Valuing Long-Haul and Metropolitan Freight Travel Time and Reliability

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ABSTRACT

Most evaluations and economic assessments of transport proposals and policies in Australia omit a valuation of the time spent in transit for individual items or loads of freight. Knowing about delays, and indeed the practical value of reliability, is useful to shippers and receivers, but this information does not necessarily appear directly in vehicle operating costs and person travel times. As a result, benefits generated by improvements from road investment and traffic management may be understated, and expenditure decisions may be biased towards passenger movements. The present paper applies contextual stated preference (CSP) methods and the associated multinomial logit models to estimate the value of such factors from an Australian survey of freight shippers using road freight transport in 1998. The estimated value of $1.40 per hour per pallet for metropolitan multidrop freight services, potentially a substantial value not currently tracked consistently or utilized in transport evaluation procedures in Australia, illustrates the significance of these results.

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INTRODUCTION

Faster, more reliable freight movements make up a substantial portion of the benefits generated by road and transport investments. However, the techniques for assessing and valuing the different components of this economic benefit have been rather limited in Australia.

Freight-travel time savings are quite different from vehicle operating cost and person-travel time savings. Freight travel time is a larger and more inclusive concept than are the inventory capital costs associated with freight holding and the transit time of the vehicle and driver. The Road User Cost Steering Group within Austroads identified this evaluation gap, resulting in the undertaking of this study by FDF Management and Oxford Systematics in conjunction with ARRB Transport Research as an Austroads NSRP Project. Freight transit times are critically important to freight shippers and, as a result, have a large impact on the potential benefits from transport investments. This concept is independent of mode and relies only on the perceptions and economic drivers of the shippers and receivers. It is appropriate, therefore, to tap these perceptions directly. These perceptions do not require the valuations of time for each mode be the same in cases where mixed or alternative modes are significant since the mode (or mode mix) choices are not explicitly modeled in the present stage of this work and mode selection is usually affected by the overall speed differences between the available modes for any particular shipment.

The survey technique of contextual stated preference (CSP) achieves this "tapping" through the construction of a series of freight service alternatives patterned after current real world freight services as defined by associated costs, delays, freight damage, and reliability factors. The alternatives can readily be translated into a questionnaire for administration to freight shippers. The questionnaire aims to force respondents to choose between bundles of variations from real world base values. This allows for the assessment of underlying utility tradeoffs without the results being dominated by travel time factors alone. In CSP surveys, an underlying conjoint design ensures that no alternative is clearly superior or inferior to all the others.

The shift toward the use of fewer and larger vehicles to move a given amount of freight has caused one of the systematic biases in current methods of road evaluation. This change may result in the association of the movement of increased tonnage with a reduction in benefits since currently the assessment of these benefits is based on vehicle operating costs factors alone. Declining benefits associated with the greater productivity of larger vehicles is an ironic outcome, and it reflects a reduction in the overall pool of road user costs that can be affected by road improvements. This observation highlights the urgent need to identify the values that can redress this basic bias.

The CSP approach for estimating freight-travel time values has been successfully used in Europe, and the method shows promise for Australia. The model on which the present work is based most closely resembles that of the Hague Consulting Group (de Jong et al. 1992; de Jong et al. 1995; de Jong 1996). These studies measured freight rates, reliability, damage, level of service, and delays using a CSP approach by examining the effects of variations on the actual observed mean values of these attributes. A number of other European studies have used stated preference methods to determine freight rate, time, damage, and reliability tradeoffs. These include an adaptive SP technique (Fowkes et al. 1989; Fowkes et al. 1991) using a laptop computer to dynamically adapt the SP design as the interview proceeds, choices between own-account and third-party carriers (Fridstrom & Madslien 1995), and freight choices made in low density rural areas in Sweden (Westin 1994).

For the present study, the choice of variables was carefully developed. The segmentation of the markets for freight does not coincide well with the types of information required to monitor freight systems (Wigan 1979), and the choice of market segments and experimental variables drew on both the current investigations and previous work. Relevant early work is summarized by Grey (1982) and by the findings of the French analyses of the large scale 1998 INRETS freight shipper survey usually referred to as the SITRAM (Information System for Freight Transport) database of the French Ministry of Transport (Bredeloupe et al.

