New Zealand Transport Outlook

Freight Model

April 2019

Short name

Freight Model

Purpose of the model

The Transport Outlook Freight Model projects New Zealand's region-to-region freight flows in millions of tonnes for 19 commodity groups for the years 2012/13, 2022/23, 2032/33, 2042/43, and 2052/53 for the given scenario, including New Zealand population and GDP by region and world GDP growth.

Software used

Excel

For questions and comments:

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Transport Outlook Freight Model Documentation

1. At a high level, what does this model do?

The Transport Outlook Freight Model projects New Zealand region-to-region freight flows in millions of tonnes for 19 commodity groups for the years 2012/13, 2022/23, 2032/33, 2042/43, and 2052/53 for the given scenario, including New Zealand population and GDP by region and world GDP growth. Region-to-region flow projections are provided separately for each commodity group for import flows from port of import to region of destination, for export flows from region of origin to port of export, and for domestic flows from region of origin to region of destination. Region-to-region projections by mode are also provided separately for each commodity group for flows by road, rail, coastal shipping, and the total by all modes.

The model is heavily based on data from the National Freight Demand Study 2014 (see www.transport.govt.nz/research/nationalfreightdemandsstudy/). There are 14 regions in the model, with the Tasman, Nelson, and Marlborough regions treated as a single region, labelled 'TNM'.

2. Where do I find the model results?

The model consists of a single Excel workbook for each scenario to be modelled. In the workbook, there are up to three sheets for each commodity group, as well as sheets for various model inputs. The sheets for individual commodity groups can be identified by the fact that the name on their tabs begin with a number, with each commodity group being assigned a number 1-19. There are also two 'Total' tabs showing results for all commodity groups combined.

Results by commodity group showing domestic flows, import flows, export flows, and total flows are shown on the commodity sheets whose name ends with "Projections" or, in the case of Manufactured Dairy products, simply "Proj". Each of these projections sheets shows results for the four modelled years in a different colour, but in an identical format. 2012/13 is shown in red in columns D-T, 2022/23 is shown in yellow in columns AD-AT, 2032/33 is shown in green in columns BD-BT, 2042/43 is shown in blue in columns CD-CT, and 2052/53 is shown in yellow in columns DD-DT.

Rows 15-30 show domestic flows. However, each domestic flow table also includes row 29 showing total import movements into each region and columns S, AS, BS, CS, and DS showing total export movements out of each region. Thus, the total flows shown in the domestic flow table match the total flows shown in the total flow table discussed below.

Rows 39-53 show export flows from region of origin to export ports only. For some commodity groups, there are no exports.

Rows 62-75 show import flows from import port to region of destination only. For some commodity groups, there are no imports.

Rows 85-99 shows total region to region flows, including domestic flows, imports and exports. Each of the region-to-region flows equal the sum of the corresponding region-to-region flows in the three tables above.

Results by commodity showing flows by road, rail, coastal shipping, and total flows are shown in the commodity sheets whose name ends with "by Mode". Each of these "by Mode" sheets shows results for the four modelled years in the same colours as in the projections sheets.

Rows 15-29 show flows by road (truck). Rows 39-53 show flows by rail. Rows 62-75 show flows by coastal shipping. For some commodity groups, there may be no flows by rail or coastal shipping.

Rows 85-99 show total region to region flows, which should match the corresponding total flows shown in the projection sheets.

Rows 108-122 are a check equal to total flow minus the corresponding road, rail, and coastal shipping flows. Since total flow should equal the sum of flows by the three modes, values in this table should always be zero, which shows up as blank.

The first sheet, labelled "Index" may be used to jump directly to the projection sheet for any commodity group simply by clicking on the link to the sheet. There are also links for several other sheets.

3. What are the inputs to this model and where do they come from?

Assumptions about regional populations, regional GDPs, and world GDP are shown in the "Assumptions" sheet. In this sheet, as everywhere in this workbook, cells whose values are supplied by external data sources have been shaded. Regional populations and regional GDPs are typically linked to the regional populations and GDPs shown in the 'Population and GDP' file for each scenario to be modelled—see the separate documentation on this file. World GDP projections are typically from the *OECD Economic Outlook No 103 - July 2018 - Long-term baseline projections (*https://stats.oecd.org/Index.aspx?DataSetCode=EO103_LTB).

