assessed:** Halving unreliability (eg to be 25% late on 20% of trips).
- **Valuation of reliability improvements:** Unit shipper benefits = $253/tonne/1-hour SD change (table F.7).

B Formula

Variance (s^2) = $\Sigma(x_i - \mu)^2 * p_i$, where:

μ = expected travel time

x_i = actual travel time

$(x_i - \mu)$ = extent of lateness (as proportion of expected time)

p_i = proportion of trips with this level of lateness.

Standard deviation (s) = $\sqrt{s^2}$

C Calculations

$(x_i - \mu)$ = 0.50 (ie 50% of expected travel time)

p_i = 0.20 (ie 20% of all trips)

$s^2 = (0.5)^2 * 0.2 = 0.05$

s = 0.236 * expected TT

= 0.236 * 6 hours = 1.42 hours.

If unreliability is to be halved, this would involve a reduction in travel time standard deviation by 1.42/2 = 0.71 hours.

Shipper benefits from reduction of 0.71 hours SD is therefore 0.71*$253/tonne = $180/tonne for the specified O-D commodity movement.

F4.2.4 Reliability ratios – comparisons of WTP values of time and reliability

In assessing and valuing reliability improvements in the freight sector, a measure commonly used in comparing values for reliability improvements with values for time savings is the 'reliability ratio' (RR).

This is defined as:

RR = VoR/VoT = value of a 1-hour change in the standard deviation (SD) of travel time / value of a 1-hour change in expected travel time.

Table F.8 shows our estimated RR values derived from the expected travel time (table F.6) and the TT reliability (table F.7) WTP questions in the market survey. It finds best estimate RR values of 7.9 for group 1 and 2.2 for groups 2–5 combined.

Table F.8 WTP results summary for improvements in travel time and reliability

Item (WTP only)	Commodity group	Responding segments (wtd by tonnes)	Total surveyed segments (wtd by tonnes)
VoT ($/tonne/hr)	1	10.98	1.13
	2–5	3.40	**0.26**
	All	5.45	0.45
	Ratio 1: (2–5)		**4.3**
VoR ($/tonne/hr SD)	1	28.44	8.95
	2-5	27.96	**0.57**
	All	28.33	2.52
	Ratio 1: (2–5)		**15.7**
RR (=VoR/VoT)	1	2.6	7.9
	2–5	8.2	**2.2**
	All	5.2	5.6
	Ratio 1: (2-5)		*3.6*

The international literature evidence on RR values is summarised in appendix B (section B3.3, table B.14) which indicates values for RR within a wide range, mostly in the order of 1.0, but with a considerable spread of values. Most of the international literature that covers values of reliability and derives reliability ratios does not make clear the basis for deriving these values: we suspect that different bases have been used in different studies, and therefore the international values for VoR and RR may not be consistent across the different studies examined.[53]

It is unclear why our group 1 RR savings value in particular is high relative to most international evidence. This may be largely because our estimated values of time savings are relatively low, reflecting a situation where most shippers do not place a great value on any improvements in expected travel times, as long as these are consistent and reliable; but they are much more concerned about unexpected travel delays and the uncertainty of goods supply associated with these delays. A further reason for the apparently high RR

[53] We note that in the case of person travel by public transport (which generally provides more consistent and better documented estimates for passenger travel time and reliability changes than does the freight sector), typically a given change in reliability (lateness of service) is valued at about 3–4 times the equivalent value for (expected) travel time – which is broadly equivalent to an RR figure of 3–4.

value for group 1 may be the variety of methods used in the international studies to derive reliability values (as above).

Some of the international literature also differentiates between RR values from the shipper perspective and from the transporter (carrier) perspective, noting that shipper values (which are the focus of this study) are generally expected to be higher than transporter values.

Our tentative view is that, while our RR values (for group 1 in particular) are very high relative to most of the international evidence, they may not be inconsistent with the situations of our survey respondents, ie:

- They generally select a transporter that offers expected travel times that fit with their business requirements: therefore, they place relatively low values on achieving faster scheduled travel times.
- On the other hand, they may be considerably inconvenienced by unexpected travel delays and therefore place a relatively high value on avoiding such delays.

F4.3 Comments on WTA and WTP survey approaches and findings

Earlier sections noted two problems encountered in interpreting and making use of the WTA responses relating to increased travel times (section F4.1.2) and reduced reliability (section F4.2.1). These problems relate to:

- difficulties in obtaining WTA valuations from a substantial proportion of the respondents likely in practice to have relatively high valuations
- the very limited samples that were able to provide WTA valuations (particularly relating to reliability).

The following provides further comments on these problems and their implications for the study findings on WTP and WTA.

The study market survey attempted to determine both WTP values (for faster and/or more reliable travel times) and WTA values (for slower and/or less reliable travel times). While the WTP survey appears to have been successful, the WTA aspects were largely unsuccessful, on account of two problems:

1. A substantial proportion of the survey respondents were reluctant to accept slower/less reliable services and would need to be offered considerable compensation to do so, but did not offer any values for the amount of compensation they would require. This meant that the WTA estimates only for those who gave quantified values would be likely to quite substantially understate the ‘true’ WTA values. Therefore the WTA values we were able to derive were not considered representative and were put to one side.
2. Only a small number of respondents gave WTA values. Therefore, even if these values were assumed to be representative of all respondents, any confidence intervals around these value estimates would have been very wide.

As a further comment, since the shipper values resulting from this study are likely to be used principally in the economic evaluation of transport (mostly road) improvement schemes, WTP (for improvements in conditions) is a more relevant measure than WTA (for deterioration in conditions).

