Development of a New Zealand national freight matrix

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1. Introduction

This Paper presents the findings of a research study undertaken as part of the Land Transport New Zealand (formerly Transfund) 2004/05 Research Programme.

The main objective of the study was:

- To develop estimates of the main (non-urban) freight movements within New Zealand, by commodity, tonnage, mode and origin-destination.

In particular, the focus was on:

- longer-distance and higher tonnage movements; and on
- existing movements, rather than forecasts of future freight movements.

The paper is structured as follows:

- **Section 2** provides a background overview of the New Zealand freight transport environment and industry
- **Section 3** presents an outline of the approach taken to developing the matrix and a summary of matrix parameters
- **Section 4** details the collection of supporting data
- **Section 5** describes the analysis and classification of the data, and presents the rail matrix
- **Section 6** explains the development of the road matrix, and presents this and the final combined road and rail matrix
- **Conclusions** are reached in Section 7.

2. Background

2.1 Context

Freight transportation is one of the key but often overlooked areas of transport policy. Policy decisions made by government can have a substantial impact on the movement of freight, however the requirements, patterns and complexities of the freight market are not well understood and the management of these is often left to industry to resolve. Although earlier New Zealand studies have investigated various aspects of domestic policy in this field, none have previously focused on the composition of long-distance freight movements - in terms of commodities moved, tonnages, origin-destination patterns and mode shares – or investigated the relationships between them. The lack of information has made it difficult for national policy makers to estimate the impacts of any policy changes (pricing, regulation etc); and for regional planners to understand and plan for freight movements to/from and within their regions. This study aimed to begin the process of filling the information void.

2.2 The freight transport environment

The movement of freight within New Zealand is governed by several influencing factors, which include both the country's geography and various forces of supply and demand (Cavana, Harrison, Heffernan, & Kissling, 1997).

Geographically, the most important feature from a freight transport perspective is the country's arrangement as two elongated main islands separated by a passage of water (Cook Strait). As a consequence of this layout, each island has complete and self-contained road and rail networks, linked with the other island via coastal shipping and inter-island road and rail ferries to form a national network, and with the outside world through gateways at international seaports and to a lesser extent airports. Mountainous terrain and the distribution of population dictate the course that the land transport networks follow within each island.

Particular factors of supply and demand that are relevant to the New Zealand situation, and that form the freight origins and destinations that comprise the freight transport task, include:

- Points of rural production, harvest or extraction. In New Zealand these particularly relate to the primary industries of agriculture, forestry and horticulture, and to mining.
- The location and size of manufacturing and processing plants and the inputs that they require for production. These range from large processing plants to those of secondary industries that are not closely tied to local inputs.
- The distribution of population. Cavana et al (1997) indicate that this is an important determinant of demand and that it consequently influences the design of logistics and distribution channels, particularly those relating to the service industry. New Zealand's population is not evenly distributed. The northern North Island dominates in both population and industrial activity and much of the warehousing and secondary industry is accordingly clustered around the Auckland region, resulting in predominantly north-south consumer-related distribution flows.
- Ports of import and export. These range from large general ports such as Tauranga, to the industry specific iron sand export 'port' of Taharoa in the Waikato region. If oil imports through Marsden Point are excluded, Auckland can be considered the largest import port, reflecting its dominance as the most populous city and major industrial area. Tauranga is the largest export port, largely due to its proximity to major forestry and agriculture related export industries.

It should be noted that the freight transport market is dynamic and constantly changing. Changes in the world and local economies impact on individual industries, changing demand levels for products and consequently changing the volumes of freight moved and the methods used to move it. This study designated 2002 as the base year and it therefore reflects the patterns of supply and demand that were in place during that year.

2.3 The freight transport industry

To perform the freight transport task, New Zealand has a highly competitive long-distance domestic freight transport industry. Services are provided by numerous single-mode and multi-modal freight companies that include road-based (truck) operators, rail (part of a multi-modal business that includes road and sea divisions), coastal shipping (provided by both local and international shipping companies), pipelines, and air transport carriers - with competition occurring between both operators and modes.