1989). Reliability, damage (or the likelihood of damage), and the form of packing used for loading, such as pallets, have been reported to be appropriate variables (Jiang, Johnson & Calzada 1995). The choice of market segments also emerged from the consultations and analyses at the first stage of the project.

FREIGHT SHIPPER SURVEY

The central issue for data collection in this project was the need to ensure that judgments and values of Australian shippers were effectively tapped and that interactions between interviewers and respondents were as effective and credible as possible. Both the full team at the field design phases and FDF management in the data collection stages took special care to ensure that the approach to shippers, the expert freight background for the interviewers, and the feedback to the respondent all complied with this goal. This later proved critical to the very high response rates and the quality of the model estimates obtained.

The survey CSP instrument was administered in the form of a printed survey, and no adaptive PC-based techniques were used. The median values of the variables were modified by 20% in either direction in the CSP design. The shippers felt these values and variations fell within a realistic range. Each shipper completed three different CSP experiments, one for each of three different market segments. This process proved time consuming but effective once all parties fully understood it. The high level of understanding within the team led to modifications to survey procedures. Normally, we would expect a significant level of non-response from a survey of this type, however, these administrative modifications increased the number of expected returns by approximately 40% over initial expectations.

The preliminary skirmish used to screen possible respondents and to obtain mean values for real world freight costs and the associated probabilities of delay and damage obtained a response rate of 25% only. Professional freight transport operators with long-standing and extensive experience of operations in Australia further assessed the values. These values were further refined at the pilot testing stage when the full survey form and process were field tested and subsequently modified for the final survey work. Interviewers expert in the freight industry administered the final survey, and the response and completion rates were very high: 43 people completed 129 responses, indicating that all of the different CSP experiments, each in a different market segment, were completed by all parties. There were no replications of the CSP experiment on the same individual within the same market segment. It is essential to note that the survey was directed at freight shippers, not vehicle operators.

"Damage" was defined as the portion of the designated delivery that was not accepted because it had been damaged in transit. "Reliability" was defined as the portion of the designated delivery that was late. These definitions were understood by interviewers and respondents, all industry experts. Both parameters raise the interesting research question of the degree to which other freight populations would apply the same interpretations. This additional work has not yet been undertaken. Flexibility and other attribute possibilities were not rated as highly. The respondents accepted the chosen attribute set as realistic.

There were other benefits in using expert freight operators as interviewers. They shared the culture of those interviewed and actively ensured a consistent interpretation of the terms "reliability" and "damage." The more common adaptive CSP approach involving personal computers was not used, and the fixed attribute sets in the personally administered designs adopted may also have been a factor in obtaining such high response rates.

A possible minor weakness of this project was the need to use an opportunity ("snowball") sample that emerged from building on the industry contacts of the team, combined with forward referrals from initial respondents. An important requirement of the method used was that all respondents be at a senior, expert, and decision-making level. Although the respondents were not randomly sampled from a specified population, they were all real and operational freight shipping managers who frequently made freight service decisions for their organizations. Consequently, the output of this project is based on a sample of respondents regularly making genuine operational

decisions and can therefore potentially be used to represent this specific group and provide a basis for further work.

STUDY DESIGN

Base case values for freight rate, travel time, damage and reliability were determined from the industry survey, and variations of 20% above and below these values were specified in order to develop contrasting freight service alternatives. This process was repeated for the three distinct freight market segments. The basic experimental technique involved a two-stage fractional factorial design (Hensher 1997) to create a series of sets of alternative values of freight rate, travel time, damage, and reliability drawn from these values. The general approach is to determine utilities for each of these four factors from the forced choices made from sets of alternatives presented to the respondents (Hensher 1994). A survey using the full range of alternatives for three attributes, for example, would be too much to administer using a straightforward design. Therefore, a fractional design was adopted (Hahn & Shapiro 1966), providing an economical and concise survey instrument, at the cost of the assumption that interaction effects could be ignored. Prior to survey activities, all components were drawn into a consistent experimental design (Thoresen 1997), developed initially for nonurban freight movements but later generalized to include urban freight movements.