We note that there is a significant international literature, across transport and other sectors (but not covered in this project) that indicates generally higher values for WTA than for WTP. Typically, this evidence finds that WTA values are between twice and four times WTP values. Given this evidence, we conclude that the WTP values recommended in this report are likely to be on the ‘conservative’ (low) side of the potential range of economic estimates that might be considered appropriate in the EEM context.

F4.4 Service frequency and loss/damage

F4.4.1 Overview

The market research included questions about frequency of service and loss and/or damage, designed in the same way as those about time and reliability, to elicit the values respondents placed on these attributes. Responses to these questions did not yield enough quantitative data to warrant detailed analysis, so as to derive generally applicable values for these attributes. A clear majority of respondents placed no value on improving frequency, and nearly all of them no value on reducing loss or damage. This appeared to be because they were generally satisfied with existing levels of both; the typical situation was that shippers already get the service frequencies they want, and loss or damage was not a significant problem. Some respondents commented that what used to be a problem with loss or damage has essentially been solved and high service levels (suited to their requirements) are now the norm.

This finding may appear in contradiction to the large proportion of respondents who answered ‘very important’ in relation to these attributes to question 11d, ‘What do you consider to be the most important factors in choosing a carrier?’. Of the 143 commodity segments, 60 thought frequency was very important and 64 ‘important’; while 50 thought loss/damage was very important and 42 important. But these results are not contradictory: while frequency and loss/damage are important factors in choosing a carrier, in making that choice in the great majority of cases shippers receive satisfactory service on these two attributes.

F4.4.2 Frequency

For 23 segments (from 11 respondents), respondents said they would trade-off price and frequency. However, only eight segments (five respondents) quantified their trade-offs in answer to the remainder of the question, ‘What is the maximum extra price you would be prepared to pay for a more frequent service?’ (or be willing to accept as a discount for less frequent service). Four of these eight segments were willing to pay more for better frequency (two would pay 7.5% more for 50% greater frequency, and one 12.5% more for doubled frequency). The other four, all transporters, thought their customers would accept a 10% discount for a 10% reduction in frequency. In over half of the 23 segments the current frequency was described as ‘daily’.

It is notable that about half the responding segments were from transporters, a much higher proportion than the 20% they represent of total segments. This suggests that transporters think their customers value frequency changes more highly than actual shippers do.

F4.4.3 Loss and damage

For 13 segments (9% of total) loss or damage was expressed as a concern. For a clear majority therefore, damage was not a concern. Those concerned represented eight respondents, mostly shippers. For all these segments, the current stated level of damage in question was only 1% or less, by value. The questionnaire allowed for damage levels of up to and over 10% of the commodity value, but no-one chose these higher values.

Only one of the segments quantified a trade-off between price and damage. That segment would pay 10% more for no loss or damage at all, ie a 100% reduction. For 99% of segments, the attribute was not important enough to quantify any potential changes.

Clearly damage is not important to the great majority of the survey respondents: this finding is consistent with the evidence that the current extent of loss or damage is very small (relative to the values of the goods transported). No quantifiable conclusions on WTP values can be drawn from the few that had concerns.

F4.5 Comparisons of market research methodology and findings with Kim study

F4.5.1 Comparison of market research methodologies

Both our study and Kim (2014) sought to understand the values shippers place on time, reliability, frequency and loss or damage.

Kim looked mainly at the manufacturing and retail sector. Ours sought to cover the total domestic transport task to fully represent the freight movements on the New Zealand roads and railways. Selecting just retail/manufacturing would be highly likely to result in higher average values of time and reliability than for the freight market as a whole.

Kim’s focus was primarily on mode choice, in a sector where choices between modes are likely. Ours was directed at all domestic freight movements and was primarily about WTP for improvements in travel time and reliability, with a lesser focus on frequency and loss/damage. Mode choice aspects were also covered, although not to the level of detail covered by Kim.

Kim sought responses from the whole population of businesses meeting certain criteria, on the basis of Statistics NZ’s *Business demographic statistics*. The defining criteria were ‘all primary sectors, manufacturers, wholesalers and retailers with more than one full-time employee that were either head offices or single locations within New Zealand’*.* This was then limited to firms in 10 product groups, and 163 freight forwarders added. Kim had a response rate of 11% from an email invitation to the 2,099 firms selected. The actual selection was done from various industry databases, including local business organisations. Kim’s survey was administered online.

Our approach was to derive a set of interviewees from our researcher’s own knowledge and enquiries, supplemented by Yellow Pages listings, with the aim of covering a high proportion of all domestic freight movements, as measured by the 2014 NFDS. Attempts to use local business organisations’ databases were unsuccessful. Our approach resulted in coverage of about one-quarter of the total annual New Zealand tonnes and one-third of tonne kilometres, as measured by NFDS. Of the 76 firms approached, initially by email and then by telephone, only three refused outright and another 18 agreed to help in principle but were unable to, giving 55 respondent firms, an overall response rate of 72% of those approached. The 24% who were sympathetic but in the end unwilling, despite repeated contact, is perhaps a symptom of the complexity of the subject matter and sensitivity of some of its content. A further four respondents were people in the same firm looking after a different region or part of the business, eg raw milk is typically separate from dairy output in its management. This gave a total set of 59 responses. Not all questions were answered by all respondents, on the grounds of confidentiality.

Kim’s 233 firm sample included 44% manufacturers, 21% wholesalers and retailers, 19% primary and raw material providers, and 16% freight agents and logistics firms. About 55% were small and medium enterprises (‘SMEs’) with fewer than 20 employees. We surveyed 55 firms. Of these 10 (18%) were transporters, including forwarders, and 45 (80%) producers and retailers. These included 5 retailers/ supermarket chains (9% of the total firms) and the rest covered a wide range of products from electrical manufacturers to lime, aggregate, and fertiliser companies to livestock, logging and milk firms. While we did not ask for the respondents’ employment numbers, we estimate that less than 5% of our respondents were SMEs.

