Data Article

Passenger transport demand, fuel consumption, and emissions data for the Irish Passenger Transport Emissions and Mobility (IPTEM) model

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A B S T R A C T

These data and analyses support the research article “How and Why We Travel – Mobility Demand and Emissions from Passenger Transport (O’Riordan et al., 2022). This article refers to a spreadsheet model, the Irish Passenger Transport Emissions and Mobility Model (IPTEM V2.9). The spreadsheet model is available for download from Zenodo (O’Riordan et al., 2022). The model and the underlying data, details the passenger transport demand by trip purpose (work, shopping, education etc.), mode type (car, rail, bus, cycling, walking) and trip distance for Ireland over the period of 2009–2019. Passenger occupancy rates for public transport modes in Ireland, CO\textsubscript{2} emissions intensities and annual CO\textsubscript{2} emissions are also included in the Data in Brief. Assumptions and equations used to develop the IPTEM V2.9 are available in the Experimental design, materials, and methods section.

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Specifications Table

| Subject | Engineering |
|---------|-------------|
| Specific subject area | Passenger transport demand and CO₂ emissions in Ireland |
| Type of data | Table, Chart, Figure |

How the data were acquired
- National transport survey data gathered from Central statistics office (CSO) [3]
- Information from the Irish Car Stock Model V 2.4 on an online repository [4]
- Calculations as mentioned in the Data in Brief's reference paper and outlined in further detail in Experimental design, materials, and methods equations: Eqs. (1)–(10).

Data format | Raw Analyzed |
Description of data collection | Irish Car Stock Model, retrieved from an online repository [4], referred to in a Data in Brief [5] that provides technological stock data of car characteristics such as stock, mileage, and energy consumption per kilometre. Population data made available from Eurostat [6] National Travel Survey Data is available from the Central Statistics Office [3] |
Data source location | Raw data sources used: National Travel Survey 2009, 2012, 2013, 2014, 2016 and 2019, available online at: https://www.cso.ie/en/statistics/ Sustainable Energy Authority of Ireland conversion rates, available online at: https://www.seai.ie/data-and-insights/seai-statistics/conversion-factors/ Irish Car Stock Model V2.4, available online at: https://zenodo.org/record/4651477#.YjD5fXrMKUk |
Data accessibility | Data is provided with this article in the following formats: Irish Passenger Transport Emissions and Mobility Model (IPTEM V2.9) is available on open-source repository Zenodo. Repository name: ZenodoData identification number: 10.5281/zenodo.6359991 Direct URL to the data: 10.5281/zenodo.6359991 |
Related research article | V. O’Riordan, F. Rogan, B. Ó Gallachóir, T. Mac Uidhir, H. Daly, How and why we travel – Mobility demand and emissions from passenger transport, Transp. Res. Part D Transp. Environ. 104 (2022). 10.1016/j.trd.2022.103195. |

Value of the Data

- This data provides clarity behind the modelling assumptions and methods used to model passenger transport demand and emissions in Ireland.
- While the data is Ireland specific, it serves as a guideline for the scientific community to ways to replicate similar modelling methods designed for other regions at a local, national, or international level.
- It provides valuable insights into the sources available at a national level which most European member states have freely available, and which can be used to replicate the modelling methods provided in the accompanying Transportation Research Part D article [1]. This data can be used to gain insights into the link between modal shift to low carbon dioxide passenger transport.
• Energy analysts can benefit from the detailed passenger transport demand information, serving to aid in replication of transport emissions and demand analyses. Policymakers also benefit from the information on occupancy rates, CO₂ emissions intensity and passenger transport demand listed.

1. Data Description

The dataset referred to in this article exists as an Excel spreadsheet available on Zenodo [2]. The spreadsheet model has a series of sheets contained within the Excel file ‘IPTEM V2.9’. The dataset within this article provides secondary data from the Irish National Travel Survey conducted by the Central Statistics Office [7], data from the Irish Car Stock Model [4,8], energy and emissions conversion factors from the Sustainable Energy Authority of Ireland [9]. Occupancy, annual energy consumption figures, and passenger numbers from public transport providers: Dublin Bus (city bus transportation system) [10], Irish Rail (national rail network in Ireland) [11], Bus Éireann (national bus network in Ireland) [12], and Luas (light rail system in Dublin, Ireland) [13], are also included. Assumptions underpinning the IPTEM V2.9 model are also shared in the sheet “PKM (Passenger Kilometre) Calculation Assumptions”. Calculations for passenger kilometre demand in Ireland by trip purpose, trip distance and mode type are found in “PKM distance by distance and mode”, “PKM by distance and journey type” sheets. Excel formulae and references to previous sheets are embedded in the calculation sheets. Calculations for CO₂ emissions by trip distance, mode type and trip purpose are found in Excel sheet “CO₂ Emissions Intensity” and “CO₂ Emissions by mode, purpose and distance”. An index and content description of the sheets in the IPTEM V2.9 model is listed in Table 1. This Data in Brief contains sample rows and entry values to describe the tables in the repository. The sample table entries are included in the data in brief to assist navigation of the accompanying Excel spreadsheet repository.