The freight market segmentation structure adopted also emerged as a key analytic issue (de Jong et al. 1995). The Hague Consulting group examined a range of dimensions: unfinished and finished goods, high and low value density, and high and low time sensitivity. A smaller number of segments was used in the study outlined in this paper.

The present study considered an additional criterion, length of haul. Replicating the Dutch study would require the surveying of eight industry sectors: one for each of the four Dutch sectors, each split further by long and short haul. Since resources were limited, this was impractical. Instead the study focused on haul length and type, resulting in the choice of the following three freight market segments:

- **Intercapital FTL (full truck load)** describes a common consignment in Australia: a fully laden articulated truck taking pallets typically on an overnight run between Melbourne and Sydney or Adelaide. Normally, these runs are from plant to plant or from plant to warehouse. On arrival, the goods go directly into stock, hence time-sensitivity is not expected to be as high as, for example, multidrops.
- **Metropolitan FTL** describes another common consignment: a fully laden articulated truck transporting loaded pallets within Melbourne. Like intercapital FTL, these runs are normally from plant to plant or plant to warehouse and are for stock. Unlike intercapital FTL, they typically occur during the day.
- **Metropolitan multidrop** is also a very common urban freight movement involving a rigid truck or light commercial vehicle with many deliveries. The consignment may consist of pallets of parcels. Normally, these runs are from plant to wholesaler, retailer, or service outlets. The goods are often required immediately, hence time-sensitivity is expected to be high.

Each respondent was offered a set of CSP alternatives in each of the three market segments. All respondents completed all three, creating 129 responses from 43 respondents.

Variation in approach and outcome between the Dutch and the present survey may reflect the differences in road transport patterns in the two locations. In Australia, for geographical reasons, there tends to be a polar split in haul length, with intercapital hauls of up to 1,000 kilometers or more, metropolitan hauls of less than 100 kilometers, and little in between. In Europe, haul lengths tend to vary continuously over a narrow range of distances.

SURVEY SEGMENTATION

Respondents for the CSP survey were drawn from the following industries: automotive parts, food and beverages, certain building materials, and packaging. Although superficially different, all respondents indicated similar freight rates per pallet and had similar transport requirements regarding reliability and damage. For these reasons, the team chose to not further segment by industry in the first instance. However, the industry of each respondent is recorded in the data set, making it possible to segment by industry in future analyses.

RESULTS

A full analysis of survey data was carried out using NLOGIT, a component of the Limdep 7 software package (Greene 1997) for several different specified multinomial logit models. None of these had a nested structure. The results were broadly comparable for each segment. The findings reported here are for the most straightforward model, which used a linear specification for all attributes. The results of the preliminary and skirmish surveys gave mean values of the attributes as shown in table 1.

Table 2 summarizes the coefficients estimated for the different attributes for the three different markets considered. The pseudo R^2 values are all above 0.5, and the coefficients estimated are all statistically significant and in the expected directions.

The standard errors for the time coefficient are substantial but not large enough to compromise statistical significance. Other coefficients have smaller relative standard errors. Table 3 shows the values in a more direct and useful form. In this table, unit values for freight travel, service reliability, and damage have been constructed from the information contained in table 2. As indicated in table 2, the estimated coefficients for travel time for intercapital FTL and multidrop were significant at the five percent level, while all other coefficients were significant at the one percent level.

INTERPRETING THE RESULTS

The values obtained here are short run values: they reflect the perceived utilities of the shippers today. Even in this context, it would be desirable to analyze a sample of real shipments to assess the relevance of CSP results and to identify hidden assumptions. One such assumption worth further investigation is the perception of respondents that they already had freight rate control, thereby leading to a greater emphasis on the other aspects of the freight service.

These results are presented irrespective of whether they will subsequently be confirmed or qualified by follow up investigations. They should also be seen as underestimates of longer term values since structural change within the industry continues and incorporates the efficiencies obtained from transport infrastructure and operational improvements (Wynter 1995).