Results of the National Freight Demand Study (NFDS) are shown in three 'NFDS' tabs. The 'NFDS Summary 2012 inc Imp+Exp Obs' sheet shows four region-to-region tables for the modelled commodity groups: total flows (columns B-Q), exports (columns S-AH), imports (columns AJ-AY), and domestic flows with a row for imports and a column for exports (columns BA-BQ) as actually observed. The 'NFDS Summary 2012 inc Imp+Exp Mod B' sheet shows the exact same data, but with a few updates reflecting significant changes known to have occurred since 2012; these flows are used as a basis for future projections. The 'NFDS Summary 2012-2042' sheet shows the NFDS projections of total region-to-regions flows for the same commodity groups for 2012 (columns B-Q), 2022 (columns T-AI), 2032 (columns AL-BA), and 2042 (columns BD-BS). These three sheets have been provided to the Ministry of Transport by Murray King and Richard Paling, the authors of the NFDS. In some cases, the data in these two sheets has been updated or revised and may differ from the numbers shown in the published NFDS.

Some commodity groups that were broken out in the NFDS have been combined in this model, usually because it would have been difficult to break out the individual commodities at this level of detail. The NFDS commodity groups included in each model commodity group are shown in the second column of Appendix B.

Mode splits are shown in the 'Modal Splits 2012 Observed' and 'Modal Splits 2012 Mode Base' sheets. The former shows the actually observed modal splits, while the latter reflects a few modal

split changes known to have occurred since 2012 or expected to occur in the future. In each sheet, region to region mode shares are shown for road (columns A-P), rail (columns R-AG), and coastal shipping (columns AI-AX) for the modelled commodity groups. The underlying data in these three sheets was originally developed for the NFDS, although only summaries of the data were published in connection with the NFDS. The sheets have been provided to the Ministry of Transport by Murray King and Richard Paling, the authors of the NFDS. In some cases the data in the three sheets has been updated or revised and may differ from the numbers shown in the published NFDS.

Final inputs are the projected total growth in New Zealand petroleum demand in 2022/23, 2032/33, 2042/43, and 2052/53, typically from MBIE's *Energy Outlook 2011* (see www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/modelling/new-zealands-energy-outlook/reference-scenario/documents-image-library/energy-outlook-2011/energy-supply-and-demand.xls/view). This data is used to derive the numbers in the "12. Petroleum Base Data" sheet, cells AY31, BY31, CY31, and DY31, respectively. Since the MBIE *Energy Outlook* data is unavailable after 2040, the value for 2042/43 is extrapolated, while the value for 2052/53 is the same as 2042/43.

4. How does this model derive its results?

Base year 2012/13 flows were taken directly from the NFDS data shown in the 'NFDS Summary 2012 inc Imp+Exp Obs' sheet. For the future projections, each of the 19 commodity groups was assigned to one of five commodity classes, depending upon the nature of the supply and demand for the commodity group. A different solution algorithm was used for each of the five commodity classes to develop the future projections. Appendix A provides further information on the algorithm used to project each of the five commodity classes, while Appendix B shows the assignment of Freight Model commodity groups to commodity classes.

Where Appendix A describes future interregional flows, demand, or supply for a commodity as being 'exogenously specified', this means it was taken from the NFDS projections shown in the 'NFDS Summary 2012-2042' sheet without change. For 2052/53, the projections are the same as 2042/43.

The five commodity classes and their characteristics are as follows.

Exogenously Specified – These are commodity groups for which New Zealand's ability to produce is limited by available resources, and for which the market is primarily for export. An assessment of the supply and demand for these commodities was performed as part of the development of the NFDS and is unlikely to change in response to the development of the New Zealand economy generally.

Supply-Driven Export Commodity Class – Only the commodity group 'logs' was assigned to this commodity class. Here the supply is limited by available resources and unlikely to change, but domestic demand may grow with the New Zealand economy. An assessment of the supply of this commodity was performed as part of the development of the NFDS. Exports take up the difference between domestic supply and domestic demand. There are no imports.

Demand-Driven Commodity Class – For commodity groups in this commodity class, domestic demand grows with the New Zealand economy; there are no exports. Neither domestic supply nor imports (if any) are limited and both grow at the same rate to meet domestic demand.

