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Emission Factors for New Zealand

Greenhouse Gas Emission Intensities for Commodities and Industries

Created by thinkstep-anz



28 Feb 2022
Draft for consultation

Document approval and revision

Report title:	Emission Factors for New Zealand: Greenhouse Gas Emission Intensities for Commodities and Industries
Report version:	v1.0
Report date:	January 2022
Report copyright:	thinkstep ltd
Cover photo:	Microsoft 365 | Unsplash
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Sensitivity:	Not confidential
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thinkstep-anz. 2024. Emission Factors for New Zealand: Greenhouse Gas Emission Intensities for Commodities and Industries. Wellington/Perth: thinkstep-anz.

Version	Date	Changes	Author	Reviewer	Approved
1.0	27/01/2022	Original version for public consultation	SL&TE	KB,CC,MH	JV

Executive summary

This report provides carbon footprint emission factors per dollar of spend for goods and services purchased in New Zealand

Organisations and individuals are often urged to vote with their wallets – to choose the products and services we buy wisely. However, it can be difficult to determine the potential environmental impacts of a product or service without detailed research.

Emissions factors per dollar spent are an easy way for individuals and businesses to get started with carbon footprinting and life cycle assessment. They allow spending per category – be it investment decisions or supermarket shops – to be multiplied by a corresponding emission factor per dollar to calculate total emissions in that category.

This report provides greenhouse gas (carbon footprint) emissions factors for goods and services purchased in New Zealand. Also known as emission intensities, these values have been calculated using Input-Output Life Cycle Assessment (IO-LCA) at the national level. They are reported in kilograms of carbon dioxide equivalent per dollar (kg CO2e/$).

Emissions factors are provided for both wholesale and retail transactions

This report provides three different types of emission factors per dollar spent:

- Industry-level emission factors
- Wholesale commodity-level emission factors (for business-to-business transactions)
- Retail commodity-level emission factors (for business-to-consumer transactions, for those commodities typically available through retailers).

The emission factors in this report include international trade

The emission factors provided in this report include all upstream emissions, including emissions embodied in international trade. The inclusion of international trade is particularly important in cases where New Zealand has little or no domestic industry (e.g., car manufacturing and textile production).

The emission factors in this report are suitable for organisations and individuals

The emission factors in this report are suitable for various applications, including:

- “Scope 3” corporate carbon footprints, particularly for purchased goods and services
- Calculating the carbon footprint of an investment portfolio
- Individuals trying to understand the carbon footprint of their purchasing decisions.

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Acknowledgements

We would like to acknowledge and thank Malcolm Gray from Stats NZ for his time and assistance in preparing earlier drafts of this document.

The input from other stakeholders through the consultation phase will be acknowledged once this report has been revised following consultation and then republished.

Any errors or omissions remain those of the authors.

1. Introduction

1.1. Background

To avoid dangerous warming of global temperatures, the Intergovernmental Panel on Climate Change calls for global reduction of anthropogenic greenhouse gas emissions by about 45% from 2010 levels by 2030, reaching net-zero emissions by 2050 (IPCC, 2018). The first step towards emissions reduction is measuring and reporting emissions, a process often called “carbon footprinting”.

The emission factors of each emission source within an organisation are essential components of carbon footprinting. Emission factors represent the amount of greenhouse gases that are emitted into the atmosphere per unit of emission source. They are usually expressed in carbon dioxide equivalent (CO_2e).

Official, New Zealand-specific emission factors are published by the Ministry for the Environment (MfE) and are expressed in physical units – similar to other internationally published emission factors. For instance, the emission factor for purchased electricity in New Zealand for calendar year 2018 is 0.101 $kgCO_2e/kWh$. This represents 0.101 kilograms of carbon dioxide equivalent ($kgCO_2e$) emitted into the atmosphere for every 1 kilowatt-hour (kWh) of purchased electricity consumed (MfE, 2020).

While using emission factors based on physical units is typically possible for energy-related activities, such as purchased electricity, it becomes more difficult for other purchased goods and services where emission factors are typically not readily available. In these cases, it is easier to use emissions factors per dollar spent.

This paper provides emission factors (also known as emission intensities) for industries and commodities in New Zealand based on dollars spent, using an Input-Output Life Cycle Assessment (IO-LCA) approach.

1.2. Purpose

This paper enables organisations and individuals to calculate the carbon footprint of goods and services purchased in New Zealand by providing three different types of emission factors per dollar spent:

- Industry-level emission factors
- Wholesale commodity-level emission factors (for business-to-business transactions)
- Retail commodity-level emission factors (for business-to-consumer transactions, for those commodities typically available through retailers).

2. Literature Review

2.1. Input-Output Life Cycle Assessment

An Input-Output Life Cycle Assessment (IO-LCA) approach was chosen to calculate the greenhouse gas emissions (carbon footprint) of New Zealand industries and commodities.

Life Cycle Assessment (LCA) has become a popular tool since the 1990s to assess environmental impacts of goods and services throughout their entire lifecycle (Guinée, et al., 2011). There are three main approaches for calculating LCA-based carbon footprints:

1. Process-based LCA: 'bottom-up' analysis of the impacts of a product or service, calculated by adding (or subtracting) the greenhouse gas emissions (or removals) of each process stage.
2. IO-LCA: 'top-down' analysis based on calculating an emission factor per dollar based on total greenhouse gas emissions (or removals) from that sector divided by total economic activity in that sector.
3. Hybrid LCA: a combination of process-based LCA and IO-LCA.

IO-LCA, has also been widely used in the literature to determine environmental impacts based on economic data (Suh & Nakamura, 2007)

In carbon footprinting, emissions are usually divided into three 'scopes':

- Scope 1: Direct emissions
- Scope 2: Indirect emissions, from purchased energy
- Scope 3: Other indirect emissions

A major benefit of using the IO-LCA approach for carbon footprinting is that it captures all economic flows within each industry, without the need for complex data collection of entire supply chains of New Zealand's industries. This ensures that both direct (Scope 1) and indirect (Scope 2 and 3) emissions are captured within each emission factor (Sharp, et al., 2016).

2.2. IO-LCA in New Zealand

A limited number of New Zealand-specific studies using IO-LCA approach have been published to date. Andrew and Forgie (2008) presented three perspectives to account for New Zealand emissions: consumption-based, production-based, and shared. In their study, Andrew and Forgie (2008) constructed input-output (IO) tables for the year 2001 by updating the 1996 IO tables which were the latest at the time of the study, and used energy and emissions data for 2001 from government sources. Andrew and Forgie's work was followed by the publication of two other papers also with a focus on the New Zealand economy: Romanos, Kerr, and Will (2014), and Chandrakumar et al. (2020).

Chandrakumar et al. (2020) aimed to quantify New Zealand's greenhouse gas emissions using production- and consumption-based approaches. Chandrakumar et al. (2020) used New Zealand-specific IO tables and environmental data from the Eora database, rather than domestic sources. The results cannot be directly compared to those of this paper

because Chandrakumar et al. (2020) has only provided total production emissions per industry.

Although these studies share similarities with this study, only Romanos et al. (2014) presented emission factors for New Zealand commodities and used similar data sources to this paper. Romanos et al. (2014) used the IO-LCA approach to provide a consumption-based analysis of New Zealand household emissions, based on 2007 IO economic data and greenhouse gas emissions data from governmental sources. Production emissions of New Zealand industries were calculated and, together with the Stats NZ Household Expenditure Survey, formed the basis of their commodity-level consumption emissions calculations.

Updated IO tables and greenhouse gas emissions data have been made publicly available by Stats NZ since 2007, the base year of the study by Romanos et al. The most up-to-date IO tables for New Zealand were published in 2013. Conceptual differences exist between the latest tables and those used by Romanos et al. (2014). Greenhouse gas emissions data have also undergone methodological changes since their publication (MfE, 2020). Furthermore, this paper takes a different approach to calculate commodity-level emission factors to those used by Romanos et al. (2014). While both studies base their commodity-level emission factors on those calculated for New Zealand industries, the methodologies used to calculate commodity-level emission factors differ.