1.1. CSO tables

The CSO tables are based on the National Travel Survey conducted by the Central Statistics Office (CSO). The survey was conducted for Ireland and is based on travel diaries by respondents in 2009, 2012, 2013, 2014, 2016 and 2019. Data for the intervening years is interpolated. A description of the mode types available in the survey is listed in Table 2.

Passenger kilometres, occupancy figures, energy, and CO₂ emissions intensity per passenger kilometre serviced are determined for the following public transit authorities in Ireland

1. Bus Éireann – The intercity and nation-wide bus service in Ireland
2. Dublin Bus – The urban bus service operating in Ireland’s largest city, Dublin.
3. Irish Rail/DART – The heavy rail cross country and commuter rail service operating in Ireland
4. Luas – The light rail service

Passenger kilometres by trip purpose was also calculated. The following trip purposes are covered in this study

• Work
• Education
• Shopping
• To eat or drink
• Other
• Entertainment/Leisure/Sports
• Personal Business
• Companion/Escort Journey
• Visit family/friends
Table 1
Index of IPTEM V2.9 Excel spreadsheets.

| Sheet label | Content Description |
|-------------|---------------------|
| Readme      | Provides information on the contact details of the author, and the latest revision date. |
| CSO Tables  | Contains secondary data from the Central Statistics Office's National Travel Surveys in 2009, 2012, 2013, 2014, 2016 and 2019. Data is referred to in Table 3 - Table 26. |
| Irish Car Stock Model V 2.4 | Contains references to the Irish Car Stock Model, which was developed by Daly and Ó Gallachóir [8,4]. Data is referred to in Table 27 - Table 34: On-road factors for diesel cars (factors), Source: Irish Car Stock Model, [1,13] |
| Occup., Energy Cons., Emission | Shorthand for “Occupancy, Energy Consumption and Emissions”. This contains information on occupancy rates, passenger kilometre estimates for public transport. Data is referred to in Tables 35–58. |
| PKM (passenger kilometres) calculation Assumptions | Contains calculations for assumptions underpinning the Irish Passenger Transport Emissions and Mobility (IPTEM) model. Data and calculation tables are referred to in Tables 59–67. |
| PKM by distance and mode | Shorthand for passenger kilometre by distance and mode. It is a calculation of total passenger kilometres by year, trip distance and mode type. A sample row with descriptions of each of the entry fields is noted in Table 68. Method to calculate the Total Passenger Kilometres is listed in Eq. (3) |
| PKM by distance and purpose | Shorthand for passenger kilometre by distance and trip purpose. A sample row with descriptions of each of the entry fields is noted in Table 69. Methods to calculate Total Passenger Kilometres is listed in Eq. (3) |
| Passenger Kilometre Tables | Contains tables derived from pivot tables from Table 68. For years unsurveyed by the National Travel Survey, the values for passenger kilometres are interpolated. The passenger kilometres by mode type, trip distance and trip purpose over the period of 2009–2019 are listed in Tables 71–73. |
| CO₂ Emissions Intensity | Data is listed in Tables 48–56. Method to calculate the CO₂ emissions intensity is listed in Eq. (9). |
| CO₂ Emission by mode, purpose, dist. Emissions tables | Shorthand for “CO₂ Emissions by mode, purpose and distance.” Data is listed in Table 74. Methods to calculate the emissions are listed in Eqs. (9) and (10). Contains calculations that are interpolations of Passenger Kilometres by trip distance, mode type and trip purpose derived from pivot tables from Table 74. Outputs are listed in Tables 75–77. |

Trip distance categories from the National Travel Survey were as follows:

- < 2 km
- 2–4 km
- 4–6 km
- 6–8 km
- > 8 km

The average of each of the categories are used in calculating overall Passenger Kilometre demand. The figure for passenger kilometres for the >8 km category was calculated through calibration with the Irish Car Stock Model.
Table 2
Overview of transport modes referred to in the IPTEM model [1].