Both studies used SP techniques to arrive at values. Kim used the CES technique[54]; and we used a contingent valuation technique. Both are valid approaches.[55] In the CES method respondents are asked to choose between hypothetical combinations of the service attributes of time, reliability, frequency and damage, and price, for a specific shipment, by a different mode or mode-combination than usually used. In our approach we asked respondents what was the maximum they would be willing to pay in the actual context of their main business segments (see below) if the journey were quicker, or more reliable, more frequent or resulted in less loss or damage. The choices did not specify a mode, nor imply a mode change.

In Kim's CES approach respondents were asked to choose between three options, for a 16 tonne 20 ft container for an interisland journey (CES 1) and within island journey (CES 2); and for a five pallet, 4 tonne LCL shipment also interisland (CES 3) and within an island (CES 4). For CES 1 the three choices were truck, truck and sea, and truck and rail. Truck represented the current, status quo operation, and the other two were choices that the respondent could make for change. For the other sets the choice was between the current owned truck, a for-hire truck, or truck and rail.

The detailed choices are set out in Kim's table 4.2, for the status quo and two options to it. There were three different values for price, time, and reliability and one or two for frequency and for probability of loss or damage. As explained in a later paper (Kim et al 2017) the medium values for cost and time were set as the base value, and values 10% above or below that were high and low values. For CES 2–4, the cost and service attributes were highest for own truck, and lowest for truck and rail. For the medium values for these CES sets, the cost of truck and rail was 15% lower than own truck, its on-time reliability 10% lower, its time taken 2.3–4 times as long, and with one choice of greater likelihood of damage available. All values were hypothetical, but grounded in reality, based on rate requests of transport firms and earlier studies. For CES 1 the choice was between truck, truck and sea and truck and rail. In this set the lowest cost, longest time, poorest frequency and lowest reliability were for the sea option, with the medium cost for that option being almost 55% lower than for truck. The rail option had intermediate values, with its cost being 37% lower than truck.

From the answers from 233 respondents, Kim derived 4,194 choice records, with 62% being from CES 3, the inter-island LCL set. These represent hypothetical choices made on the parameters presented; in essence, whether they would choose a lesser performing mode for a cheaper price – and to what extent. From these he derived values for the four service attributes, using mixed logit and generalised mixed logit modelling techniques.[56] We asked for information from each respondent on a series of 'segments', which were a combination of commodities and distance bands. Our survey yielded information on 143 segments, an average of 2.4 per firm (we asked for the top four segments per firm).

Our survey directly asked the maximum people would be prepared to pay for improvement in the service attributes. In the example below we asked what they would be willing to trade off between price and a quicker journey time. For instance, if they would achieve a journey time improvement of 10%, they were invited to say what maximum extra price (in percentage terms) they would be willing to pay for it, in each of the four commodity/distance segments defined earlier. Time savings of 25% and 50% were also offered.

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[54] In the literature, this technique is often referred to as choice modelling.

[55] A more detailed discussion of the attributes and relative merits of the two approaches is provided in Denne et al (2018).

[56] We have used the mixed logit model data from Kim: he concluded there was no statistically significant difference between the two models. Kim (2014, p179).

The possibility of trading-off a lower price for a longer journey time was also canvassed, asking for the minimum price discount the respondent was willing to accept for a longer time.

Similar questions were asked with respect to the trade-off between price and reliability, frequency and loss/damage. For reliability the WTP choices were late 25% and 50% less often, or never late. For WTA the choices were late 25% and 50% more often, and twice as often. For frequency the WTP choices were 10%, 20%, 50% and 100% more frequent, and WTA 10%, 20%, and 50% reduction. For loss and damage, respondents were asked about their WTP for 25%, 50% and 100% reduction or WTA for 25%, 50% and 100% increase.

The value of a 10% rise in the current freight rate was also asked for, by segment, so the answers on WTP/WTA could be expressed in $ terms and values produced.

Our survey was essentially assessing WTP for change from the status quo, a forward-looking perspective. This was in keeping with the aim of the whole project, as to what value to place on these attributes for evaluation of future transport improvement projects. Many respondents placed no or minimal value on change from the status quo, ie they were happy with their current service attributes.

F4.5.2 Comparisons of findings

When compared using a common unit, tonnes, Kim's LCL sets, especially the dominant CES 3, have values for time well above the FCL ones. This might be expected since smaller consignments are more likely to be dispatched on a just-in-time basis. The higher values for LCL also occur for reliability, but only in relation to long haul. LCL cargo appears to value frequency less than FCL cargo, which is a little surprising in view of the value of time result. Damage is not included in the WTP valuations. It appears to be a significant factor only for CES 3. As noted above, Kim's sample is strongly related to retail and manufacturing, as the dominance of CES 3 attests. This corresponds to our group 1.

Tonnage figures derived from Kim's tables should be treated with caution, as the primary unit he measured is the shipment, and tonnes, cubic metres, and value of product (all set for LCL at a quarter of FCL values) appear to be nominal values. We did not measure shipment or cubic metres, and the commodity valuations we used were as close to actual values as possible and varied widely by commodity.

Table F.9 provides a summary comparison of Kim's results with our results for commodity group 1. For group 1, our results are generally similar to Kim's. Overall, if other commodities are included, our results are lower than Kim's figures.

Based on his mixed logit model, Kim's central values are as shown in table F.9, originally in NZ$ (2012) and here converted to NZ$ (2017). These are shown only per tonne for comparability with our study (Kim also gave values per shipment). The values derived from our study are also shown in the table for group 1, the market segment most comparable to Kim, and for all groups.