Flexi Commodity Class – For commodity groups in this commodity class, supply, exports (if any) and demand may grow with the New Zealand economy. Imports take up any difference between domestic demand plus exports and domestic supply or, if domestic supply exceeds domestic demand plus exports even after imports have been driven to zero, the exports take up the remaining difference.

Waste Commodity Class – Only the commodity group 'waste' was assigned to this commodity class. Here the 'supply' may grow with the New Zealand economy. 'Demand' and exports (if any) grow to meet 'supply'.

Where supply or demand grows with the New Zealand economy, specific variables or functions of specific variables have been assigned as drivers for each commodity group. These drivers are shown in the table of Assignment of Commodity Groups to Commodity Classes in Appendix B. In the model workbook, formulae for these drivers are specified in the sheets with tabs ending in 'Base Data' for 2012/13, 2022/23, 2032/33, 2042/43 and 2052/53 in cells w15:y29, aw15:ay31, bw15:by31, cw15:cy31, and dw15:dy31, respectively. Commodity groups in the exogenously specified commodity class do not have 'Base Data' sheets as they do not need to be modelled at all and do not have drivers.

For all commodity classes except the exogenously specified commodity class, the first step of the solution process, performed in the 'Base Data' sheets, is to use the appropriate drivers to calculate a desired total demand by region and/or (depending upon the commodity class) desired total supply by region for each future year. The second step, performed in the 'Projection' sheets, is to grow the base year 2012/13 region-to-region flows to match the desired total demand by region or total supply by region by multiplying each row or column by the desired total demand or total supply divided by the original 2012/13 total supply or total demand. Imports and exports may also be adjusted in this process, depending upon the commodity class.

For the supply-driven export commodity class and the flexi-commodity class, region-to-region flows must be grown to match both a desired total demand by region and a desired total supply by region. There is no closed-form formula that can accomplish this. Instead, an algorithm known as 'furnessing' is used (see the discussion of the 'Furness Distribution Model' at www.transportmodeller.com/distributionoverview.html). This process repeatedly scales rows then columns to match their desired total values until both the row and column totals are sufficiently close to their desired values. The Excel macros used to accomplish furnessing are explained on the 'Macros' sheet of the model workbook.

The desired total demands by region may be scaled to match a desired national total demand. The desired national total demand for 2022/23, 2032/33, 2042/43, and 2052/53 is shown in cells AY31, BY31, CY31, and DY31, respectively, of the Base Data sheet and the scaling of the regional demands is performed on row 31 of that sheet. This feature is currently used only for petroleum demand, which is scaled to match the national demand projections from MBIE's 2011 *Energy Outlook*.

Appendix A - Transport Outlook Freight Model Commodity Classes

1. **Exogenously Specified Commodity Class**
    a. **How aggregate supply and demand is determined:** Total Inter-regional flows are exogenously specified. Many of these commodities are export commodities where domestic demand is assumed to be minor, with most domestic movement between stages of the supply chain.
    b. **How future flows are grown:** Total inter-regional flows are exogenously specified.
    c. **Handling of imports and exports:** Exports flows on each lane (that is, each origin and destination combination) grow with total flows on the lane. If there are imports, import flows on each lane also grow with total flows on the lane.
    d. **Commodities in this group:** liquid milk, dairy manufacturing, wool, fish, livestock, meat and meat products, horticulture, other agriculture, coal.

2. **Supply-Driven Export Commodity Class**
    a. **How aggregate supply and demand is determined:** Domestic supply is exogenously specified, domestic demand grows with the driver specified in Appendix B below.
    b. **How future flows are grown:** Iterative scaling (furnessing) is used to match region-to-region flows to both supply plus imports and demand plus exports.
    c. **Handling of imports and exports:** There are no imports. Exports take up any difference between domestic supply and domestic demand.
    d. **Commodities are in this group:** logs.