| Mode                  | Description                                                                 |
|-----------------------|-----------------------------------------------------------------------------|
| Private Car – Driver  | People travelling in a car as the main driver                               |
| Private Car – Passenger| People travelling in a car driven by another person                         |
| Walk                  | People walking, this is also categorized as an “active mode” of transport   |
| Bus                   | People taking the bus, there are two main bus transit providers in Ireland,  |
|                       | Dublin Bus, which operates urban driving style city routes in Dublin,        |
|                       | Ireland, and Bus Éireann, which provides a mix of urban and intercity        |
|                       | driving. Private bus transport is assumed to be negligible.                  |
| Cycle                 | Includes the use of both mechanical bikes and e-bikes for cycling and is also|
|                       | categorized as an “active mode” of transport                                |
| Rail/DART/Luas        | This mode choice refers to the three rail providers in Ireland; Irish Rail - |
|                       | which operates long distance rail in Ireland, DART- the Dublin Area Rapid   |
|                       | Transit, a commuter rail operating in the Greater Dublin area and Luas - a   |
|                       | city light rail which operates in Dublin                                     |
| Taxi/hackney          | People travelling in a car operated by a registered taxi driver             |
| Lorry/Motorcycle/Other| This mode includes lorries, motorcycles and any other mode choice not       |
|                       | included in the preceding categories                                        |

Table 3
Percentage distribution of journey distance for all regions, 2009–2019 Source: CSO, National Travel Survey [7].

|       | 2009 | 2012 | 2013 | 2014 | 2016 | 2019 |
|-------|------|------|------|------|------|------|
| <2 km | %    | %    | %    | %    | %    | %    |
|       | 22   | 22.3 | 21.1 | 18.8 | 25.5 | 28.6 |

Table 4
Percentage distribution of journeys by mode of travel and distance < 2km, 2009 - 2019, Source: CSO, National Travel Survey [7].

|       | 2009 | 2012 | 2013 | 2014 | 2016 | 2019 |
|-------|------|------|------|------|------|------|
|       | %    | %    | %    | %    | %    | %    |
| Private car - Driver | 40  | 51.9 | 46.3 | 49.1 | 50.3 | 51.4 |

Table 5
Percentage distribution of journeys by mode of travel and distance 2–4 km, 2009–2019, Source: CSO, National Travel Survey [7].

|       | 2009 | 2012 | 2013 | 2014 | 2016 | 2019 |
|-------|------|------|------|------|------|------|
|       | %    | %    | %    | %    | %    | %    |
| Private car - Driver | 63.4 | 69.5 | 67.4 | 65.6 | 66.1 | 66.1 |

Table 6
Percentage distribution of journeys by mode of travel and distance 4–6 km, 2009–2019, Source: CSO, National Travel Survey [7].

|       | 2009 | 2012 | 2013 | 2014 | 2016 | 2019 |
|-------|------|------|------|------|------|------|
|       | %    | %    | %    | %    | %    | %    |
| Private car - Driver | 71.7 | 72.6 | 73.1 | 70.6 | 71.9 | 70.6 |

Table 7
Percentage distribution of journeys by mode of travel and distance 6–8 km, 2009–2019, Source: CSO, National Travel Survey [7].

|       | 2009 | 2012 | 2013 | 2014 | 2016 | 2019 |
|-------|------|------|------|------|------|------|
|       | %    | %    | %    | %    | %    | %    |
| Private car - Driver | 71.7 | 73.1 | 73.9 | 75.4 | 75.6 | 70.6 |
Table 8  
Percentage distribution of journeys by mode of travel and distance >8 km, 2009–2019, Source: CSO, National Travel Survey [7].

|          | 2009 | 2012 | 2013 | 2014 | 2016 | 2019 |
|----------|------|------|------|------|------|------|
| Private car - Driver | 74.0 | 79.7 | 79.3 | 78.3 | 80.2 | 71.9 |

Table 9  
Population, 2009–2019, Source: Eurostat [6].

|          | 2009  | 2012  | 2013  | 2014  | 2016  | 2019  |
|----------|-------|-------|-------|-------|-------|-------|
| Population | 4,521,000 | 4,589,000 | 4,610,000 | 4,638,000 | 4,726,000 | 4,904,000 |

Table 10  
Number of respondents, National Travel Survey, 2009–2019, Source: CSO, National Travel Survey [7].