Table F.11 Comparison of results from Kim and this study

Item	Units	Kim study				This study	
		CES 1	CES 2	CES 3	CES 4	Group 1	All groups
		Long haul FCL	Short haul FCL	Long haul LCL	Short haul LCL		
Values per tonne							
Time	Per hour redn					$1.13	$0.45
Reliability	Per % increase	$1.18	$3.43	$2.44	$2.44		
Reliability	Per hour SD redn					$8.95	$2.52
Frequency	Per increased trip per day	$7.21	$3.61	$1.00	$1.06	na	na
Response data							
# Respondents		46	15	144	28	11	20
Choice records/ segments		828	270	2592	504	17/17	31/25

Source: Kim (2014) Tables 6.1 and 7.1 and this study appendix F4. Respondents and segments are those that had trade-offs between price and/or reliability. Segment numbers are first for time, secondly for reliability.

From this table we have drawn the following main comparative conclusions for the two studies:

- Group 1:
  - *Travel time:* Both studies have generally similar results. Our group 1 figure is a little higher than Kim's FCL figure, and a little lower than his LCL figure.
  - *Reliability:* The studies cannot be compared as they use different reliability measures (our measure has been chosen to be consistent with the current EEM approach to measuring reliability).
  - *Frequency*: Our study has not been able to quantify WTP for frequency improvements, but indications are that these are not a substantial concern for the great majority of freight movements, so any WTP for improvements will be relatively low. Kim's results are about the value of one increased departure per day, in the context of relatively few departures.
  - *Loss/damage*: This attribute is relatively unimportant (in both studies}, which is consistent with the relatively low extent of loss/damage occurring currently.
- Other commodity groups:
  - *Travel time and reliability*: Our study indicates that, for these groups, WTP is generally an order of magnitude less than for group 1. These other groups were not covered by Kim, so no comparisons have been possible between the two studies.

Annex FA: Comparisons of domestic freight statistics – survey statistics (2017) and National Freight Demand Study estimates (2012)

Table FA.1 compares the NFDS totals for all respondents, by O-D group, with the (unadjusted) survey results.

Table FA.1 Survey vs NFDS comparisons – by O-D groups (unadjusted)

	Local	Inter-regional (within island)	Inter-island	Total
Tonnes (m)				
NFDS (2012)	183.18	48.09	4.73	236.00
Survey (2017)	37.52	21.13	1.10	59.75
Survey %	20.48%	43.93%	23.24%	25.32%
Tonne kilometres (m)				
NFDS (2012)	8,560	12,750	4,880	26,190.00
Survey (2017)	2151.58	6,117.36	1,368.70	9,637.64
Survey %	25.14%	47.98%	28.05%	36.80%
Average haul (km)				
NFDS (2012)	47	265	1,032	111
Survey (2017)	57	290	1,245	161

The inclusion of transporters as well as shippers in our survey resulted in some double counting of local and within-island inter-regional traffic (same hauls reported by shippers and transporters). The appropriate figures after excluding the double counting are shown in table FA.2.

Table FA.2 Survey vs NFDS comparisons – by O-D groups (adjusted)

	Local	Inter-regional (within island)	Inter-island	Total
Tonnes (m)				
NFDS (2012)	183.18	48.09	4.73	236
Survey (2017)	33.92	18.79	1.10	53.81
Survey %	18.52	39.07	23.24	22.80
Tonne kilometres (m)				
NFDS (2012)	8,560	12,750	4,880	26,190
Survey (2017)	1,982.03	5,654.04	1,368.70	9,004.77
Survey %	23.15	44.35	28.05	34.38
Average haul (km)				
NFDS (2012)	47	265	1032	111
Survey (2017)	58	301	1,245	167

Note: The NDFS numbers include coastal shipping as some respondents included it.

These figures, on a commodity group basis in place of the O-D basis, are shown in table FA.3.

Table FA.3 Survey vs NFDS comparisons – by commodity group

	Group 1	Group 2	Group 3	Group 4	Group 5	Total
Tonnes (m)						
NFDS (2012)	83.2	28.1	56.1	8.4	60.3	236.1
Survey (2017)	13.0	3.9	19.9	3.5	13.5	53.8
Survey %	15.63	13.88	35.47	41.19	22.39	22.77
Tonne kilometres (m)						
NFDS (2012)	9,660	2,660	7,230	1,350	5,360	26,260
Survey (2017)	3,699	325	2,247	1,041	1,693	9,005
Survey %	38.29	12.21	31.08	77.08	31.59	34.29
Average haul (km)						
NFDS (2012)	116	95	129	161	89	111
Survey (2017)	285	83	113	301	125	168

Note: This table excludes NFDS coastal shipping because at this level of granularity it would distort.

Commodity 1 has a low % of NFDS for tonnes but not for tonne-km; we appear to have captured fewer short-distance movements. For tonne-km, commodity groups 2 and 4 appear to depart from the norm in terms of % of NFDS in the survey. Commodity 2 appears under-counted; this is likely to be because it includes raw milk, and the biggest haulier of raw milk, Fonterra, was included in NFDS but not in the survey. Commodity 4 appears over-represented; there was strong representation in this group from the two major firms involved.

Appendix G: Recommended values for EEM

G1 Introduction

The original project proposal was to estimate the EEM values from Kim (2014), using his work as representing group 1 general freight. We proposed to then use international research to establish relationships between that group and other commodity groups and extrapolate Kim's values accordingly. When we studied the international literature, it proved to be inadequate for the task, especially as the commodity-specific data was somewhat sparse. We therefore embarked on a conventional WTP survey methodology, sampling the whole New Zealand freight market. We did, however, retain the international literature findings as a quality and reasonableness check on the values we obtained from the market research. Values from all sources were adjusted to a common level, of NZ$ (2017).