3. **Demand-Driven Commodity Class**
    a. **How aggregate supply and demand is determined:** Demand grows with drivers specified in the fourth column of Appendix B below; supply and imports (if any) grow to meet demand as described in (b) and (c) below.
    b. **How future flows are grown:** Domestic flows and imports (if any) into each region scale up to match regional demand. Aggregate supply from each region equals the sum of the flows from that region into other regions; no furnessing.
    c. **Handling of imports and exports:** imports (if any) in each region grow at the same rate as domestic supplies. There are no exports of these commodities.
    d. **Commodities in this group:** petroleum, aggregate, concrete, and other minerals.

4. **Flexi Commodity Class**
    a. **How aggregate supply and demand is determined:** Supply and demand grow with the driver specified in Appendix B below.
    b. **How future flows are grown:** Iterative scaling (furnessing) is used to match region-to-region flows to both supply and demand.
    c. **Handling of imports and exports:** Aggregate exports (if any) are assumed to grow with aggregate domestic supply. Imports take up any difference between domestic demand plus exports and domestic supply. If domestic supply exceeds domestic demand plus exports even after imports have been driven to zero, then exports take up the remaining difference.
    d. **Commodities in this group:** processed timber, limestone-fertiliser-cement, steel and aluminium, manufactured goods-retail goods-NES.

Waste Commodity Class

    e. **How aggregate supply and demand is determined:** Supply grows with the driver specified in Appendix B below. Demand grows to meet supply as described below.
    f. **How future flows are grown:** Domestic flows and exports (if any) in each region scale up to match regional supply. Aggregate demand into each region equals the sum of the flows into that region; no furnessing.
    g. **Handling of imports and exports:** There are no imports of these commodities.
    h. **Commodities in this group:** waste.

Appendix B - Assignment of Commodity Groups to Commodity Classes

Commodity Group	Incorporates NFDS Commodity Groups	Commodity Class	Assume Domestic Supply Growth Is Driven By Growth of:	Assume Domestic Demand Growth Is Driven By Growth of:
1. Liquid Milk	Liquid Milk	Exogenously specified commodity	NFDS Liquid Milk Supply (Exogenous)	NFDS Liquid Milk Demand (Exogenous)
2. Manufactured Dairy	Dairy Manufacturing	Exogenously specified commodity	NFDS Manufactured Dairy Supply (Exogenous)	NFDS Manufactured Dairy Demand (Exogenous)
3. Logs	Export Logs, Logs to Sawmills, Inputs to Panel Making, Inputs to Pulp and Paper	Supply-driven export commodity	NFDS Export Logs Supply+Logs to Sawmills Supply+Inputs to Panel Making Supply+Inputs to Pulp and Paper Supply (All Exogenous)	Processed Timber Demand Growth as per NFDS Section 7.4.3, which would be 70.6% National Population Growth and 29.4% World Real GDP Growth
4. Processed Timber	Sawn Timber, Pulp and Paper, Panels	Flexi commodity	70.6% National Population Growth and 29.4% World Real GDP Growth[1]	Regional Population Growth as per NFDS Section 7.4.3
5. Meat and Meat By-Products	Meat and Meat By-Products	Exogenously specified commodity	NFDS Meat and Meat Products Supply (Exogenous)	NFDS Meat and Meat Products Demand (Exogenous)
6. Livestock	Livestock	Exogenously specified commodity	NFDS Livestock Supply (Exogenous)	NFDS Livestock Demand (Exogenous)
7. Horticulture	Horticulture	Exogenously specified commodity	NFDS Horticulture Supply (Exogenous)	NFDS Horticulture Demand (Exogenous)
8. Wool	Wool	Exogenously specified commodity	NFDS Wool Supply (Exogenous)	NFDS Wool Demand (Exogenous)
9. Other Agriculture	Other Agriculture, Grain	Exogenously specified commodity	NFDS Other Agriculture Supply (Exogenous)	NFDS Other Agriculture Demand (Exogenous)

[1] From NFDS Table 7.9, logs to sawmills demand is 60% domestic, panel demand is 50% domestic, and pulp demand is 100% domestic. From Table 7.10, logs to sawmills were 7.16 million tones, panels were 2.98 million tonnes, and pulp was 4.68 million tonnes in 2012. The weighted average would be (0.6*7.16+0.5*2.98+1.0*4.68)/(7.16+2.98+4.68) = 0.706 or 70.6% domestic.