Whilst many of the transport companies involved in the New Zealand industry confine themselves to a particular mode or niche area of specialisation, the trend within the industry, across all modes, is towards greater consolidation and the provision of a wider range of service offerings. Most of the major freight providers thus offer a broad array of additional logistics services, covering the entire supply chain and including such areas as warehousing and international freight. The larger freight companies do not confine themselves to one transport mode, but instead use multiple modes to take advantage of the particular time/cost/capacity advantages that each alternative offers.

This paper focuses on the three main freight transport modes in terms of tonne-km: road, rail, and coastal shipping. Figure 1 indicates that these provide the majority (over 99%) of non-pipeline freight transportation, with pipelines primarily moving gas and petroleum products. The other major mode - air - is primarily used to carry time-sensitive or perishable products (Cavana el al, 1997), reflecting its comparatively high cost and low capacity, and it therefore has only a minor share of the freight tonnage carried and tonne-km travelled. Road and rail shares are based on the findings of this study, sea and air shares are calculated from data from the Ministry of Transport (2005) and Cavana et al (1997) respectively. Sea excludes inter-island ferry traffic. Figure 2 shows equivalent shares by tonnes carried.

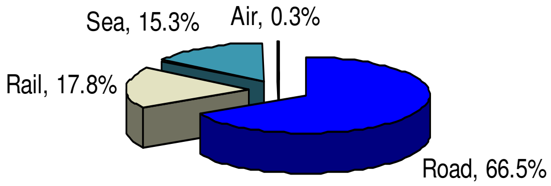

Figure 1: Estimated Mode Share by Tonne-km (2002)

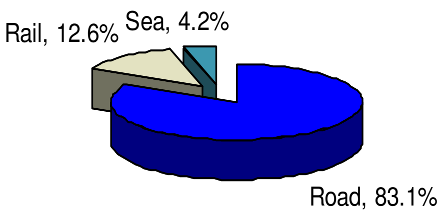

Figure 2: Estimated Mode Share by Tonnes Carried (2002)

Road transport is the dominant freight transport mode, with an estimated 67% of the total tonne-km moved. Many of the road movements that contribute to this mode share are short distance local moves, however a substantial number are longer distance movements that often compete directly against other modes utilising the 10,700 kilometres of the state highway network.

Rail is the second largest mode in terms of freight tonne-km moved, with an approximate 18% market share. Due to its cost structure, it tends to be more competitive in the high tonnage and/or long distance freight markets and it has a greater market share in those areas. The New Zealand rail system covers a network of 3900 kilometres, with a main trunk line that runs from Auckland to Invercargill via Hamilton, Palmerston North, Wellington, Christchurch and Dunedin and secondary or branch lines serving most other major towns. Inter-island road/rail ferries between Wellington and Picton link the lines in each island.

Coastal shipping accounts for an approximate 15% share of tonne-km moved. It can be divided into three component groups: inter-island road and rail ferry (not included in the estimate of mode share), private bulk shipping, and general 'public' coastal shipping. Sea movements were researched for this study, however a shortage of data prevented the inclusion of this mode in the final matrices, which accordingly focus only on land-based movements.

3. Overall approach to matrix development

3.1 Methodology

The methodology used to produce the freight matrix was governed by the project's objectives, which were to estimate the main long-distance, higher tonnage freight movements, define these by commodity, tonnage, mode, origin and destination, and to relate them to the location of processing/export facilities and to population. Given the complexity and detail required, a 'bottom–up' approach, based around the freight flows and factors of supply and demand discussed in Section 2, was employed to research and build the matrix.

The process involved the following steps, which have also been used as a basis for the structure of the remainder of this report:

- Establishment of parameters relating to the research required for construction of the matrix.
- Assessment of the key industries responsible for the production and attraction of freight, to serve as a basis for the collection of data relating to 'major' freight flows.
- Collection of data through the market survey of freight consignors for 'major' flows and freight carriers for 'dispersed' flows to build a matrix of movements with known origin, destination, tonnage, commodity and mode.
- Collection of data from other publicly available sources, to supplement the matrix movements collected through the market surveys. This data could then be processed to produce freight origins or destinations based on total production/attraction of freight.
- Analysis and classification of all data collected, with separation by mode to allow a rail matrix to be constructed and a matrix estimation process to be used to estimate the balance of unknown road movements.
- Development of the road matrix using the matrix estimation process. Known road movements were utilised to develop a starting matrix, and other information was then used to estimate a final matrix. There was always an expectation that this step would be required to build the road matrix, given the high complexity and disaggregated nature of the road industry.
- Assembly of the final total freight matrix based on the estimated road matrix and known rail matrix.