|          | 2009 | 2012 | 2013 | 2014 | 2016 | 2019 |
|----------|------|------|------|------|------|------|
| Number of respondents | 7,221 | 14,759 | 14,759 | 10,382 | 11,027 | 8,400 |

Table 11  
Total journeys per person per day, National Travel Survey, 2009–2019, Source: CSO, National Travel Survey [7].

|          | 2009 | 2012 | 2013 | 2014 | 2016 | 2019 |
|----------|------|------|------|------|------|------|
| Number of journeys per day | 2.43 | 1.88 | 1.88 | 1.74 | 1.78 | 3     |

Table 12  
Total journeys per year total, National Travel Survey, 2009–2019, Source: CSO: National Travel Survey [7].

|          | 2009       | 2012       | 2013       | 2014       | 2016       | 2019       |
|----------|------------|------------|------------|------------|------------|------------|
| Number of journeys | 4,007,543,571 | 3,165,688,023 | 3,171,485,717 | 2,940,102,001 | 3,079,198,792 | 5,369,880,000 |

Table 13  
Private vehicle activity (vehicle kilometres, vkm), based on the Irish Car Stock Model, 2001–2018, Source:

|          | 2009       | 2012       | 2013       | 2014       | 2016       | 2019       |
|----------|------------|------------|------------|------------|------------|------------|
| vkm      | 32,873,713,915 | 29,535,056,173 | 31,821,299,194 | 32,323,075,433 | 36,171,159,701 | 36,195,324,272 |

Table 14  
Average journey distance by mode (vehicle kilometres), Source: CSO, National Travel Survey [7].

|          | 2009 vkm | 2012 vkm | 2013 vkm | 2014 vkm | 2016 vkm | 2019 vkm |
|----------|----------|----------|----------|----------|----------|----------|
| Private car - driver | 14 | 14.3 | 15.4 | 15.6 | 16.3 | 13.6 |

Table 15  
Weighting factor for distance based on mode, 2009–2019, calculation based on Eq. (1).

|          | 2009 | 2012 | 2013 | 2014 | 2016 | 2019 |
|----------|------|------|------|------|------|------|
| Private car - driver | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
### Table 16
Percentage distribution of journeys by reason of travel and distance <2 km, 2009 – 2019, Source: CSO, National Travel Survey.

|       | 2009 | 2012 | 2013 | 2014 | 2016 | 2019 |
|-------|------|------|------|------|------|------|
| Work  | 13   | 13.6 | 16.4 | 15.2 | 17.4 | 14.2 |

### Table 17
Percentage distribution of journeys by reason of travel and distance, 2–4 km, 2009–2019, Source: CSO, National Travel Survey [7].

|       | 2009 | 2012 | 2013 | 2014 | 2016 | 2019 |
|-------|------|------|------|------|------|------|
| Work  | 17.0 | 16.8 | 19.1 | 20.3 | 24.4 | 17.4 |

### Table 18
Percentage distribution of journeys by reason of travel and distance 4–6 km, 2009–2019, Source: CSO, National Travel Survey [7].

|       | 2009 | 2012 | 2013 | 2014 | 2016 | 2019 |
|-------|------|------|------|------|------|------|
| Work  | 23.0 | 18.9 | 22.5 | 21.8 | 27.3 | 22.1 |

### Table 19
Percentage distribution of journeys by reason of travel and distance 6–8 km, 2009–2019, Source: CSO, National Travel Survey [7].

|       | 2009 | 2012 | 2013 | 2014 | 2016 | 2019 |
|-------|------|------|------|------|------|------|
| Work  | 24.0 | 24.5 | 23.4 | 22.6 | 33.3 | 22.3 |

### Table 20
Percentage distribution of journeys by reason of travel and distance >8 km, 2009–2019, Source: CSO, National Travel Survey [7].

|       | 2009 | 2012 | 2013 | 2014 | 2016 | 2019 |
|-------|------|------|------|------|------|------|
| Work  | 37   | 32   | 21.8 | 33.4 | 38.1 | 31.4 |

### Table 21
Average journey distance by purpose of travel, 2009–2019 (kilometres), Source: CSO, National Travel Survey [7].

|       | 2009 |
|-------|------|
| Work  | 18   |

### Table 22
Reason for car journeys by percentage, based on average values from Dublin and rest of county as specified in Eq. (2).

|       | 2009 | 2012 | 2013 | 2014 | 2016 | 2019 |
|-------|------|------|------|------|------|------|
| Work  | 24.4 | 24.4 | 24.4 | 25.2 | 28.8 | 21.3 |