It should be noted that the segmentation of the freight industry is quite different from that for pas-

TABLE 1 Mean Values of the Attributes

Mean values	Intercapital (FTL)	Metropolitan (FTL)	Metropolitan Multidrop Loads
Freight Rate (pallet)	35.087	9.0440	12.032
Time (hours)	15.033	4.0045	6.0026
Reliability	0.0502	0.0501	0.0498
Damage	0.0030	0.0031	0.0031

TABLE 2 Summary Results for Linear Attribute Models

Segment	Freight rate/pallet	Time	Reliability	Damage	Pseudo R^2
Intercapital (FTL)					
Coefficient	–0.100[a]	–0.066[b]	–25.6[a]	–497[a]	0.51
Standard error	0.014	0.031	2.9	48	
Metropolitan (FTL)					
Coefficient	–0.298[a]	–0.401[a]	–37.1[a]	–545[a]	0.56
Standard error	0.054	0.110	3.4	52	
Metropolitan multidrop deliveries					
Coefficient	–0.177[a]	–0.244[b]	–34.9[a]	–479[a]	0.52
Standard error	0.049	0.102	3.2	49	

[a] $p < 0.001$
[b] $p < 0.05$

TABLE 3 Freight Travel Time: Implicit Unit Values (in 1998 $ AUD)

Segment	Freight travel time	Reliability	Damage
Intercapital (FTL)	$0.66 pallet/hour	$2.56 per 1% reduction	$49.70 per 1% reduction
Urban (FTL)	$1.30 pallet/hour	$1.25 per 1% reduction	$18.29 per 1% reduction
Metropolitan multidrop deliveries	$1.40 pallet/hour	$1.97 per 1% reduction	$27.06 per 1% reduction

senger transport. The three segments selected here, however, show a heartening degree of broad agreement. In terms of results, it may be necessary to extend the coverage of the current study and improve precision in order to apply these values in economic evaluation processes. However, initial results indicate that this is both practicable, reasonable, and worthwhile.

It is critical to note that the values estimated are in many cases likely to be applicable across all modes due to the structure of Australian population center. To that extent, some of the long-standing concerns of inherent modal biases in freight evaluation may be directly addressed using this approach on a larger and more varied sample of shippers. However, this does not substitute for mode-specific analyses in cases where alternative modes are significant and decisions need to be made on a mode by mode basis.

Further study should examine many more market segments, with special attention to cross-modal measurements and a broader range of transport service attributes. The process will also clarify the requirements for expanded variables and formulations in the utility modeling to allow for specific situations and the determination of critical interactions for Australian circumstances.

CONCLUSIONS

Key results include the estimated value of long-haul freight transport travel time per pallet per hour on intercity routes at $0.7, while for metropolitan (intracity) routes it is estimated at $1.3. These estimates indicate that metropolitan freight travel time is more highly valued than that of intercity freight movements. The value of multidrop freight travel time per delivery per hour on strictly metropolitan routes is estimated at $1.4, similar to the metropolitan FTL estimate of $1.3.

The pseudo R^2 values are reasonable (~0.5), but improved models or variable specifications may be required in conjunction with larger scale or refined data collection methods to obtain more broadly applicable results. The detailed findings of this project need further corroboration but nevertheless provide a useful basis for developing a fuller set of freight travel time values.

A critical finding is that expert understanding of the freight industry and great care in survey design, data collection, and follow up are essential. For survey tasks, interviewers must either be practitioners themselves or very familiar with the industry. The data quality was vastly improved by this approach. While the models estimated provide an initial set of values for experimental use, the broader application of these methods across the freight operations in Australia is now a clear priority.

These values provide a first basis for bringing in previously unmeasured benefits in the movements of freight in Australia. This process also offers considerable benefits by estimating appropriate freight travel time values that redress the imbalance between passenger and freight valuations in economic assessment of transport proposals.

Significantly larger samples will be required to obtain more precise values for freight travel time. However, the results of this initial study are not only encouraging but also provide a first step for estimating the extent of previous biases in the freight evaluation components of a range of transport evaluation studies in Australia.

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