3.2 Parameters

A number of parameters were defined at the start of the project, relating to the base year, the classification of commodities, spatial classification (of origins and destinations), and other details relating to the transport movements.

2002 was selected as the base year for the study. This was chosen as the year offering the greatest range of published statistical data, and was subsequently found to be the year for which data was most commonly provided by survey participants. Data from other years was estimated to 2002 levels using a freight growth index derived from Gross Domestic Product.

All freight movements were assigned to a commodity group – either to one of the fifteen commodity groups based on key commodities identified (Cement, Coal, Dairy Products, Fertiliser, Livestock, Logs, Meat, Metals, Milk, Minerals, Oil Products, Produce, Sawn Timber, Wood Products, Wool) or to an 'other' group which included all other movements. The classification of movements by commodity was one of the main objectives of this project, and it was originally envisaged that such information would be readily available and would provide an extra dimension to the results. Unfortunately, whilst information was gathered and classified by commodity during the data collection and analysis phases, data gaps precluded the inclusion of a breakdown by commodity in the matrix building process and, as a result, the final completed matrix does not classify movements by commodity as initially intended.

The complexity of the final matrix was dependent on the spatial level at which data was to be collected and the Territorial Authority (TA) was selected as the best level to at which to work. This enabled the country to be divided into 74 localised zones, permitting intra-regional movements to be tracked, and allowed the use of statistical data already collected at TA level by Statistics New Zealand and other organisations. All freight origins and destinations were assigned to a TA, however the final matrix was developed at a regional level, both to comply with data confidentiality requirements and for clarity. Movements were thus assigned to fourteen region-based zones, based on regional government areas.

Additional standards relating to the definition of distance, tonnage and mode were also defined to ensure consistency in the collection and processing of data. Long distance was defined as any movement of more than approximately 50km or inter-TLA movement (outside of the main urban areas). High tonnage was defined as any annual net tonnage of more than 5000 tonnes per annum (to minimise the effect of irregular movements and encourage survey response), although data was included to a minimum level of 100 tonnes per annum where it was supplied in this detail. Multi-modal journeys were broken into their component journeys where these could be determined.

4. Data collection

4.1 Key industries

A review of key industries and firms was undertaken as an initial research step. While not intended to be comprehensive, it identified major commodities using the country's freight transport system, estimated the annual road tonne-km (as a guide to total tonne-km) and national production tonnage for each commodity where possible, and provided a profile of the relevant industry and suggested key firms within it. Data was sourced from central government and reports from a variety of other sources, and used to construct a list of significant commodities or industries and provide an approximate ranking of these by tonne-km carried. As expected given their dominance as exports, most of the high tonne-km and/or tonnage groups related to the primary industries such as agriculture and forestry, or to minerals such as coal.

4.2 Market survey

The market survey followed on from the initial industry research, and was used to collect a matrix of movements with known origin, destination, tonnage, commodity and mode. as the basis for the building of the complete freight matrix. Two types of flow were identified: 'major' (one-to-one or many-to-one) flows associated with specific activities or industries, and 'dispersed' many-to-many flows of multiple products and customers.

4.2.1 Freight consignors

The primary source for information on 'major' flows was the surveying of freight consignors. The firms that had been identified by the initial research as important consignors within each of the commodity groups were approached and invited to contribute information on their freight flows to the study. Additional firms were contacted as they were identified as significant freight consignors. Industry organisations, such as the New Zealand Forest Owners Association (NZFOA), were also surveyed to provide additional sources of information, particularly for industries where tonnages were estimated to be high but where industry disaggregation made it difficult to identify dominant firms.

Organisations were asked to provide estimates of their principal annual freight movements (both inbound and outbound) for the most recent available year (with 2002 or 2003 stated as preferences), with a breakdown by commodity, origin and destination, tonnage, and transport mode or modes.

In the event this stage was a significant undertaking, with in excess of 70 companies and industry organisations being contacted and invited to contribute data to the project. The response was disappointing given the commitment of resources, although it was in line with the anticipated response for a survey of this type. Of those approached, 26 companies provided full or partial details of their logistics operations, a 38% response rate. A further nine organisations, representing 13% of those contacted, indicated that their freight movements would not be relevant to the survey, either because tonnages were minor or because movements were of a short-haul nature only.