G2 International literature

The process for deriving values from the international literature, and the values themselves, are described in appendix B. For consistency with the market research, for the derivation of EEM values we focused on those values expressed in $/tonne/hour, rather than per shipment or per truck, neither of which were typically defined in terms of weight. We similarly looked at values for reliability in terms of the variability of travel time, as measured by its standard deviation, still in tonnage terms.

As noted, it was difficult to find many studies that differentiated by commodity. There were enough, however, to give a range for most of the commodity groups. This range is set out in table G.1. The values from Kim's work were more straightforward, as they originated in New Zealand and represented one of our commodity groups, group 1.

We used this information to compare our results and gauge their reasonableness.

G3 Market research

Having ascertained that the original approach was unlikely to give useful values, we expanded the market research in scope and volume, doubling the number of interviews originally proposed and including specific questions on WTP (for more timely and reliable service) and WTA (for poorer service for lower cost). While not everyone had significant (non-zero) WTP or WTA values (a large number were satisfied with current timeliness and reliability), there were sufficient respondents to establish values. Our survey methodology and analyses for doing this are described in appendix F. It is worth noting that, since a large proportion of respondents effectively gave a nil response to valuing time and reliability, the results have been calculated to reflect an average value over all participants, not just those who placed significant values on time or reliability. This approach gives a realistic view of the whole industry (by sector), which is necessary given the end purpose of the values is to help assess the economic benefits of transport projects.

This process resulted in the unit values of time and reliability shown in the fifth column of table G.1. The survey data did not include enough information to give values for each commodity group but it was possible to derive separate values for group 1, groups 2–5 together, and all groups combined.

Our market research analyses were expressed in $/tonne/hour. For group 1, this data is comparable to Kim's estimates. Kim's data was organised around short and long haul, LCL and FCL. Our group 1 value lies between that for Kim's two FCL results and his two LCL results, slightly higher than his within-island

FCL, over twice his inter-island FCL, and less than half of either of his LCL values. Kim thus focused on particular parts of the group 1 market, with only the within-island FCL being potentially comparable. It is likely that our survey had less inter-island traffic and less LCL in it than Kim's results did. In both cases these are relatively small parts of the total market: even for group 1, inter-island traffic is only 2% of the total tonnes in NFDS (Deloitte 2014), and retail and courier/post (not all of which is LCL) only 8%. In summary, allowing for the different commodity mix between our market research and Kim's, the correspondence between the two sets of results is very satisfactory.

Our results are also in the same ballpark as the international review values, though towards the lower end for group 1, and generally lower for groups 2–5. Commodity mix differences are likely to influence these comparisons. Our values for reliability (per tonne per hour SD) are of the same order for group 1, and lower for all commodities, compared with the one comparable international study. Our reliability ratio estimates are, however, substantially greater than those in Kim (2014). We believe the difference is not such that we should question our values, especially as the informal comments during the interviews did suggest that people value reliability highly (per hour reduction in the SD of travel time) and much more so than changes in expected travel time (per hour reduction in average travel time).

G4 Current EEM values

Values are given in the EEM for time savings to freight shippers, additional to any time-related savings in transport costs, as detailed in appendix A. The values are now quite old, and do not represent the full value that time savings might bring to the shipper. We understand they are based primarily on stockholding costs, whereas shippers value time savings for a number of reasons, including the value of getting their goods to customers just in time (which could be regarded as a second order stockholding cost in effect). However, actual increased stockholding (and thus interest costs on stocks) may not be that important according to at least one international study (Hirschman et al 2016).

The shipper value given in EEM (in NZ$ 2002) is $2.16 per truck per hour. Using the uplift factor of 1.47 provided in EEM (appendix 12.3), the 2017 equivalent is $3.18. The EEM values are not differentiated by commodity; so this single figure covers all trucks.

EEM provides a generic methodology for estimating the benefits of changes (positive and negative) in reliability for road traffic in general, but mentions in this methodology the use of a different multiplier factor in the case of freight movements relative to other traffic movements. In the case of other traffic, it is clear that improvements in reliability represent a benefit to persons travelling by (eg) car, but in the case of freight it is less clear whether such improvements are in effect a benefit to the transport operator (allowing for improved vehicle utilisation etc) or to the shipper. Having discussed this matter with Waka Kotahi (steering group and peer reviewers), we have taken the view that any changes in reliability calculated under the current EEM formulation are a proxy for benefits to the transport operator – rather than a component of shippers' costs. Given this viewpoint, the full reliability benefits estimated in our market research need to be treated as additional to any values currently in EEM (ie this will not involve any double counting of benefits). This is reflected in our computations in table G.1.

G5 Conversion from tonnes/hr to trucks/hr

The EEM values-of-time (and reliability) are per vehicle per hour. To be useful in assessing projects, we also need to derive values in per vehicle terms as well. This was done by multiplying our values per tonne by a typical load per truck. Note that the weight of the freight is the relevant parameter, not the gross weight of the loaded truck, as it is the value of freight to shippers that is being assessed, and not any cost to the trucking operator.

Basing the parameter on tonnes/hour also enables conversion to typical rail wagon loads should that be required.