3. Approach

This paper provides the following New Zealand-specific emission factors per dollar spent, using the IO-LCA approach:

- Industry-level emission factors
- Wholesale commodity-level emission factors
- Retail commodity-level emission factors (for those products that are sold by retailers).

A copy of the calculations used to create emission factors for New Zealand is provided in the Microsoft Excel file "Greenhouse gas emission factors for New Zealand industries and commodities".

3.1. Industry-level Emission Factors

The main data sources used to calculate emission factors for New Zealand industries were the Greenhouse Gas Emissions (industry and household) dataset[1], and National Accounts IO tables, both published by Stats NZ. This paper is based on the 2018 and 2013 versions of these datasets, respectively. Given that a 2019 version of the Greenhouse Gas Emissions (industry and household) dataset has now been released, the emission factors will be updated at the conclusion of the stakeholder consultation process.

A mapping of industries within each dataset mentioned above was required. This was due to differences in the number and aggregation of industries between the two datasets. The resulting 114 industries formed the basis for all further calculations.

Industry-level emission factors were calculated as shown in Equation 1.

Equation 1: Equation used to calculate industry-level emission factors (EF)

$$EF_i = EF_{domestic,i} + EF_{embodied\ imports,i} \qquad \forall \text{ industries } i$$

where

$$EF_{domestic,i} = \frac{TDE_{domestic,i}}{GO_{domestic,i}} \bullet (I - A)^{-1}$$

$(I - A)^{-1}$ = Leontief inverse matrix

$TDE_{domestic,i}$ = Total direct emissions from industry i

GO_i = Gross economic output from industry i from Inter-industry transactions table[2]

[1] Stats NZ's New Zealand Greenhouse Gas Emissions (industry and household) is based on the New Zealand's Greenhouse Gas Inventory published by the Ministry for the Environment. The datasets used in this paper are representative of the year 2018 (Stats NZ, 2020), and emissions in CO2e are based on AR4 GWP-100. The dataset relates to New Zealand's economic residents only. Emissions from non-residents are excluded, and emissions from residents abroad are included.

[2] Total gross outputs from Stats NZ National Accounts IO table 4 were adjusted for inflation to better represent 2018 economic data.

Domestic emission factors were calculated by multiplying direct emission factors by the Leontief inverse matrix ($(I\text{-}A)^{-1}$). The Leontief inverse matrix, represented as the IO 'Total requirements table' in Stats NZ National Accounts, presents the direct and indirect economic flow required in the production of one million dollar of a particular industry (Stats NZ, 2016). Hence, multiplying direct emission factors by Leontief inverse matrix ensured indirect emissions were accounted for in the final emissions intensities of New Zealand industries.

Calculations used for the emission factors for embodied imports are detailed in section in section 3.1.1.

3.1.1. Emissions Embodied in Imports

Emission factors for the 2015 calendar year available commercially through Eora (Lenzen, Kanemoto, Moran, & Geschke, 2012; Lenzen, Moran, Kanemoto, & Geschke, 2013) were used to calculate emission factors embodied in imports used in the production of goods and services by New Zealand domestic industries. An import matrix (M) was constructed to represent the portion of imported commodities used in the production of domestic industry's output. The import matrix was based on Stats NZ's IO 'Import', and 'Inter-industry transactions' table.

Industry-level emission factors for emissions embodied in imports were calculated as shown in Equation 2.

Equation 2: Equation used to calculate emission factors for embodied imports

$$EF_{embodied\ imports,i} = (EF_{imports,i} \bullet M) \bullet (I - A)^{-1}$$

where

$EF_{imports,i}$ = Emission factors from Eora

M = Import matrix, defined below in Equation 3.

Eora-based emission factors ($EF_{imports,i}$) account for the emission of goods and services that are imported into New Zealand. The Eora database provides emission factors for upstream supplier countries into New Zealand, per commodity. Commodities as per IO tables were matched to their respective Eora counterpart. Where one-to-many commodity concordance occurred (IO commodity to Eora commodity), an average of the two Eora commodities was taken.

The original Eora commodity-level emission factors for New Zealand upstream suppliers encompass the emission factors of each upstream supplier country to New Zealand, including New Zealand to New Zealand. New Zealand to New Zealand portion of the emission factors were removed to subtract the domestic emissions from the overall Eora upstream suppliers' emission factors. The remaining emission factors were adjusted to only represent the proportion of imports from the total gross output of main New Zealand industries. This process ensured that the emission factors of imported goods and services accounted for the emissions and economic output related to imported goods only. Eora-based emission factors were then converted to New Zealand dollar (NZD), adjusted for inflation, and converted to kilotonnes of carbon dioxide equivalents per million dollars (ktCO2e/$M).

The import matrix (M) was calculated as per Equation 3 below.

Equation 3: Equation used to calculate the Import matrix (M), per element

$$M = \text{import matrix } c \times i \qquad \forall \text{ commodities } c$$

$$m_{c,i} = \frac{import\ value_{c,i}}{GO_i}$$

The Eora-based emission factors per IO commodity were then multiplied by import matrix, resulting in the direct import emission factors related to the production of $1m of domestic production.

3.1.2. Sub-industries

To ensure accurate representation of industry sectors within New Zealand, two IO industries needed to be broken down further: “Sheep, beef cattle, and grain farming”, and “Poultry, deer, and other livestock farming”. The resulting sub-industries are as follows:

AA121 Sheep, beef cattle, and grain farming

AA121-1 Sheep

AA121-2 Beef cattle

AA121-3 Grain farming

AA141 Poultry, deer, and other livestock farming

AA141-1 Poultry

AA141-2 Deer

AA141-3 Swine

AA141-4 Other livestock farming

The original equation to calculate final industry-level emission factors remained the same as shown in Equation 1. However, sub-industry domestic emission factors and embodied import emission factors were re-calculated.

Sub-industry domestic emission factors were calculated for by applying weighting factors to the respective industry’s total emissions and gross output as shown in Equation 4. Domestic emissions weightings were calculated based on MfE’s Greenhouse Gas Inventory (2020), and economic gross output weightings based on Ministry for Primary Industries’ (MPI) Situation and Outlook for Primary Industries: June 2019 (2019).

Equation 4: Equation used to calculate sub-industry emission factors

$$EF_{domestic,s} = (EF_{domestic,i} * \frac{E_s}{\sum_s E_s}) \bullet (I - A)^{-1} \qquad \forall \text{ sub-industries } s \in S$$

where

$E_s =$ Emissions from a sub-industry s

$S =$ Number of sub-industries s in an industry i

Emission factors for embodied imports for the sub-industries were calculated by applying economic gross output weightings, as described above, to the original industry-level emission factors for embodied imports.

3.2. Commodity-level Emission Factors

Commodity emission factors were calculated based on the emission factor of their respective industry. Two types of commodity-level emission factors were calculated:

- Wholesale commodity-level emission factors
  - Excludes GST
  - Excludes exports
- Retail commodity-level emission factors
  - Includes GST
  - Includes retail margin on goods and services
  - Includes imported goods and services sold directly to the consumer
  - Includes emissions arising from retailer's own operations
  - Excludes exports

Industry-commodity concordance was needed to ensure the emission factors related to the domestic production of goods and services is well represented within the commodity-level emission factors. Concordance was largely based on Stats NZ NZSIOC[3]-NA06CC[4] concordance document, which was provided by Stats NZ to thinkstep-anz for internal use.