The detail of freight movements for some commodity groups was able to be gathered to a reasonably complete point at the survey stage. The Coal, Minerals, Cement, Fertiliser and Metals groups were well covered, largely as a result of the limited number of participants in these industries, but also due to the willingness of most to contribute to the study. An acceptable level of data was also gathered for the Meat, Oil Products, Logs, Sawn Timber, Wood Products and Other categories, although most forestry related data came from existing research rather than direct industry participation. The Livestock, Wool, Milk, Dairy and Produce groups proved very difficult to research, having little or no input from industry.

There were a number of critical issues that appear to have limited the response from freight consignors. Principal amongst these was the issue of commercial confidentiality, which was the most common reason given for non-participation in the study. Another problem was that many organisations did not retain records of freight weights or volumes, and as a consequence were unable to provide more than a rough estimate of tonnages for this study. Finally, the issue of industry disaggregation made it difficult to obtain information for some commodity groups with expected high tonnages. The wool industry illustrated this situation, having relatively high tonnages but many independent industry players and no central industry organisation coordinating or recording activities.

4.2.2 Freight carriers

The primary source for information on 'dispersed' flows was the surveying of freight carriers, with different approaches undertaken for each mode. It was originally intended that only the land transport modes - road and rail – would be included in the study, however coastal shipping was added at the research stage, in recognition of its 'strategic fit' and market share.

Road proved to be the most difficult mode for which to obtain data, a situation not entirely unexpected given the dispersed nature of the road industry. For a number of reasons, road transport surveys were not subsequently undertaken, and data from other sources and a process of elimination were instead used to quantify road transport tonnages.

In contrast to the difficulties in obtaining road data, a full matrix of rail tonnage data for the 2002 year was supplied by Toll Rail. This information was made available on condition that certain aspects were kept confidential. Coastal shipping data was obtained through the survey of operators and the local shipping industry organisation - the New Zealand Shipping Federation.

4.3 Supplementary data sources

Additional data was collected from sources other than through the survey of freight consignors and carriers. Most of this information was publicly available; and it was used to supplement survey data, enabling analysis of commodities where survey response from industry was weak, not available, or not requested; or to allow the cross-checking of other data.

The supplementary data sources generally provided information on single trip ends, as commodity tonnages either originating or terminating, which contrasted with the matrices of origin-destination pairs supplied by the survey sourced data. Information in this form was less useful than the full matrix movements, however it was still valuable to the process and it allowed lists of vector inputs to be created for the matrix estimation stage.

Production data was used to estimate approximate tonnages of primary products produced by TA. It was obtained from a variety of government sources and was supplemented by data sourced from industry organisations.

Export data was used to determine the tonnage and port of departure for exports, and in some cases to quantify imports. Export data was obtained principally from Statistics New Zealand's database of exports and imports by port, but it was also supplemented with Ministry of Agriculture & Forestry and port company information.

Industry data was used to determine locations and production levels of manufacturing plants and the origins and destinations of freight relating to these. In some cases it enabled transport paths to be traced from source through to points of export or consumption. Data was obtained from Statistics New Zealand (principally data relating to industry within each TA), from industry organisations and from other industry sources such as annual reports and commercial web sites.

Two studies were referenced for estimates of the freight task in tonne-km. The Heavy Vehicle Limits Project (HVLP) report for Transit New Zealand (2001) estimated the 1999 road freight task by region and industry, in payload tonne-km; while the Freight Transport Industry in New Zealand working paper, by Cavana et al (1997), provided 1994/95 estimates for major commodities moved by truck in addition to other general transport information. These were used to estimate commodity group and total movements by road, and provide a cross-check of information gathered from other sources.

Additional key sources included the Heavy Vehicle Movements in New Zealand report for the Land Transport Safety Authority by TERNZ (2003) (which provided assessments of heavy transport movements for some commodities) and various regional reports. TERNZ also supplied background research data relating to forestry industry transport movements.