### Table 23
Reason for public transport journeys by percentage, based on average values from Dublin and rest of county as specified in Eq. (2).

| Reason for public transport journeys by percentage | 2009 | 2012 | 2013 | 2014 | 2016 | 2019 |
|-------------------------------------------------|------|------|------|------|------|------|
| Work                                           | 28.8 | 28.8 | 28.8 | 25.3 | 32.2 | 35.4 |
Table 24
Reason for walking/cycling journeys by percentage, based on average values from Dublin and rest of county as specified in Eq. (2).

|       | 2009 | 2012 | 2013 | 2014 | 2016 | 2019 |
|-------|------|------|------|------|------|------|
| Work  | 17.7 | 17.7 | 17.7 | 15.6 | 18.5 | 21.0 |

Table 25
Reason for Lorry/motorcycle/other journeys by percentage, based on average values from Dublin and rest of county as specified in Eq. (2).

|       | 2009 | 2012 | 2013 | 2014 | 2016 | 2019 |
|-------|------|------|------|------|------|------|
| Work  | 52.1 | 52.1 | 52.1 | 50.9 | 57.8 | 48.3 |

Table 26
Reason for journey (percentage), Source: Irish Car Stock Model [7].

| Reason for journey by percentage | 2009 | 2012 | 2013 | 2014 | 2016 | 2019 |
|----------------------------------|------|------|------|------|------|------|
| Work                             | 25   | 23.0 | 24.8 | 25.0 | 29.3 | 23.6 |

1.2. Irish car stock model V 2.4

The tables listed in the sheet "Irish Car Stock Model V2.4" are extracted from an open source model [4]. A Data in Brief article corresponding to elements of an earlier version of the Irish Car Stock Model is available [5]. The methodology behind the calculation of vehicle kilometres and fuel consumption of private vehicles in Ireland is based on a study on technology stock modelling of private cars in Ireland [14].

Table 27
Energy consumption of hybrid vehicles (Source: Irish Car Stock Model, [4,5]).

| Energy Consumption of Hybrid Vehicles | Year   | 2001 |
|--------------------------------------|--------|------|
| Engine size: < 1300cc                | MJ/100km | 1.45 |
| Engine size: 1300cc–1700cc           | MJ/100km | 1.45 |
| Engine size: > 1700cc                | MJ/100km | 2.73 |
| Diesel energy consumption            | MJ/100km | 1.87 |
| Diesel Energy consumption            | MJ/km   | 0.02 |
| Share of Petrol based energy consumption | %        | 0.60 |
| Share of Electricity based energy consumption | %      | 0.40 |
| Electrical Energy consumption of a Hybrid | MJ/km  | 0.02 |
| Total Energy consumption of a Hybrid | MJ/KM   | 0.04 |

Table 28
Energy Consumption of Plug in Hybrid (MJ/100km), Source: [5].

| Energy Consumption Plug in Hybrid | MJ/100km | 2001 |
|----------------------------------|----------|------|
| Share of Diesel based energy consumption | %      | 40%  |
| Share of Electricity based energy consumption | %  | 60%  |
| Average Diesel Plug in Hybrid    | (MJ/100km) | 1.06 |
| Diesel Plug in Hybrid            | (MJ/km)  | 0.01 |
| Electric                         | (MJ/km)  | 0.03 |
| Total                            |          | 0.04 |
**Table 29**  
Energy Consumption of Electric cars (MJ/km), Source: Irish Car Stock Model, [4,15]).

| Energy Consumption of Electric cars | 2001–2018         |
|-------------------------------------|--------------------|
|                                     | MJ/km              |
|                                     | 0.042222222        |

**Table 30**  
Energy Consumption of Hybrid vehicles (MJ/km), Source: [4]

|            | 2001               |
|------------|--------------------|
| Diesel     | MJ/KM              |
| Electric   | 0.0140             |
| Electric   | All                |
| Electric   | 0.0309             |

**Table 31**  
Energy Consumption of Electric cars (kWh/km), Source: Irish Car Stock Model, [4,14].

| Energy Consumption of Electric cars | 2001–2018  |
|-------------------------------------|------------|
|                                     | kWh/km     |
|                                     | 0.152      |

**Table 32**  
Energy Consumption of Plug-in Hybrids (kWh/km), Source: Irish Car Stock Model, [4,14].

| Energy Consumption of Plug in Hybrids | 2001–2018 | kWh/km |
|---------------------------------------|-----------|--------|
| Diesel                                | 0.0382364 |
| Electricity                           | 0.0912    |
| **Total**                             | 0.1294364 |