Although NA06CC provided similar commodities to those used in the IO tables, further commodity matching was needed between NA06CC commodities and IO commodities. Manual mapping was based on two criteria:

- Similarities of wording between NA06CC and IO Commodities
- Stats NZ NZSIOC classifications of Levels 1, 2, 3 and 4

In cases of many-to-one matching (industry-to-commodity) occurrences, a conservative approach was used to match commodities with the industry with highest emission factor. This approach did not have a significant impact on the final emission factors of most commodities. However, three commodities were significantly impacted by this conservative

[3] NZSIOC: New Zealand Standard Industrial Output Categories

[4] NA06CC: National Accounts 2006 Commodity Classification

approach, and a manual calculation of their wholesale emission factors was necessary. This is explained in more detail in the next section, 3.2.1.

3.2.1. Wholesale Commodity-level Emission Factors

Industry-level emission factors were matched to their respective commodities to provide the final wholesale commodity emission factors.

As mentioned previously, for commodities with many-to-one (industry-to-commodity) matching where the emission factors from the differing industries varied greatly, manual calculation of wholesale commodity emission factors was needed. This was true for only three commodities: *Z3 Living plants, buds, seeds, spice, and aromatic crops*, *Z10 Cattle*, and *Z87 Wastes and scraps*. The wholesale emission factors for these commodities were calculated as follows:

Z3 Living plants, buds, seeds, spice, and aromatic crops

This commodity was matched to industries *AA111 Horticulture and fruit growing*, and *AA121-3 Grain farming*. The wholesale emission factor for *Z3 Living plants, buds, seeds, spice, and aromatic crops* was then calculated by taking a weighted average of the emission factors of *AA111 Horticulture and fruit growing*, and *AA121-3 Grain farming*.

The same methodology was applied to calculate the emission factor of commodity *Z10 Cattle,* which was matched to industries *AA121-2 Beef cattle,* and *AA131 Dairy cattle farming*.

Z87 Wastes and scraps

This commodity was matched to *CC111 Meat and meat product manufacturing*, *CC321 Pulp, paper and converted paper product manufacturing*, and *CC711 Primary metal and metal product manufacturing*. A weighted average of the emission factors for *CC111 Meat and meat product manufacturing*, and *CC321 Pulp, paper and converted paper product manufacturing* was taken, based on the proportion of degradable organic carbon arising from each of the industries. *CC711 Primary metal and metal product manufacturing* was excluded as metals are inert.

Sub-commodities:

Emission factors for the commodity *Z34 Meat and offal* is also represented as 5 sub-commodities: *Z34-1 Lamb*, *Z34-2 Beef*, *Z34-3 Poultry, Z34-4 Venison*, and *Z34-5 Pork*. This was done to ensure the different amount of greenhouse gases that are emitted by each of these commodities are represented.

Emission factors for the sub-industries *AA121-1 Sheep*, *AA121-2 Beef cattle*, *AA141-1 Poultry*, *AA141-2 Deer*, and *AA141-3 Swine* had already been calculated as mentioned in section 3.1.2. The commodity *Z34 Meat and offal* was matched to industry *CC111 Meat and meat product manufacturing*, rather than industries *AA121 Sheep, beef cattle, and grain farming* and *AA141 Poultry, deer, and other livestock farming*, which were used to calculate the sub-industries *AA121-1 Sheep*, *AA121-2 Beef cattle*, *AA141-1 Poultry*, *AA141-2 Deer*, and *AA141-3 Swine*.

The split of *Z34 Meat and offal* into *Z34-1 Lamb*, *Z34-2 Beef*, *Z34-3 Poultry, Z34-4 Venison*, and *Z34-5 Pork* was done by extracting the final emission factors for *CC111 Meat and meat product manufacturing* that was calculated as part of each Leontief multiplication done to obtain final emission factors for sub-industries *AA121-1 Sheep*, *AA121-2 Beef cattle*, *AA141-1 Poultry*, *AA141-2 Deer*, and *AA141-3 Swine*.

3.2.2. Retail Commodity-level Emission Factors

Retail commodity-level emission factors were calculated as per Equation 5.

Equation 5: Equation used to calculate retail commodity-level emission factors (EF_{retail})

$$EF_{retail,c} = \frac{(E_{domestic,c} + E_{embodied\ imports,c} + E_{retail,c})}{P_c}$$

where

$E_{domestic,c}$ = Emissions from domestic production of commodity

$E_{embodied\ imports,c}$ = Emissions embodied in imports of that commodity sold directly to consumers

$E_{retail,c}$ = Emissions attributable to the sale of that commodity

P_c = Commodity's purchaser's price[5]

Represented in Stats NZ's IO 'Supply' table, commodities' purchasing price (P_c) represent the total economic value of the supply of each commodity to consumers throughout New Zealand. This value includes domestic production, imported goods and services, margins, and taxes (including GST).

Total emissions from commodities ($E_{domestic,c}$) were calculated by multiplying the emission factor of the representative industry, with the total economic value of the commodity's domestic production ('Total industry' column of Stats NZ IO 'Supply' table).

Emissions embodied in imports sold directly to consumer ($E_{embodied\ imports,c}$) were calculated by multiplying the related Eora emission factor for a commodity (as mapped in section) with the 'Sub-total final consumption on expenditure' column of Stats NZ IO 'Imports' table.

Retail emissions attributable to the sale of commodities ($E_{retail,c}$) were calculated as per Equation 6. The authors' note that this equation is not perfect. It disaggregates emissions from an industry into commodities based on the ratio of household spending on a commodity. However, given the small effect of retail emissions, this equation is considered fit-for-purpose for the current report.

Equation 6: Equation used to calculate retail emissions attributable to the sale of a commodity

[5] Total purchaser's price from Stats NZ National Accounts IO table 1 was adjusted for inflation.

$$E_{retail,c} = \sum_{i=1}^{I} E_{retail,i} \times \sum_{i=1}^{I} \frac{S_c}{\sum_{i=1}^{I} S_{retail,i}} \quad \forall \text{ industries } i \in I$$

where

$E_{retail,i}$ = Emissions of retailing industries i where commodity c sold

S_c = Household expenditure on commodity c

$S_{retail,i}$ = Household expenditure on all commodities sold at retailing industries i

I = Number of industries

Sixty-three IO commodities are commodities that would need to be purchased from a retailer in order to reach their final users. These were mapped to the relevant retailing IO industries where they are expected to be sold at. Ten IO industries were defined as *retailing industries* and were matched to each of the sixty-three *retailing commodities*. The ten retailing industries are:

- GH111 Motor vehicle and parts retailing
- GH112 Fuel retailing
- GH121 Supermarket and grocery stores
- GH122 Specialised food retailing
- GH131 Furniture, electrical, and hardware retailing
- GH132 Recreational, clothing, footwear and personal accessory retailing
- GH133 Department stores
- GH134 Pharmaceutical and other store based retailing
- GH135 Non-store and commission based retailing
- GH212 Food and beverage services

The *retailing commodities* to *retailing industries* mapping process allowed emissions of retailing industries to be accounted for in $E_{retail,c}$.

Total annual household expenditure data (S_c and $S_{retail,i}$) were sourced from Stats NZ's "Household Expenditure Survey" (Stats NZ, 2020).

Sub-commodities

Retail emission factors for sub-commodities followed the same calculations as shown in Equation 6. However, weighting factors were applied to the total emissions and purchaser's price. Emissions weightings were calculated based on MPI's Situation and Outlook for Primary Industries, and purchaser's price weightings for each commodity as per Stats NZ Household Expenditure Survey.

3.3. Primary Data Sources

Table 1 below provides an overview of main publicly available data sources used when calculating emission factors for New Zealand industries and commodities.