5. Data analysis

5.1 Supplementary industry analysis

Additional analysis, using data obtained from sources other than from the surveys, was performed on a number of commodity groups in two situations. The first was where the survey returns were not considered to have provided a satisfactory proportion of the total estimated movements of a commodity. This applied to the Milk, Livestock, Produce, Wool and Meat groups. The second situation was where the freight consignors within a commodity group had not been approached during the survey phase, where sufficient public and carrier data was deemed to be available to map freight movements without directly approaching the industry concerned. This applied only to the forestry related commodity groups - Logs, Sawn Timber, and Wood Products.

This analysis was primarily aimed at providing an estimate of bulk movements relating to the first stage of the production process - from collection/harvest/production in rural areas to the initial points of processing or manufacture - although it was also used to estimate further stages of the logistics process for the Wool, Meat, Sawn Timber and Timber Products groups. It was not possible to produce a full matrix of origin-destination movements for each commodity using this approach; rather two separate lists were generated, one listing the estimated originating tonnages by TA and the other listing estimated terminating tonnages by TA. These origins and destinations were then added as vectors into the road matrix estimation process once any ‘actual’ known road/rail/sea movements (i.e. full origin-destination movements) had been subtracted.

5.2 Commodity tables

A summary table was created for each commodity group. Both matrix and vector based movements were added to create a summary database of information collected from all sources for each group. As data was added to the tables, origins and destinations were assigned to the appropriate TA, tonnages were aligned to the base year using the freight growth index described in Section 3.2, and each movement was assigned to the appropriate mode.

Where the origin/destination location was specified in the industry survey or analysis, assignment to the correct TA was a simple process. Where it was not specified or where data was supplied on a regional or national basis, two principal methods were used to allocate the traffic to the correct TA/TAs. The preferred method was to assign origin or destination tonnages based on the statistics of some driver of supply or demand, such as the number of people employed in a relevant industry, the capacity/location of ports, the number of animals farmed, or the number of hectares planted within each TA in a region. Where this method could not be applied, supply or demand was assigned to the largest town or city based TLA within a region on the assumption that business and population would concentrate economic activity in that area.

The road tonnages from the commodity tables were retained and used as inputs to the matrix estimation process. Rail and sea tonnages supplied by freight consignors were disregarded, and operator-supplied data, being deemed more accurate, was instead used to provide information on the movements relating to these modes. Coastal shipping was excluded from further consideration at this point, due to a shortage of data.

5.3 The rail matrix

A high proportion of rail tonnage is related to the productions and attractions associated with the locations of major industrial plants, mines and ports. This is to be expected, given that heavier train movements occur where tonnage is higher and these usually relate to the locations of the above facilities. Two corridors can be used as examples: from Manawatu-Wanganui the highest tonnage destination is Taranaki, and this is the location of a major dairy processing plant that serves as a terminating point for unit milk trains from the Manawatu area; while the most important destination for rail tonnage originating on the West Coast is Canterbury, the location of the export port of Lyttelton, which serves as a terminating point for unit coal trains from the Buller and Grey districts on the West Coast.

Based on data supplied, the rail matrix shows that Bay of Plenty region with its large port (Tauranga), major forestry-related industry and good rail links, is both the largest producer (22% of total) and attractor (35% of total) of rail freight. Waikato (with large agriculture and forestry industries) and the West Coast (with coal mines) are the next largest producers of rail freight, with 20% and 15% shares of the total respectively. Canterbury is the only additional significant attractor of freight (above 10% share) with a 23% of the total, most likely related to the previously mentioned coal exports and its role as an important distribution centre. Somewhat surprisingly, intra-regional rail movements are significant in most parts of the country, although it is likely that most of these are moving over longer distances within each region.

6. Road matrix

6.1 Introduction

Matrix estimation formed the core part of the development of the road freight matrix. This related matrix-based data (TA to TA freight movements) to link-based data (highway road vehicle counts) and used an iterative process to update the matrix until convergence was reached. A similar approach was used for the Commercial Transport Study (Transport & Population Data Centre, 2002), which provided 2002 and base year (1996) estimates of trips by light commercial, rigid and articulated trucks between each travel zone in the Greater Metropolitan Region of Sydney, Australia.