We asked 30 of our survey respondents to tell us the typical maximum load they carried on a 44 tonne curtain-side truck and trailer unit, on a 50 tonne 50MAX truck, and on larger HPMVs. These 30 respondents together covered all commodity groups: 24 of them used 44 tonne rigs, 22 used 50MAX and 12 used larger HPMVs. For all groups the median truck load was 27 tonne for a 44 tonne gross rig, and 30.5 tonne on the 50MAX unit. We could also estimate group 1 and groups 2–5, respectively, at 24 tonne and 27 tonne (44 tonne) and 28.5 tonne and 27.6 tonne (50 tonne). Fewer larger HPMV trucks were used, and of different sizes, though typically 58 tonne gross, and their median payload was about 34.5 tonne.

Clearly the impact on the road is not always a full truck, so we needed to make an estimate of load factors. Groups 2–5 were typically bulk commodities, for which a typical haul would be out full and return empty, a 50% load factor. Some parts of this group achieve more, including surprisingly some milk tankers, so we added a nominal 10% backload, to make the average load factor 55%.

In group 1 there are likely to be greater opportunities for return loads, so a nominal figure was less appropriate. We therefore looked at inter-regional hauls for retail and manufacturing in NFDS and assessed the imbalance of freight between each pair of regions. Overall the result was that 45% got a backload, giving a load factor of 72.5% for this group.

The weighted average load factor over all groups (weighted by their share of total tonnage in NFDS) was 62%. In 1991, Allan's (1991) report on road user charges estimated an overall load factor in calculating RUC at 67%. He said then that this factor was felt by the industry to be too high. On balance, we think our estimate is reasonable.

The load factors adjust the values of time for the freight carried to values for the average load. It is these values that we recommend for inclusion in EEM. We have calculated them for 44 tonne and 50MAX, and also a weighted average assuming the 50MAX is 60% and 44 tonne 40%. The weighted values are, per truck per hour: group 1 $21.87, groups 2–5 $4.24, and all groups $8.12 (refer table G.1, last column).

A similar process was followed for reliability figures, calculating a per tonne value (per SD of travel time), and then multiplying the value by the number of tonnes payload, adjusted for load factor. The resultant weighted values are $173.25 for group 1, and $45.46 for all groups average. There was insufficient information to provide separate estimates for each of groups 2–5 (refer table G.1, last column).

The reliability ratios are independent of payload and size of truck. We estimated these at 7.5 for group 1 and 5.6 for all groups.

The steps in the analysis and the results are shown in table G.1.

Table G.1 Derivation of recommended unit values for freight shipper travel time and reliability (NZ$ (2017) for inclusion in EEM

VFTR Commodity gp	Current EEM	International (i/quart range)	Kim[b]	Study market survey	This study -- recommended shipper values for EEM				
	HCV2				HCV2		New HCV		Average
					44 tonne gross		50 tonne gross		40% 44 tonne, 60% 50 tonne
	Av load				Av load		Av load		Av load
EXPECTED TRAVEL TIME									
	Av load tonne	**Per tonne per hr**	**Per tonne per hr**	**Per tonne per hr**	**Av load tonne**	**Per truck per hr**	**Av load tonne**	**Per truck per hr**	**Per truck per hr**
Group 1		$1.03–$5.76	$0.55, $1.03 $2.76, $3.20	$1.13	17.40	$19.66	20.66	$23.35	$21.87
Groups 2–5		$0.42–$4.55		$0.26	14.85	$3.86	17.33	$4.50	$4.24
Groups 2,3,5		$0.42–$4.55							
Group 4		$0.34–$3.66							
All groups	**$3.18[a]**	$0.52–$5.91		$0.45	16.74	$7.53	18.91	$8.51	$8.12
RELIABILITY OF TRAVEL TIME									
		Per tonne per hr (CPCS only)		**Per tonne per hr SD**	**Av load tonne**	**Per truck per hr SD**	**Av load tonne**	**Per truck per hr SD**	**Per truck per hr SD**
Group 1	na	$7.24		$8.95	17.40	$155.73	20.66	$184.93	$173.25
Groups 2–5		$3.36–$9.65		$0.57	14.85	$8.47	17.33	$9.88	$9.32
Groups 2,3,5		$4.76–$12.05							
Group 4		$3.72							
All groups	na	$3.72–$7.24		$2.52	16.74	$42.18	18.91	$47.65	$45.46
RELIABILITY RATIOS									
Group 1		0.4–1.33		7.9	n.a.	7.9		7.9	7.9
Groups 2–5		0.48–2.20		2.2		2.2		2.2	2.2
Groups 2,3,5		0.50–2.40							
		0.6–1.05							
All groups		**0.4–2.13**		**5.6**	**n.a.**	**5.6**		**5.6**	**5.6**

[a] EEM (2002) number $2.16 *1.47 as per EEM July 2017 update (based on freight stockholding costs).

[b] Kim order CES 1 (FCL inter-island); CES 2 (FCL within island); CES 3 (LCL inter-island); CES 4 (LCL within island)

G6 Application of the new values

Currently, EEM, table A4.2 provides values of vehicle and freight time, in $/truck hr. These include a component for freight costs, assessed at $2.16 (July 2002 prices) for heavy vehicles, category II (see appendix A, table A.1). This $2.16 figure covers shipper-related costs that are a component of the shipper costs covered by the present study and should be replaced by the values in this study.

The new numbers should be used in the same way as those in EEM, table A4.2. Table G.2 below gives the new values, expressed in 2002 dollars for consistency with EEM values. The values in this table can be updated in future years simply by using Waka Kotahi's relevant published uplift factors.