Commodity Group	Incorporates NFDS Commodity Groups	Commodity Class	Assume Domestic Supply Growth Is Driven By Growth of:	Assume Domestic Demand Growth Is Driven By Growth of:
10. Fish	Fish	Exogenously specified commodity	NFDS Fish Supply (Exogenous)	NFDS Fish Demand (Exogenous)
11. Coal	Coal	Exogenously specified commodity	NFDS Coal Supply (Exogenous)	NFDS Coal Demand (Exogenous)
12. Petroleum	Petroleum	Demand-driven commodity	Regional Outputs Scale to Match Demand (Not Furnessed)	Regional Population Growth (Final Demand), but with Regional Demands Scaled to Match MBIE Projections for Growth of Total National Petroleum Demand
13. Aggregate	Aggregate	Demand-driven commodity	Regional Output Scales to Match Demand (Not Furnessed)	65% Regional GDP Growth * 1.3 (Roading Demand), 27% Regional Population Growth * 1.09 (Building Demand), 8% Regional Population Growth (Other Demand); Demand Reduced 35% from 2017 Onwards in Canterbury to Reflect Completion of Christchurch Rebuild as per NFDS Section 7.4.11
14. Limestone-Cement-Fertiliser	Limestone-Cement -Fertiliser	Flexi commodity	40% National Concrete Demand Growth (Growth in Fertiliser Demand Assumed to Met Mostly by Imports as Recommended by Murray King)	60% Regional Liquid Milk Demand Growth, 40% Regional Concrete Growth as per NFDS 7.4.12
15. Concrete	Concrete	Demand-driven commodity	Regional Output Scales to Match Demand (Not Furnessed)	Regional GDP Growth * 2.2; Demand Reduced 35% from 2017 Onwards in Canterbury

Commodity Group	Incorporates NFDS Commodity Groups	Commodity Class	Assume Domestic Supply Growth Is Driven By Growth of:	Assume Domestic Demand Growth Is Driven By Growth of:
				to Reflect Completion of Christchurch Rebuild as per NFDS 7.4.13;
16. Steel and Aluminium	Steel and Aluminium	Flexi commodity	National Population Growth as per NFDS Section 7.4.14	Regional Population Growth as per NFDS Section 7.4.14
17. Manufactured Goods-Retail Goods-NES	Manufactured Goods, Supermarket and Food Goods, Other Retail Goods, Imported Cars, Couriers and Post, General Freight	Flexi commodity	78.9% Regional Population Growth (Productivity Increases Result in Higher Quality of Output) as per NFDS Section 7.4.15, 21.1% 1.56 * Regional GDP Growth[2]	78.9% Regional Population Growth (Productivity Increases Result in Higher Quality of Output) as per NFDS Section 7.4.15, 21.1% 1.56 * Regional GDP Growth
18. Waste	Waste	Waste commodity	60% Regional Aggregate Demand Growth (Cleanfill) and 40% Regional Population Growth (Other Waste and Recycling) as per NFDS Section 7.4.16	Demands grow to match supply (not Furnessed)
19. Other Minerals	Other Minerals	Demand-driven commodity	Regional Output Scales to Match Demand (Not Furnessed)	1.56 * Regional GDP Growth as per NFDS Section 7.4.17[3]

[2] The 1.56 is for 2012 and shrinks linearly to zero by 2052 as per NFDS assumptions (2022 = 1.42, 2032 = 1.28, 2042 = 1.14, 2052 = 1.0). 78.9% assumption is from NFDS Tables 7.23 and 7.25. Manufactured Goods (19.45 million tonnes in 2012), Supermarket and Food Goods (10.57 million tonnes in 2012) and Imported Cars (0.32 million tonnes in 2012) are driven by population growth while Other Retail (7.74 tonnes in 2012) and Couriers and Post (0.39 million tonnes in 2012) are driven by 1.56 * GDP growth. The fraction driven by population growth is (19.45 + 10.57 + 0.32)/(19.45 + 10.57 + 0.32 + 7.74 + 0.39) = 0.789. General Freight is not considered in this formula, as its drivers are assumed to be the same as the others.

[3] The 1.56 is for 2012 and shrinks linearly to zero by 2052 as per NFDS assumptions (2022 = 1.42, 2032 = 1.28, 2042 = 1.14, 2052 = 1.00).