The process took data inputs relating to the production and attraction of freight at specific locations. Where full information was given, no further processing was required, but where data was incomplete, estimation processes filled in the gaps to give a best estimate of a road freight matrix. This starting (or ‘seed’ matrix) was then used as an input to further estimation processes, which matched matrix information with flow-based information from Transit New Zealand vehicle counts, with the output giving the best estimate matrix. Finally, the road freight matrix was combined with the rail freight matrix, to give a total land-based freight matrix.

6.2 Data inputs

Data inputs were either matrix-based or link-based. Matrix-based information was used as a starting point (since it was not comprehensive) and link-based information gave an independent and more complete source with which to improve the starting point.

Matrix-based information took the form of either a full matrix, where data had been supplied on the origin and destination of freight movements; or at a vector level, where information was only available at a origin and/or destination level (but not between).

Link-based traffic information, based on data collected at telemetry sites, was provided by Transit New Zealand for the 2002 year. This gave average annual daily total flows at 12 directional and 67 non-directional link locations on the state highway network, and the proportion of heavy vehicles (HMVs) at each location. These were used to give average annual daily heavy vehicle movements. Figure 3 shows the observed HMV count locations and their relative magnitude. At a few locations data was available by direction, but at most locations it was not. Analysing the links where the direction could be determined showed that the average was around 50:50, indicating that the flows were fairly symmetrical. It was therefore assumed that where the direction was not determined, the flow was split evenly in both directions.
Representative links within the model were determined and observed flows read in as one of the link attributes. As flows were received as 'average daily vehicles', they were converted to annual tonnes to match the matrix.

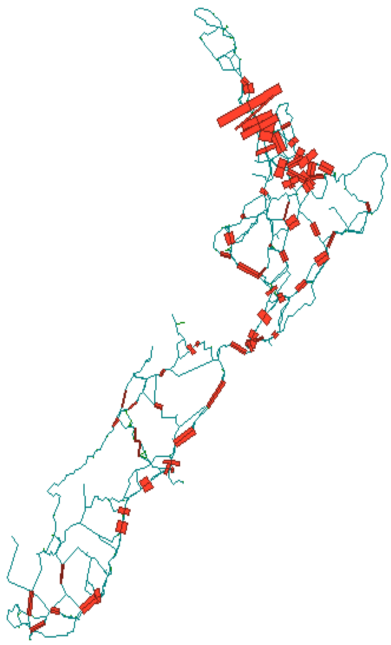

Figure 3: Observed HMV Count Locations

Average load factors were determined using data from the Heavy Vehicle Limits Project (Transit New Zealand, 2001), which gave annual vehicle km and payload tonne-km by region and vehicle type for 1999. The average payload took account of both empty running and partly laden travel.

6.3 Development of the seed matrix

The 'seed' matrix was the starting matrix whereby assigned network flows were matched to observed network flows. It was created using information from freight transport operators, relating to generation, attraction, and individual movements between geographic areas, and represented the best initial matrix based on the operator information available.

The first part of the estimation process was to convert vector-based information into matrix-based flows, with specific origin to destination flows. Generally this is achieved by taking the row and column totals (origin and destination vectors) and distributing trips between them based on a distance function (to represent utility), so as to ensure an average trip length. An entropy model was used for this purpose.

A series of balancing factors were determined for each origin and destination zone, so that when these were multiplied with the entropy matrix, the row and column totals match the origin and destination vectors. The sum of the balanced matrices and the full supplied matrices formed the 'seed' or starting matrix to be used in the assignment-based matrix re-estimation. The structure of this seed matrix partly represented relative freight movements; however it also tended to reflect areas of data availability or deficiency.

6.4 Development of the final matrix

The seed matrix was used as an input to a link-based form of matrix estimation. Observed freight tonnages by link were loaded onto the highway network and the starting matrix assigned on the network. The assigned link flows were then compared with the observed and the difference computed. A gradient matrix could then be determined, which adjusted the freight matrix in the right direction based on the largest discrepancy so as to minimise the total impact on the seed matrix. This routine was repeated until the correlation of observed to modelled (after assignment) was high. The process of updating the matrix only changes cells where there is a value, since the factors are multiplicative, so each zero-cell was given a minimum value of 0.001 to allow trips to be generated where required, a standard procedure in any matrix estimation process.