Table G.2 Values of time combined with EEM values and expressed in $2002 (per truck per hour)

$2002	LCV	MCV	HCVI	HCV2	50MAX	Weighted[a]
Current EEM						
Vehicle and freight (EEM)[b]	1.70	6.10	17.10	28.10		
Freight component[b]	0.13	0.50	0.92	2.16		
Net vehicle	1.57	5.60	16.18	25.94	29.47c	28.10
This study						
This study – all groups[d,e]	1.33	1.9	3.03	5.12	5.79	5.52
This study – group 1[d,e]	3.90	5.57	8.91	13.37	15.88	14.88
New values						
New vehicle and freight – all groups[f]	2.90	7.50	19.21	31.06	35.26	34.62
New vehicle and freight – group 1[f]	5.47	11.17	25.09	39.31	45.35	42.98

a HCV2 and 50MAX weighted 40:60.

b See appendix A, table A.1; EEM table A4.2.

c 50 tonne is 44 tonne scaled 50/44.

d NZ$ (July 2002); this study's values divided by Waka Kotahi uplift factor to July 2017 (1.47)

e Estimated gross weight LCV 12 tonne, no trailer (tare 5 tonne); MCV 20 tonne, incl trailer (tare 10 tonne) HCVI 30 tonne, incl trailer (tare 14 tonne). Gross weight based on *WIM annual report 2016* (NZ Transport Agency 2016b) for MCV and HCVI; assumed LCV is Waka Kotahi's Vehicle Equipment Standards Class NB.

Gross load capacity derived by using tare weights based on Isuzu trucks and Truck Rentals' trailers. Load factors as for HCV2; see section G.6, above.

f Sum of 'net vehicle' and 'this study.

The current study focused on HCV2 and heavier vehicles. Figures for lighter vehicles are assessed using the shipper values per tonne per hour from the study ($0.45 for all groups; $1.13 for group 1, in NZ$ (2017), together with estimates of the load capacity (gross weight less tare) as set out in the notes to table G.2. Similarly, the EEM does not have vehicle values for vehicles heavier than HCV2. Equivalent values for these have been scaled from the 44 tonne HCV2 value. The EEM should be updated on a more precise basis for these heavier trucks, perhaps as a new HCV3 class

Where there is sufficient information on traffic composition, the higher numbers for group 1 (general freight) could be used, or the weighting between general and other freight adjusted to better reflect the specific case. Similarly, we have used the heaviest class of vehicle to derive the numbers, as these handle most of the traffic. The new time values are based on a per tonne of freight per hour value so can be readily adjusted for different vehicles, different average loads, and different mixes of 44 tonne and heavier vehicles. If average loads are available for lower weight classes of vehicle, the shipper value can be calculated. For LCV and MCV the general freight number might be more applicable than the overall values.

Our reliability figures are entirely new, not represented in the current EEM. In estimating the benefits of a project, any reliability benefits can simply be added to all the other benefits. They can be applied where there is sufficient information available on how expected delivery times and the variation around them are estimated to be affected by the roading project being evaluated. Note, however, that while the unit reliability benefits value is an apparently large number (averaging $28.69 (NZ$ 2002) per truck per hour SD for HCV2 trucks), this figure relates to a one-hour change (reduction) in the SD of travel time, which seems unlikely to be obtainable on most truck trips.

Table G.3 gives the reliability values in NZ$ (2002). Note that the new reliability figures were derived on a per tonne basis (in NZ$ 2017), $2.52 per tonne per hour SD for all groups and $8.95 for group 1), so can be readily scaled to reflect specific vehicle sizes and traffic mix.

Table G.3 Values of reliability in NZ$ (2002) (per truck per hour change in SD)

NZ$ (2002)	LCV	MCV	HCVI	HCV2	50MAX	weighted
All groups	7.44	10.63	17.01	28.69	32.41	30.93
Group 1	30.90	44.14	70.63	105.94	125.80	117.86

Notes a, d and e from table G.2 apply to this table.

In principle, since the values in tables G.2 and G.3 represent shippers' values of time and reliability, they are mode independent. Care needs to be taken in applying them to non-road modes in two respects. The traffic mix on rail for example is different than for the market as a whole and includes less 'general freight' and more of the other categories. The appropriate commodity value or weighting will need to be used, not the overall figure.

The second reservation is that the time value may be less applicable to non-road modes in certain circumstances. For instance, for rail's general freight, travel time is typically not valued by shippers on a per hour or minute basis, but simply on whether delivery targets ('time gates') are met. An investment in rail might save 15 minutes of time, as an example, but that may be of no value if it still does not allow the freight to arrive in time for delivery to supermarkets at the times they set. On the other hand, it may be the catalyst for accessing a market that was not otherwise available, and thus potentially be worth more than 15 times the per minute value. The same is probably true for road, but the higher number of individual movements means that the generally linear approach (with each minute valued equally) is more realistic for road. Further research into longer distance road hauls of general freight might, however, reveal that time savings are often valued in a similar way to rail.

On the other hand, the reliability number would be applicable to rail as much as road, given that it relates to the freight itself, though the same comment about traffic mix would apply.

G7 Conclusion

We consider that our methodology, of deriving unit values for freight transport time and reliability changes from the market research and relating them to values from other work in New Zealand and internationally, has led to robust estimates of shipper values of time and reliability (by commodity group) for inclusion in the EEM.

The two key outputs of this work are:

- New unit values of time savings for freight movements (group 1, other groups, all groups), incorporating (separately) shipper values and transporter values, to replace those in the current EEM, table A4.2.
- Unit values for travel time reliability improvements for freight movements (group 1, other groups, all groups) from the shipper perspective: equivalent values are not currently included in the EEM.

Appendix H: Case studies

H1 Introduction

A small number of case studies were developed to illustrate the application of the travel time and reliability values (from the freight shipper perspective) that we have recommended, including the effects of applying these values to the benefits estimated for the small sample of roading projects.