Table 1: Overview of main data sources per calculation step

Industry-level emission factors	
Industry mapping	Stats NZ (2020): NZ Industries in Greenhouse Gas Emissions (industry and household): year ended 2018 Stats NZ (2016): NZ Industries in Input-output tables for year 2013
Emission factors for domestic production	Stats NZ (2020): NZ Industries in Greenhouse Gas Emissions (industry and household): year ended 2018 Stats NZ (2016): *Table 4: Inter-industry transactions* from National Accounts input-output tables: year ended March 2013 Reserve Bank of New Zealand (2021): Inflation calculator, 2015 Q2 to 2018 Q4 Stats NZ (2016): *Table 5: Industry by industry total requirements (direct & indirect)* from National Accounts input-output tables: year ended March 2013
Emission factors for embodied imports	Lenzen, Kanemoto, Moran, & Geschke (2012) and Lenzen, Moran, Kanemoto, & Geschke (2013): 2015 Eora Multipliers for New Zealand, Upstream Suppliers Stats NZ (2016): *Table 3: Imports into industries and categories of final demand* from National Accounts input-output tables: year ended March 2013 Stats NZ (2016): *Table 4: Inter-industry transactions* from National Accounts input-output tables: year ended March 2013 Stats NZ (2016): *Table 5: Industry by industry total requirements (direct & indirect)* from National Accounts input-output tables: year ended March 2013
Emission factors for sub-industries	MfE (2020): Tables 3s1 and 3s3: Sectoral Report for Agriculture, Table 3F: Field burning of agricultural residues, and Table 3D: Direct and indirect N_2O emissions from agricultural soils, from the New Zealand's Greenhouse Gas Inventory: 1990 to 2018 MPI (2019): Table 21 Gross agricultural revenue and expenditure, year ending March 2015-23

Commodity-level emission factors	
Wholesale sub-commodity emission factors	Stats NZ (2016): *Table 4: Inter-industry transactions* from National Accounts input-output tables: year ended March 2013 Reserve Bank of New Zealand (2021): Inflation calculator, 2013 Q2 to 2018 Q4 Stats NZ (2016): *Table 5: Industry by industry total requirements (direct & indirect)* from National Accounts input-output tables: year ended March 2013
Retail sub-commodity emission factors	Stats NZ (2016): *Table 1: Supply of products in basic prices* from National Accounts input-output tables: year ended March 2013 Stats NZ (2016): *Table 3: Imports into industries and categories of final demand* from National Accounts input-output tables: year ended March 2013 Reserve Bank of New Zealand (2021): Inflation calculator, 2013 Q2 to 2018 Q4 Lenzen, Kanemoto, Moran, & Geschke (2012) and Lenzen, Moran, Kanemoto, & Geschke (2013): 2015 Eora Multipliers for New Zealand, Upstream Suppliers Reserve Bank of New Zealand (2021): Inflation calculator, 2015 Q2 to 2018 Q4 Stats NZ (2020): Detailed household expenditure: Year ended June 2019

3.4. Limitations

The main limitations of the approach used in this paper are:

- **Categorisation of data:** Due to differing industry and commodity categorisation within the many sources used in this paper, manual mapping was required in some cases. Therefore, it is expected that minor to medium levels of uncertainty may exist within the emission factors provided.
- **Averaged emission factors for imported goods and services:** StatsNZ import IO tables do not differentiate the share of imports by country of origin for each commodity. Therefore, Eora-based commodity emission factors for New Zealand imported goods and services represent an average import emission factor for each IO commodity.
- **Averaged retail commodity-level emission factors:** Commodity-level retail emission factors are not split by imported and domestic goods. Instead, a weighted average emission factor for all IO commodities supplied within New Zealand is used.
- **Inflation:** Economic data as per Stats NZ IO tables, and Eora multipliers were adjusted for inflation to 2018 rates using average inflation rates provided by the Reserve Bank of New Zealand. This approach does not account for differing inflation rates between industries, between commodities, or the differing levels of imported goods and services per year.

4. Emission Factors

New Zealand-specific industry-level and commodity-level emission factors are provided in Sections 4.1 and 4.2 respectively. Table 2 below provides an outline on different uses of the industry-level and commodity-level emission factors.

General notes on the use of emission factors:

1. Emission factors are provided in kg CO_2e/$. This unit is equivalent to $ktCO_2e$/$M when used at the national level.
2. All dollars are in NZD for the year 2018. To calculate total emissions of purchased goods and services for years after 2018, adjustment for inflation is recommended.
3. All emission factors are national averages. They do not reflect the emissions of specific products or specific industries, but rather of all products and services in each industry in New Zealand. As such, they cannot be used to choose between two different products/services produced by the same industry.

Table 2: Outline of uses of the different types of emission factors

Industry-level emission factors **Wholesale commodity-level emission factors**
Industry-level and wholesale commodity-level emission factors are designed to be used by organisations that purchase goods and service from a wholesaler. This is due to the value of these goods not including taxes and margins, and the emissions not including emissions associated with the retailing of goods. Wholesale commodity-level emission factors represent more disaggregated emission factors than their representative industry-level emission factors. However, no additional calculations were done between industry-level and wholesale commodity-level emission factors. Use of wholesale commodity-level emission factors are preferred as they represent a more accurate description of goods and services. However, there might be instances in which the good or service that a company is looking for is not catered by the commodity-level emission factors. In this case, industry-level emission factors might be more appropriate.

Retail commodity-level emission factors
Retail commodity-level emission factors are designed to be used by organisations and individuals that purchase goods from a retailer, such as a supermarket. These emission factors account for emissions associated with retailing of these commodities, as well as emissions embodied in imports that do not require further transformation by a New Zealand industry. They are also based on the retailing value of those commodities, which include margins and taxes.

4.1. Industry-level Emission Factors

Table 3 provides a full list of emission factors for New Zealand industries in kg CO_2e/$

Notes on the use of industry-level emission factors are as follows:

1. The emission factors provided in this table are at a wholesale level, and therefore exclude taxes (and therefore GST), and margins.
2. Industry-level emission factors account for emissions embodied in imported goods and services that are used in the process of production of domestic goods and services. Imported goods and services that are supplied directly to the consumer are excluded in this category.

Table 3: Industry-level emission factors, including the direct, direct import and indirect emission factors that make up industries' final emission factors (kg CO_2e/$)

Code	New Zealand industries	Emission Factors
AA111	Horticulture and fruit growing	0.572
AA121	Sheep, beef cattle, and grain farming	3.696
AA121-1	Sheep	4.815
AA121-2	Beef cattle	3.351
AA121-3	Grain farming	0.223
AA131	Dairy cattle farming	1.823
AA141	Poultry, deer, and other livestock farming	1.287
AA141-1	Poultry	0.564
AA141-2	Deer	2.634
AA141-3	Swine	0.821
AA141-4	Other livestock farming	0.724
AA211	Forestry and logging	0.377
AA311	Aquaculture*	0.584
AA312	Fishing*	0.584
AA321	Hunting and trapping*	0.408
AA322	Agriculture, forestry and fishing support services*	0.408
BB111	Coal mining	0.887
BB112	Oil and gas extraction	0.270
BB113	Metal ore and non-metallic mineral mining and quarrying	0.407
BB114	Exploration and other mining support services	0.230
CC111	Meat and meat product manufacturing	1.852

Code	New Zealand industries	Emission Factors
CC121	Seafood processing	0.412
CC131	Dairy product manufacturing	1.552
CC141	Fruit, oil, cereal and other food product manufacturing	0.486
CC151	Beverage and tobacco product manufacturing	0.298
CC211	Textile and leather manufacturing	1.095
CC212	Clothing, knitted products and footwear manufacturing	0.405
CC311	Wood product manufacturing	0.334
CC321	Pulp, paper and converted paper product manufacturing	0.411
CC411	Printing	0.456
CC511	Petroleum and coal product manufacturing	1.151
CC521	Basic chemical and basic polymer manufacturing	1.253
CC522	Fertiliser and pesticide manufacturing	0.432
CC523	Pharmaceutical, cleaning and other chemical manufacturing	0.329
CC531	Polymer product and rubber product manufacturing	0.337
CC611	Non-metallic mineral product manufacturing	0.738
CC711	Primary metal and metal product manufacturing	1.171
CC721	Fabricated metal product manufacturing	0.362
CC811	Transport equipment manufacturing	0.250
CC821	Electronic and electrical equipment manufacturing	0.276
CC822	Machinery manufacturing	0.310
CC911	Furniture manufacturing	0.305
CC912	Other manufacturing	0.716
DD111	Electricity generation and on-selling	0.752
DD112	Electricity transmission and distribution	0.219
DD113	Gas supply	0.236
DD122	Sewerage and drainage services	0.484
DD123	Waste collection, treatment and disposal services	2.960
EE111	Owner-builder construction (national accounts only)*	0.282
EE112	Residential building construction*	0.282
EE113	Non-residential building construction	0.405