The resulting matrix was much larger than the seed, by around 75% in volume and 90% in tonne-km. Whilst there were no corresponding observed volume numbers to compare against, tonne-km estimates from the HVLP study (Transit New Zealand, 2001) provided an alternative benchmark. These gave a total of 12.8bn tonne-km across all vehicles for 1999, which compared well with our 2002 estimate of 12.9bn tonne-km. It is difficult to assess the exact changes to the freight market since 1999, but with freight movements somewhat correlated with GDP, we would expect 2002 levels to be higher than those of 1999. Using GDP-based growth estimates and the HVLP figures, the total 2002 tonne-km level could have been as high as 15.8bn tonne-km. As such, our estimate may well have been on the conservative side, accounting for 82% of tonne-km by this measure (12.9bn vs. 15.8bn tonne-km), however it is clearly in the right order of magnitude. It should be noted that this study and the HVLP determined these estimates using alternative approaches.

As a further check, the tonne-km were divided by the average load factor to give vehicle-km, which was then compared with the HVLP. The 12.9bn tonne-km equated to approximately 1.36bn vehicle-km (VKM). The HVLP gave the nationwide total for A, B and R type vehicles as 0.69bn VKM, and as 1.24bn VKM for other smaller commercial vehicles. In constructing our matrix we used a weighting of ½ for the smaller commercial vehicles (to give the average payload) and this gave a nationwide vehicle-km value of 1.32bn. This was around 3% lower than our value, which could be partially explained by a difference in base year, however it did indicate that the matrix was broadly consistent with other information.

6.5 The road matrix

The final road matrix shows that the Auckland region has a significant share of both the production (23% of total) and attraction (25% of total) of freight movements. This reflects its dominant role of that city noted in Section 2. Waikato (contributing 20% of productions and 16% of attractions) and Canterbury (13% productions and 12% attractions) are also large players, and the Bay of Plenty region is also both a strong producer and attractor of road freight. Intra-regional freight movements comprise around 55% of the total.

Figure 4 shows the road freight flows throughout New Zealand. Where the red bar is wider, the corresponding flow on the highway network is greater. Most of the activity is centred on the Auckland, Waikato and Bay of Plenty region in the North Island. In the South Island, most freight movements are restricted to the East Coast. However it should be noted that because speed, gradient and road curvature were not included in the assignment attributes, some of the paths chosen between two points may not be the most optimal.

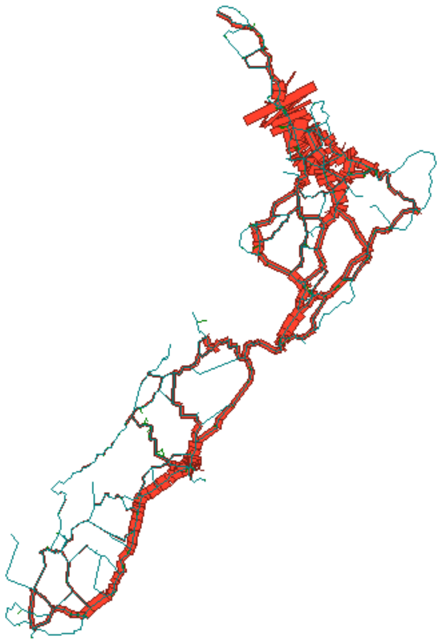

Figure 4: Assigned Freight Movements from Road Final Matrix

6.6 Combining road with rail

Once the road matrix had been generated through the modelling process described in this section, it was combined with the previously described rail matrix to create a total land transport matrix of freight movements. This matrix largely reflects the road matrix trends (as expected given the high mode share of road) and shows that the Auckland region again dominates in both production (21% of total) and attraction (22% of total) of freight movements. Waikato (contributing 20% of productions and 14% of attractions), Bay of Plenty (12% of productions and 16% of attractions) and Canterbury (12% productions and 13% attractions) are also large players. The shares attributed to each region are in accordance with the types of freight flows noted in Section 2.

Table 1: Road and Rail Matrix Statistics

Matrix	Tonnage (million)	Tonne-km (million)	Ave Trip Length
Road	89.6	12923	144.2
Rail	13.6	3463	254.4
Total	***103.2***	***16386***	***158.7***
Road (% of land transport)	87%	79%	
Rail (% of land transport)	13%	21%	

Note:
(1) Tonnage and tonne-km are based on midpoint payload.
(2) Tonne-km are calculated using model distances and may differ from tonne-km calculated using other methods.