The case studies were to be studies of roading projects, to assess the impact of the new values relative to those currently in EEM. We proposed to take some current Waka Kotahi projects (at the planning stage or recently completed) for routes with a significant level of freight traffic. Projects that had a marginal BCR could be expected to have benefited from the new values. By focusing on such projects we would highlight the importance of using these new values in the estimation of benefits for future roading projects (or indeed other transport projects).

H2 Availability of data

To do this successfully we would have needed access to detailed data on the freight benefits already assessed and to the levels of freight involved. We asked Waka Kotahi to provide such examples with data we could interrogate; however, this proved not to be possible. One case we did explore was a bypass in the Tauranga area, which looked relevant. This project had progressed to a programme business case stage, but we were advised that at this stage the information on traffic volumes and thus benefits came from traffic models and was not in the detail we would need. No information was forthcoming on a second suggested example in the Christchurch area. Therefore, these case studies were not pursued.

H3 Illustration of application

A second type of case study involved projects that would make a difference to particular freight sectors. Again, no examples of such projects could be provided, although the type of benefit was illustrated by one of the firms interviewed for the market research. This firm processed fresh vegetables in a regional area, with markets throughout the country. The product was highly perishable and delivered to supermarkets on a just-in-time basis, usually daily. The firm was very dependent on the reliability of the roading links out of the area, and suffered losses when the roads were closed, as they were from time to time. The value that the firm put on reliability was such that it was considering developing new processing plants closer to its primary markets.

Clearly the unit values of travel time and reliability we derived in this project were averaged and might not fully represent the values put on time and reliability improvements by each individual firm. But even the values we recommend should favourably influence any future improvements to the roads in that area or corridor.

H4 Commodity types

Our values also distinguish between general freight and other freight. General freight includes (for example) the distribution of supermarket goods, and the movement of inputs and outputs from small and medium manufacturing businesses. It has been found to have much higher values on both time and reliability savings than other freight. On average, this study indicates that general freight shippers' value time savings (per tonne) at over four times those shipping other freight, and value reliability savings at almost 16 times. A number of these respondents highlighted the impact of congestion on their businesses, in terms of both expected time and reliability, and in terms of more costly arrangements like night deliveries. Projects in major urban areas and for key inter-regional routes used for distribution are especially likely to benefit this sector. The emphasis on reliability could also impact on rail projects.

To reflect these benefits will require better information on the movements of heavy vehicles. Currently we understand that traffic counts form the main traffic inputs to the economic benefit assessment for roading projects, supplemented by data on the proportion of heavy vehicles within the traffic stream. This data may be supplemented by specific information from weigh-in-motion and fixed weighing sites. This information can readily be used to relate to the overall values we have established, but in areas with a greater than average proportion of general freight, those values will tend to under-value the actual benefits of improving time and reliability. Thus, it may repay better specification of the type of heavy vehicles that will use the project once completed. Sound time-saving estimates and (where possible) reliability changes will also be needed.

H5 Conclusion

It would be valuable to test the case study methodology (and the values) on a few selected current or future projects, using both the existing and the proposed unit values for travel time and reliability benefits.

Appendix I: Glossary

AET	Association for European Transport
BITRE/BTRE	Bureau of Transport and Regional Economics (Australia)
CES	choice experiment sets, a stated preference analysis methodology. See Kim (2014)
Contingent valuation	stated preference analysis methodology as used in this study
DOT	Department of Transportation (US)
EEM	*Economic evaluation manual,* Waka Kotahi NZ Transport Agency
ETC	European Transport Conference
FCL	full container load freight
FTL	full truck load freight
HCV	heavy commercial vehicle
HCV1	rigid truck with or without a trailer, or an articulated vehicle, with 3 or 4 axles in total
HCV2	trucks and trailers, and articulated vehicles, with or without trailers, with 5 or more axles in total
HEATCO	Harmonised European Approaches for Transport Costing.
HPMV	high productivity motor vehicle
ICTAP	International Comparisons of Transport Appraisal Practice (2013 study by Institute of Transport Studies, University of Leeds)
IER	Institute of Energy Economics and the Rational Use of Energy, University of Stuttgart.
LCL	less than container load freight
LCV	light commercial vehicle
LTL	less than truck load freight
MCA	multi-criteria analysis/multi-criteria appraisal
MCV	medium commercial vehicle
ML	mixed logit model
MPL	marginal productivity of labour
na	not applicable
NCFRP	National Cooperative Freight Research Program (US)
NCHRP	National Cooperative Highway Research Program (US)
NFDS	National Freight Demand Study (NZ), Deloitte (2014)
O-D and o-d	origin-destination
Producer	someone that makes, grows, imports etc products to be shipped; a shipper
Reliability	variability in arrival time (of freight)
Reliability ratio or RR	VoR/VoT
SD or sd	standard deviation

SHRP	State Highway Research Program (US)
Shipper	producer or controller of freight being transported
SIKA	Swedish Institute for Transport and Communications Analysis. Now part of Trafikanalys, 'Transport analysis'
SME	small and medium enterprise(s)
Stated preference (SP)	Technique for understanding choices people make based on their stated reaction to specified choices
TIC	Transport and Infrastructure Council, Australia
TØI	Transport Economics Institute (Norway)
Transporter	carrier of freight for a shipper
TRB	Transportation Research Board (US)
TTV	travel time variability (reliability)
Value density	$value/tonne of a particular commodity
V/C	volume/capacity
VFTR	valuing freight transport time and reliability (shortened version of title of this research project)
VOC	vehicle operating costs
VoF	value of frequency (improvements)
VoR	value of reliability (improvements)
VoT or VTTS	value of travel time (savings)
WebTAG or TAG	Transport Analysis Guidance (transport appraisal manual of UK Department for Transport)
WTA	willingness to accept a discounted price for reductions in service
WTP	willingness to pay more for an enhanced service