Code	New Zealand industries	Emission Factors
EE121	Heavy and civil engineering construction	0.291
EE131	Construction services	0.274
FF111	Basic material wholesaling	0.234
FF112	Machinery and equipment wholesaling	0.128
FF113	Motor vehicle and motor vehicle parts wholesaling	0.136
FF114	Grocery, liquor and tobacco product wholesaling	0.258
FF115	Other goods wholesaling*	0.154
FF116	Commission based wholesaling*	0.154
GH111	Motor vehicle and parts retailing	0.137
GH112	Fuel retailing	0.303
GH121	Supermarket and grocery stores	0.179
GH122	Specialised food retailing	0.233
GH131	Furniture, electrical and hardware retailing	0.110
GH132	Recreational, clothing, footwear and personal accessory retailing	0.141
GH133	Department stores	0.087
GH134	Pharmaceutical and other store based retailing*	0.124
GH135	Non-store and commission based retailing*	0.124
GH211	Accommodation	0.262
GH212	Food and beverage services	0.288
II11	Road transport	0.429
II121	Rail transport	0.494
II122	Water transport*	0.605
II123	Air and space transport	1.152
II124	Scenic and sightseeing transport*	0.605
II125	Other transport*	0.605
II131	Postal and courier pick up and delivery services	0.247
II132	Transport support services	0.071
II133	Warehousing and storage services	0.164
JJ111	Publishing (except internet and music publishing)	0.209
JJ112	Motion picture and sound recording activities	0.167

Code	New Zealand industries	Emission Factors
JJ113	Broadcasting and internet publishing	0.123
JJ121	Telecommunications services*	0.117
JJ122	Internet service providers, web search portals and data processing services*	0.117
JJ123	Library and other information services	0.087
KK111	Banking and financing*	0.071
KK112	Financial asset investing*	0.071
KK121	Life insurance	0.065
KK122	Health and general insurance	0.087
KK131	Auxiliary finance and insurance services	0.082
LL111	Rental and hiring services (except real estate)*	0.138
LL112	Non-financial asset leasing*	0.138
LL122	Non-residential property operation	0.106
LL123	Real estate services	0.177
LL211	Owner-occupied property operation (national accounts only)	0.085
MN111	Scientific, architectural and engineering services	0.118
MN112	Legal and accounting services	0.061
MN113	Advertising, market research and management services	0.157
MN114	Veterinary and other professional services	0.099
MN115	Computer system design and related services	0.083
MN211	Travel agency and tour arrangement services	0.169
MN212	Employment and other administrative services	0.133
MN213	Building cleaning, pest control and other support services	0.225
OO111	Local government administration	0.405
OO211	Central government administration and justice	0.122
OO212	Defence	0.158
OO213	Public order, safety and regulatory services	0.126
PP111	Preschool education	0.092
PP112	School education	0.093
PP113	Tertiary education	0.105
PP114	Adult, community and other education	0.161

Code	New Zealand industries	Emission Factors
QQ111	Hospitals	0.141
QQ112	Medical and other health care services	0.137
QQ113	Residential care services and social assistance	0.116
RS111	Heritage and artistic activities	0.112
RS112	Sport and recreation activities	0.241
RS113	Gambling activities	0.087
RS211	Repair and maintenance	0.162
RS212	Personal care, funeral and other personal services	0.168
RS213	Religious services*	0.122
RS214	Civil, professional and other interest groups*	0.122

* Disaggregated industries. The greenhouse gas emissions dataset provides data for each disaggregated industry. However, as Stats NZ IO tables were published in 2013, IO data is only provided for the aggregated level of these industries. For example, IO data for *RS213 Religious Services*, and *RS214 Civil, professional and other interest groups* were provided for the aggregated industry called "Religious services; civil, professional, and other interest groups". Emission factors for each disaggregated industry were calculated at aggregated-level industry. Therefore, the emission factors for disaggregated industries are the same as their counterpart.

4.2. Commodity-level Emission Factors

4.2.1. Wholesale Commodity-level Emission Factors

Table 4 provides a list of wholesale-level emission factors for New Zealand commodities in kg CO_2e/$.

Notes on the use of wholesale commodity-level emission factors:

1. The emission factors provided in this table are at a wholesale level, and therefore exclude taxes (including GST), and margins.
2. Wholesale commodity-level emission factors account for emissions embodied in imported goods and services that are used in the process of production of domestic goods and services. Imported goods and services that are supplied directly to the consumer are excluded in this category.

Table 4: Wholesale commodity-level emission factors (kg CO_2e/$)

Code	Commodities	Wholesale Emission Factors
Z3	Living plants, buds, seeds, spice, and aromatic crops	0.507
Z4	Vegetables	0.572
Z5	Kiwifruit	0.572
Z6	Pome fruit (apples, pears)	0.572
Z7	Other fruit and nuts	0.572
Z8	Forage products, fibres, sugar crops, unmanufactured tobacco	3.696
Z9	Cereals	3.696
Z10	Sheep	3.696
Z11	Cattle	2.161
Z12	Other livestock	1.287
Z13	Deer	1.287
Z14	Pigs	1.287
Z15	Raw milk	1.823
Z16	Wool	3.696
Z17	Other animal products	1.287
Z18	Wood and non-wood forest products	0.377
Z19	Standing timber	0.377
Z20	Fish	0.584
Z21	Crustaceans	0.584
Z22	Support services to agriculture (including animal husbandry)	3.696
Z23	Support services to forestry and logging	0.377
Z24	Fishing services	0.408
Z25	Coal, coke, and tar products	0.887
Z26	Crude petroleum	0.270
Z27	Natural gas	0.270
Z28	Iron ores, non-ferrous metal ores, and concentrates	0.407
Z29	Gypsum, limestone, cement, and building stone	0.407
Z30	Sands, pebbles, gravel, clays, stone, and bitumen	0.407

Code	Commodities	Wholesale Emission Factors
Z31	Chemical and fertilizer minerals and salt	0.407
Z32	Precious metals and stones	0.407
Z33	Services incidental to mining	0.230
Z34	Meat and offal	1.852
Z34-1	Lamb	2.221
Z34-2	Beef	1.592
Z34-3	Poultry	1.696
Z34-4	Venison	1.796
Z34-5	Pork	1.709
Z35	Bacon, ham, and smallgood products	1.852
Z36	Hides and skins	1.852
Z37	Prepared fish	0.412
Z38	Milk and cream in solid or processed liquid form	1.552
Z39	Other dairy products	1.552
Z40	Prepared vegetables	0.486
Z41	Prepared fruit and nuts	0.486
Z42	Animal and vegetable oils and fats	0.486
Z43	Grain products	0.486
Z44	Starches	1.552
Z45	Animal feed	0.486
Z46	Bakery products	0.486
Z47	Sugar and confectionery products	0.486
Z48	Macaroni and noodles	0.486
Z49	Food products	0.486
Z50	Beer, soft drinks, and fruit juices	0.298
Z51	Spirits and tobacco products	0.298
Z52	Wines	0.298
Z53	Natural and man-made textile fibres	1.095
Z54	Yarn and thread	1.095
Z55	Woven fabrics	1.095