Table 1 summarises some key background statistics from the estimated matrices relating to the land-based modes, giving a comparison of tonnage carried, tonne-km travelled and a corresponding average trip length and mode shares. It shows that the average trip length of rail is significantly higher than road and that whilst rail provides 13% of freight tonnage, its contribution to tonne-km is much higher at 21%. This confirms the expectation that rail is predominately used to move freight over longer distances than road.

In summary, the final matrix shows that Auckland, Waikato, Bay of Plenty and Canterbury are the dominant freight producing and receiving regions. Many freight movements are intra-regional, and most are over the relatively short distances in which road dominates; with a high proportion of less than 200km. Rail has most impact on the medium distance freight movements.

7. Conclusions

This study has investigated the movement of freight within New Zealand. Through the survey of freight consignors and carriers, the use of other data sources and the Emme/2-based estimation process, it has estimated the main long-distance high tonnage freight movements within the country during the 2002 year, and has assembled matrices of movements for the main land transport modes - road and rail – listing the approximate tonnages moving between and within origin and destination regions during that year. An indication of the significant commodities and industries utilising the freight networks has also been provided, although such information has not been incorporated into the matrices. This is the first time that such matrices have been attempted or that inter-regional freight movement has been investigated in this detail.

The main findings are:

- Of the three main modes, road transport conveys the majority of freight within New Zealand, having an approximate 83% share of tonnage and a 67% share of tonne-km. Rail has an approximate 13% of tonnage and 18% of tonne-km, and coastal shipping has a corresponding 4% of tonnage and 15% of tonne-km. Road has the shortest average haul of the three main modes, whilst coastal shipping (excluding the inter-island ferries) has the longest.
- Three regions - Auckland, Waikato and Bay of Plenty - are responsible for the production and attraction of over half of all road and rail freight, reflecting a concentration of population and industry. Canterbury, the largest region by area, is the only other region with a share of more than 10% of total freight productions and attractions.
- Over two thirds of all road movements are of less than 200km, with the Auckland region dominating with around a quarter of both the production and attraction of all freight. The

greatest road tonnage corridors are, in descending order, Auckland to Auckland, Canterbury to Canterbury, Waikato to Waikato, Bay of Plenty to Bay of Plenty, Waikato to Auckland, and Waikato to Bay of Plenty. These corridors account for nearly half of all road freight tonnage and show preponderance by road to short-haul movements.

- Higher rail tonnages correspond to the locations of major industrial plants, mines and ports. The greatest tonnage corridors for rail are, in descending order, Bay of Plenty to Bay of Plenty, West Coast to Canterbury, and Waikato to Bay of Plenty. These three corridors account for nearly half of all rail tonnage.
- A significant proportion (over half) of all freight cannot be easily classified into the specific commodity groups as defined. This includes general freight movements, and those relating to wholesale/retail, construction and other business sectors.
- The primary industries of agriculture and forestry are the largest originators of freight that can be categorised into a specific commodity group. The transport of logs, milk and livestock account for a significant share of total freight movements.

It should be noted that the results of this study have been limited by the availability of data and the associated assumptions that have been made. The issue of commercial confidentiality reduced both participation in the survey phase and the usefulness of the data supplied. This coupled with the lack of statistics measuring freight and commodity data by weight have restricted the detail that could be included. Additionally, the constantly evolving nature freight transport market has limited the results presented here to a snapshot only, of the economy as it was in 2002.

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References

Cavana, R.Y., Harrison, I.G., Heffernan, F.E.B., and Kissling, C.C. (1997) Freight transport industry in New Zealand. GSBGM Working Paper Series 2/97, Victoria University of Wellington.

Ministry of Transport. (2005) Coastal shipping cargo: 2004/05. Available from the Ministry of Transport web site at www.mot.govt.nz

Transit New Zealand. (2001) Heavy vehicle limits project (HVLP): Report 4 - industry economics.

Transport & Population Data Centre. (2002) Commercial Transport Study. Details available at the Transport & Population Data Centre web site at www.planning.nsw.gov.au/tpdc

Tranz Rail. (2003) Tranz Rail Holdings Annual Report 2003.

TERNZ (2003) Heavy vehicle movements in New Zealand. Prepared for Land Transport Safety Authority.