Code	Commodities	Wholesale Emission Factors
Z56	Other textiles	1.095
Z57	Tanned skins and leather; handbags and articles of leather	1.095
Z58	Carpets	1.095
Z59	Clothing and knitted fabrics	0.405
Z60	Footwear	0.405
Z61	Wood	0.334
Z62	Panels, boards, veneer sheets, and plywood	0.334
Z63	Building joinery	0.334
Z64	Wood containers and other wood products	0.334
Z65	Pulp, paper, and paperboard	0.411
Z66	Books and other printed material	0.411
Z67	Newspapers and journals	0.411
Z68	Petrol	1.151
Z69	Diesel	1.151
Z70	Other petroleum products	1.151
Z71	Basic chemicals; other paper and paperboard products	1.253
Z72	Other chemical products and man-made fibres	0.337
Z73	Fertilisers and pesticides	0.432
Z74	Plastics in primary forms	1.253
Z75	Pharmaceutical products	0.329
Z76	Soap and perfumes	0.329
Z77	Paints	0.337
Z78	Rubber tyres and tubes	0.337
Z79	Rubber	0.337
Z80	Semi-manufactures of plastics	0.337
Z81	Packaging products of plastics	0.337
Z82	Other plastics products	0.337
Z83	Glass and glass products	0.738
Z84	Non-structural ceramic ware and clay products	0.738
Z85	Plaster, lime, and cement	0.738

Code	Commodities	Wholesale Emission Factors
Z86	Articles of concrete and stone	0.738
Z87	Wastes and scraps	0.940
Z88	Basic iron, steel, and other metals	1.171
Z89	Steel products, semi-finished metal products	1.171
Z90	Structural metal products	0.362
Z91	Prefabricated buildings	0.362
Z92	Metal containers and steam generators	0.362
Z93	Other fabricated metal products	0.362
Z94	Weapons and ammunition; accumulators, primary cells, and batteries	0.362
Z95	Motor vehicles, trailers, and semi-trailers; bodies (coachwork)	0.250
Z96	Ships, pleasure, and sporting boats	0.250
Z97	Other transport equipment and parts	0.250
Z98	Aircraft and spacecraft	0.250
Z99	Domestic appliances	0.276
Z100	Computers, parts, and office machinery	0.276
Z101	Electric motors, generators, and transformers	0.276
Z102	Other electrical equipment and parts thereof	0.276
Z103	Television, cameras, and other electronic goods	0.276
Z104	Medical equipment	0.276
Z105	Photographic and scientific equipment	0.276
Z106	Engines	0.310
Z107	General industrial machinery	0.310
Z108	Agricultural and forestry equipment	0.310
Z109	Other special-purpose machinery	0.310
Z110	Machinery for mining	0.310
Z111	Machinery for food production	0.310
Z112	Furniture	0.305
Z113	Jewellery	0.716
Z114	Sports goods	0.716

Code	Commodities	Wholesale Emission Factors
Z115	Games and toys	0.716
Z116	Services incidental to manufacturing	0.716
Z117	Electricity	0.752
Z118	Gas	0.236
Z119	Water	0.000
Z120	Sewerage services	0.484
Z121	Waste disposal, recycling, and environmental protection services	2.960
Z122	Residential building construction	0.282
Z123	Non-residential building construction	0.405
Z124	Civil engineering services	0.291
Z125	Pre-erection work	0.274
Z126	Other installation work	0.274
Z127	Electrical installation work	0.274
Z128	Plumbing and other installation services	0.274
Z129	Building completion work	0.274
Z130	Land and land improvements	0.291
Z131	Wholesale trade	0.154
Z132	Accommodation	0.262
Z133	Meal services	0.288
Z134	Takeaways	0.288
Z135	Beverage services	0.288
Z136	Road transport freight services	0.429
Z137	Road passenger transport	0.429
Z138	Railway transport freight services	0.494
Z139	Railway passenger transport	0.494
Z140	Sea transport freight services	0.605
Z141	Passenger transportation by waterborne vessels	0.605
Z142	Air transport freight services	1.152
Z143	Air passenger transport	1.152

Code	Commodities	Wholesale Emission Factors
Z144	Travel arrangement and sightseeing transportation services	0.605
Z145	Postal and courier services	0.247
Z146	Cargo handling services	0.164
Z147	Supporting services for road and rail transport	0.071
Z148	Supporting services for water transport	0.071
Z149	Supporting services for air transport	0.071
Z150	Freight transport agencies and other supporting transport services	0.071
Z151	Storage and warehousing services	0.164
Z152	Publishing, printing, and reproduction services	0.456
Z153	Packaged software, tapes, audio, and video records	0.209
Z154	Motion picture, radio, TV services	0.167
Z155	Broadcasting, programming, and programme distribution services	0.123
Z156	Telecommunications services	0.117
Z157	Internet telecommunications services and online content	0.117
Z158	News agency, library, and archive services	0.209
Z159	Financial intermediation services	0.071
Z160	Life insurance	0.065
Z161	Other insurance services	0.087
Z162	Superannuation and individual pension services	0.000
Z163	Services auxiliary to financial services	0.082
Z164	Equipment hire services	0.138
Z165	Computer software and services	0.138
Z166	Intellectual property licensing services	0.138
Z167	Capitalised exploration	0.230
Z168	Leased residential property services	0.177
Z169	Leased commercial property services	0.106
Z170	Other real estate services	0.177
Z171	Owner - occupied dwellings	0.085

Code	Commodities	Wholesale Emission Factors
Z172	Research and development	0.118
Z173	Architectural and engineering services	0.118
Z174	Other business services	0.099
Z175	Legal services	0.061
Z176	Accounting and taxation services	0.061
Z177	Advertising and marketing services	0.157
Z178	Management consultancy	0.157
Z179	Placement and supply of personnel	0.133
Z180	Cleaning	0.225
Z181	Other support services	0.133
Z182	Local government administration services	0.405
Z183	Central government administration services	0.122
Z184	Investigation and security services	0.126
Z185	Preschool education	0.092
Z186	Primary education	0.093
Z187	Secondary education	0.093
Z188	Higher education	0.161
Z189	Other education services	0.161
Z190	Hospital and nursing care	0.141
Z191	Medical, dental, and other health services	0.137
Z192	Accommodation for the aged	0.116
Z193	Child care services	0.116
Z194	Other social services	0.116
Z195	Libraries, museums, and art	0.112
Z196	Sport and recreation services	0.241
Z197	Gambling services	0.087
Z198	Maintenance of domestic and office equipment	0.162
Z199	Maintenance of transport machinery and equipment	0.162
Z200	Maintenance of other equipment	0.162
Z201	Other personal and community services	0.168

4.2.2. Retail Commodity-level Emission Factors

Table 5 provides a list of retail-level emission factors for New Zealand commodities in kg CO_2e/$.

Notes on the use of retail commodity-level emission factors:

1. The prices in the retail commodity-level emission factors are inclusive of taxes (including GST), and margins.
2. Retail commodity-level emission factors are inclusive of embodied emissions in both imported goods and services used in the domestic production of commodities, and on imports sold directly to the consumer.
3. Retail commodity-level emission factors include emissions associated with retailing of commodities (distribution, warehousing, and retail).

Table 5: Retail commodity-level emission factors, and split by main contributors to final emission factors (kg CO_2e/$)

Code	Commodities	Retail Emission Factors
Z3	Living plants, buds, seeds, spice, and aromatic crops	0.164
Z4	Vegetables	0.333
Z5	Kiwifruit	0.476
Z6	Pome fruit (apples, pears)	0.394
Z7	Other fruit and nuts	0.316
Z8	Forage products, fibres, sugar crops, unmanufactured tobacco	3.423
Z9	Cereals	2.254
Z10	Sheep	3.696
Z11	Cattle	2.150
Z12	Other livestock	1.002
Z13	Deer	1.287
Z14	Pigs	1.121
Z15	Raw milk	1.823
Z16	Wool	3.555
Z17	Other animal products	1.086
Z18	Wood and non-wood forest products	0.374
Z19	Standing timber	0.377
Z20	Fish	0.590
Z21	Crustaceans	0.493

Code	Commodities	Retail Emission Factors
Z22	Support services to agriculture (including animal husbandry)	3.674
Z23	Support services to forestry and logging	0.377
Z24	Fishing services	0.373
Z25	Coal, coke, and tar products	0.861
Z26	Crude petroleum	0.067
Z27	Natural gas	0.269
Z28	Iron ores, non-ferrous metal ores, and concentrates	0.400
Z29	Gypsum, limestone, cement, and building stone	0.384
Z30	Sands, pebbles, gravel, clays, stone, and bitumen	0.369
Z31	Chemical and fertilizer minerals and salt	0.193
Z32	Precious metals and stones	0.354
Z33	Services incidental to mining	0.210
Z34	Meat and offal	1.578
Z34-1	Lamb	1.886
Z34-2	Beef	1.359
Z34-3	Poultry	1.461
Z34-4	Venison	1.530
Z34-5	Pork	1.461
Z35	Bacon, ham, and smallgood products	1.195
Z36	Hides and skins	1.834
Z37	Prepared fish	0.335
Z38	Milk and cream in solid or processed liquid form	1.445
Z39	Other dairy products	1.475
Z40	Prepared vegetables	0.366
Z41	Prepared fruit and nuts	0.336
Z42	Animal and vegetable oils and fats	0.266
Z43	Grain products	0.318
Z44	Starches	1.025
Z45	Animal feed	0.272
Z46	Bakery products	0.400

Code	Commodities	Retail Emission Factors
Z47	Sugar and confectionery products	0.412
Z48	Macaroni and noodles	0.401
Z49	Food products	0.372
Z50	Beer, soft drinks, and fruit juices	0.197
Z51	Spirits and tobacco products	0.089
Z52	Wines	0.228
Z53	Natural and man-made textile fibres	0.939
Z54	Yarn and thread	0.771
Z55	Woven fabrics	0.435
Z56	Other textiles	0.449
Z57	Tanned skins and leather; handbags and articles of leather	0.732
Z58	Carpets	0.654
Z59	Clothing and knitted fabrics	0.302
Z60	Footwear	0.226
Z61	Wood	0.319
Z62	Panels, boards, veneer sheets, and plywood	0.311
Z63	Building joinery	0.294
Z64	Wood containers and other wood products	0.261
Z65	Pulp, paper, and paperboard	0.360
Z66	Books and other printed material	0.267
Z67	Newspapers and journals	0.220
Z68	Petrol	0.372
Z69	Diesel	0.745
Z70	Other petroleum products	0.710
Z71	Basic chemicals; other paper and paperboard products	0.568
Z72	Other chemical products and man-made fibres	0.232
Z73	Fertilisers and pesticides	0.254
Z74	Plastics in primary forms	0.262
Z75	Pharmaceutical products	0.167
Z76	Soap and perfumes	0.215

Code	Commodities	Retail Emission Factors
Z77	Paints	0.194
Z78	Rubber tyres and tubes	0.134
Z79	Rubber	0.149
Z80	Semi-manufactures of plastics	0.165
Z81	Packaging products of plastics	0.242
Z82	Other plastics products	0.211
Z83	Glass and glass products	0.423
Z84	Non-structural ceramic ware and clay products	0.289
Z85	Plaster, lime, and cement	0.618
Z86	Articles of concrete and stone	0.576
Z87	Wastes and scraps	0.572
Z88	Basic iron, steel, and other metals	0.766
Z89	Steel products, semi-finished metal products	0.738
Z90	Structural metal products	0.281
Z91	Prefabricated buildings	0.283
Z92	Metal containers and steam generators	0.223
Z93	Other fabricated metal products	0.174
Z94	Weapons and ammunition; accumulators, primary cells, and batteries	0.408
Z95	Motor vehicles, trailers, and semi-trailers; bodies (coachwork)	0.115
Z96	Ships, pleasure, and sporting boats	0.183
Z97	Other transport equipment and parts	0.128
Z98	Aircraft and spacecraft	0.035
Z99	Domestic appliances	0.110
Z100	Computers, parts, and office machinery	0.117
Z101	Electric motors, generators, and transformers	0.121
Z102	Other electrical equipment and parts thereof	0.150
Z103	Television, cameras, and other electronic goods	0.095
Z104	Medical equipment	0.093
Z105	Photographic and scientific equipment	0.069

Code	Commodities	Retail Emission Factors
Z106	Engines	0.034
Z107	General industrial machinery	0.117
Z108	Agricultural and forestry equipment	0.143
Z109	Other special-purpose machinery	0.164
Z110	Machinery for mining	0.069
Z111	Machinery for food production	0.224
Z112	Furniture	0.161
Z113	Jewellery	0.289
Z114	Sports goods	0.287
Z115	Games and toys	0.293
Z116	Services incidental to manufacturing	0.700
Z117	Electricity	0.719
Z118	Gas	0.236
Z119	Water	0.000
Z120	Sewerage services	0.483
Z121	Waste disposal, recycling, and environmental protection services	2.860
Z122	Residential building construction	0.261
Z123	Non-residential building construction	0.398
Z124	Civil engineering services	0.290
Z125	Pre-erection work	0.265
Z126	Other installation work	0.266
Z127	Electrical installation work	0.264
Z128	Plumbing and other installation services	0.263
Z129	Building completion work	0.274
Z130	Land and land improvements	0.291
Z131	Wholesale trade	0.090
Z132	Accommodation	0.256
Z133	Meal services	0.287
Z134	Takeaways	0.296
Z135	Beverage services	0.285

Code	Commodities	Retail Emission Factors
Z136	Road transport freight services	0.390
Z137	Road passenger transport	0.393
Z138	Railway transport freight services	0.494
Z139	Railway passenger transport	0.498
Z140	Sea transport freight services	0.754
Z141	Passenger transportation by waterborne vessels	0.597
Z142	Air transport freight services	1.525
Z143	Air passenger transport	0.925
Z144	Travel arrangement and sightseeing transportation services	0.577
Z145	Postal and courier services	0.233
Z146	Cargo handling services	0.133
Z147	Supporting services for road and rail transport	0.069
Z148	Supporting services for water transport	0.065
Z149	Supporting services for air transport	0.164
Z150	Freight transport agencies and other supporting transport services	0.073
Z151	Storage and warehousing services	0.157
Z152	Publishing, printing, and reproduction services	0.391
Z153	Packaged software, tapes, audio, and video records	0.166
Z154	Motion picture, radio, TV services	0.162
Z155	Broadcasting, programming, and programme distribution services	0.123
Z156	Telecommunications services	0.116
Z157	Internet telecommunications services and online content	0.110
Z158	News agency, library, and archive services	0.229
Z159	Financial intermediation services	0.088
Z160	Life insurance	0.301
Z161	Other insurance services	0.135
Z162	Superannuation and individual pension services	0.027
Z163	Services auxiliary to financial services	0.077

Code	Commodities	Retail Emission Factors
Z164	Equipment hire services	0.130
Z165	Computer software and services	0.111
Z166	Intellectual property licensing services	0.092
Z167	Capitalised exploration	0.230
Z168	Leased residential property services	0.186
Z169	Leased commercial property services	0.105
Z170	Other real estate services	0.165
Z171	Owner - occupied dwellings	0.085
Z172	Research and development	0.117
Z173	Architectural and engineering services	0.110
Z174	Other business services	0.096
Z175	Legal services	0.059
Z176	Accounting and taxation services	0.058
Z177	Advertising and marketing services	0.148
Z178	Management consultancy	0.129
Z179	Placement and supply of personnel	0.132
Z180	Cleaning	0.223
Z181	Other support services	0.130
Z182	Local government administration services	0.405
Z183	Central government administration services	0.122
Z184	Investigation and security services	0.125
Z185	Preschool education	0.091
Z186	Primary education	0.092
Z187	Secondary education	0.095
Z188	Higher education	0.159
Z189	Other education services	0.158
Z190	Hospital and nursing care	0.140
Z191	Medical, dental, and other health services	0.124
Z192	Accommodation for the aged	0.103
Z193	Child care services	0.110

Code	Commodities	Retail Emission Factors
Z194	Other social services	0.110
Z195	Libraries, museums, and art	0.159
Z196	Sport and recreation services	0.234
Z197	Gambling services	0.100
Z198	Maintenance of domestic and office equipment	0.155
Z199	Maintenance of transport machinery and equipment	0.156
Z200	Maintenance of other equipment	0.156
Z201	Other personal and community services	0.160

5. Recommendations

The use of Input-Output Life Cycle Assessment (IO-LCA) approach to carbon footprinting is still in an early phase in New Zealand. This section provides recommendations to improve publicly available data to better facilitate the growth and development of the IO-LCA field in New Zealand.

5.1. Industry disaggregation

The main domestic data sources for IO-LCA in New Zealand are Stats NZ's Greenhouse Gas Emissions (industry and household), and National Accounts IO tables.

Both datasets use NZSIOC industry categorisation and are based on the source of economic production rather than the type of process used by each industry (Stats NZ, 2020). Aggregation of industries by economic production is at times inconsistent with the level greenhouse gases they might emit.

Take for example the category *AA121 Sheep, beef cattle, and grain farming*. thinkstep-anz's calculated domestic emission factors for each element of this industry are as follows:

AA121-1 Sheep: 4.7 kg CO_2e/$

AA121-2 Beef cattle: 3.3 kg CO_2e/$

AA121-3 Grain farming: 0.1 kg CO_2e/$

If not separated, emission factors for *AA121 Sheep, beef cattle, and grain farming* would present an average emission factor of the three sub-industries. Therefore, emissions from sheep, for example, would be artificially low, while emissions for grain farming would be artificially high.

This paper separated sub-industries from their overarching industry when possible. For the above three sub-industries, publicly available data enabled the calculation of their own emissions and gross output.

Other industries, where a differing level of emissions might occur, were not able to be separated. An example is 'Primary metal and metal product manufacturing'. This industry includes both ferrous and non-ferrous metals. The total direct emissions of 'Primary metals' is 2248.0 kt CO_2e. 90% of New Zealand's domestically made aluminium and 24% of New Zealand's domestically made steel are exported. Aluminium has much lower direct (Scope 1) greenhouse gas emissions than steel per dollar, which means that New Zealand exports most of the less carbon intensive portion of this sector and uses the majority of the high emitting portion.

Further desegregation of IO tables, taking account the differing emissions intensities of industries, would greatly increase the quality of IO-LCA studies.

5.2. Annual release of IO tables

The latest IO tables, which were used in this paper, were released in 2013. Although it is expected that the New Zealand's economy has not drastically changed since then, some industries have.

Furthermore, more frequent releases of IO tables would also improve the representation of imports and the gross outputs of each industry.

5.3. Import IO table to represent share of imports per country

As mentioned in section 0, current Import IO tables do not differentiate the share of imports by country of origin for each commodity. Therefore, an average import emission factor is needed to be allocated for each IO commodity in order to calculate total emissions from imported goods and services that are consumed directly by final categories. Import data by country of origin would likely increase the accuracy of calculations of total emissions from imported goods and services.

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Applicability and Limitations

Restrictions and Intended Purpose

This report has been prepared by thinkstep-anz with all reasonable skill and diligence within the agreed scope, time and budget available for the work. thinkstep-anz does not accept responsibility of any kind to any third parties who make use of its contents. Any such party relies on the report at its own risk. Interpretations, analyses, or statements of any kind made by a third party and based on this report are beyond thinkstep-anz's responsibility.

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Legal Interpretation

Opinions and judgements expressed herein are based on our understanding and interpretation of current regulatory standards and should not be construed as legal opinions. Where opinions or judgements are to be relied on, they should be independently verified with appropriate legal advice.

Annex A Consumption emissions of New Zealand

The IO-LCA emission factors presented in this report allowed the calculation of New Zealand's consumption-based emissions. Table 6 and

Figure 1 outline New Zealand's total consumption-based emissions.

Table 6: New Zealand's total consumption-based emissions

Domestic Production	67,650.84
Households	9,394.50
Direct Use Imports	17,235.39
Embodied imports	26,134.97
Exports (Domestic Production + Embodied Imports)	51,819.36
Total	**68,596.34**

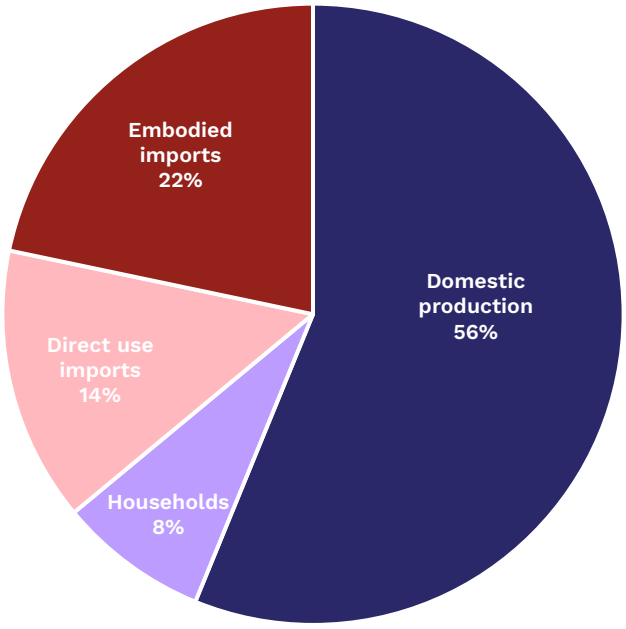


Figure 1: New Zealand's total consumption-based emissions, by emission source (excluding exports)

Approach:

A consumption-based accounting (CBA) approach was used to calculate the carbon footprint accounts for emissions at the point of final consumption. To calculate consumption-based emissions at a national level, domestic production of goods and services need to be reallocated to their final user. Direct emissions from households also

need to be included (e.g., energy use, domestic refrigeration, domestic wastewater, and domestic vehicle use).

Consumption-based emissions for New Zealand were calculated as per Equation 7.

Equation 7: Equation used to calculate New Zealand's total consumption-based emissions

$$CBA_{New\ Zealand} = D + H + Imp_{direct} + Imp_{embodied} - (X_{domestic} + X_{embodied})$$

where:

D = total emissions from domestic production of goods and services

$$D = EF_{domestic}\, Y$$

H = total household emissions, as per Stats NZ's Greenhouse Gas Emissions (industry and household): year ended 2018

Imp_{direct} = total emissions from direct use of imports

$$Imp_{direct} = EF_{import}\, V$$

$Imp_{embodied}$ = total emissions from embodied imports into domestic production of goods and services

$$Imp_{embodied} = EF_{embodied\ imports}\, Y$$

$X_{domestic}$ = total emissions from domestic production of goods and services that were exported

$$X_{domestic} = EF_{domestic}\, Y_{export}$$

$X_{embodied}$ = total emissions from embodied imports into domestic production of goods and services that were exported

$$X_{embodied} = EF_{embodied\ imports}\, Y_{export}$$

A.1. To calculate total emission from domestic production of goods and services (D), and from embodied imports into domestic production of goods and services ($Imp_{embodied}$), the associated emission factors needed to be multiplied by the total expenditure by final use categories (Y)[6].

Total emissions from the direct use of imports (Imp_{direct}) were calculated by multiplying the associated emission factor with the total expenditure on direct use of imports by final use categories (V)[7].

[6] Final use categories include Exports, Households, Non-profit Institutions Serving Households, Central Government, Local Government, Capital Formation, and Change in Inventories. Total expenditure can be found in Stats NZ IO table 4 “Inter-industry transactions”.
[7] Final use categories include Exports, Households, Non-profit Institutions Serving Households, Central Government, Local Government, Capital Formation, and Change in Inventories. Total expenditure can be found in Stats NZ IO table 3 “Imports”.