**Table 33**  
Energy consumption of Hybrid cars (kWh/km).

|            | 2001    | 2002    | 2003    | 2004    | 2005    | 2006    | 2007    | 2008    | 2009    | 2010    | 2011    | 2012    | 2013    | 2014    | 2015    | 2016    | 2017    | 2018    |
|------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| **kWh/km** | 0.050   | 0.050   | 0.050   | 0.048   | 0.054   | 0.059   | 0.062   | 0.063   | 0.069   | 0.068   | 0.067   | 0.067   | 0.067   | 0.067   | 0.067   | 0.067   | 0.067   | 0.067   |
| Diesel     |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |

**Table 34**  
On-road factors for diesel cars (factors), Source: Irish Car Stock Model, [4,16].

|            | 2001    | 2002    | 2003    | 2004    | 2005    | 2006    | 2007    | 2008    | 2009    | 2010    | 2011    | 2012    | 2013    | 2014    | 2015    | 2016    | 2017    | 2018    |
|------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| **On-road factor** | 0.13    | 0.13    | 0.13    | 0.13    | 0.12    | 0.14    | 0.16    | 0.17    | 0.2    | 0.25    | 0.27    | 0.33    | 0.39    | 0.41    | 0.42    | 0.42    | 0.42    |
1.3. Occupancy, energy consumption and emissions

Table 35
Occupancy Public Transport, based on passenger kilometres (Table 34) and Vehicle kilometres (Table 39).

| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|------|------|------|------|------|------|------|------|------|------|
| Dublin Bus (Urban Bus) | 27 | 21 | 21 | 27 | 31 | 31 | 20 | 20 | 34 |

Table 36
Passenger kilometres from Public Transport, based on passenger kilometres by mode (Table 71).

| Year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|------|------|------|------|------|------|------|------|------|------|------|------|
| pkm  | 1,657,005,445 | 1,249,888,239 | 1,214,931,149 | 1,536,441,904 | 1,765,668,627 | 1,777,305,989 | 1,160,134,746 | 1,195,332,290 | 1,962,684,829 |
| Dublin Bus (Urban Bus) |

Table 37
Multiplication of number of passengers serviced (Table 38) by public transport vehicle kilometres (Table 39).

| Year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|------|------|------|------|------|------|------|------|------|------|------|------|
| Non-unit factor | 7.2356E+15 | 6.9139E+15 | 6.4891E+15 | 6.2994E+15 | 6.2892E+15 | 6.8297E+15 | 7.1825E+15 | 7.9575E+15 | 7.9962E+15 |
| Dublin Bus (Urban Bus) |

Table 38
Number of passengers serviced by each public transport type.

| Year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|------|------|------|------|------|------|------|------|------|------|------|------|
| Number of passengers | 117,050,000 | 115,050,000 | 113,280,000 | 112,480,000 | 116,280,000 | 119,820,000 | 123,350,000 | 136,260,000 | 140,040,000 |
| Dublin Bus (Urban Bus) |
| Table 39 | Vehicle kilometres by public transport provider. |
|----------|-----------------------------------------------|
| Vehicle kilometres | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
| vkm | | | | | | | | | | | |
| Dublin Bus (Urban Bus) | 61,800,000 | 60,086,340 | 57,372,160 | 56,000,000 | 57,000,000 | 57,000,000 | 57,000,000 | 56,400,000 | 57,100,000 | |

| Table 40 | Diesel consumption per year Public Transport (kWh). |
|----------|--------------------------------------------------|
| kWh | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
| | | | | | | | | | | | |
| Dublin Bus (Urban Bus) | 318,229,000 | 305,663,000 | 284,767,000 | 278,385,000 | 279,911,000 | 280,847,000 | 279,405,000 | 280,716,000 | 267,592,000 | |

| Table 41 | Electricity consumption per year Public Transport (kWh). |
|----------|--------------------------------------------------|
| kWh | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
| | | | | | | | | | | | |
| Dublin Bus (Urban Bus) | 6,500,000 | 6,422,000 | 5,786,000 | 5,430,000 | 5,240,000 | 5,223,000 | 4,614,000 | 4,517,000 | 4,457,000 | |

| Table 42 | Natural Gas consumption per year Public Transport (kWh). |
|----------|--------------------------------------------------|
| kWh | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
| | | | | | | | | | | | |
| Dublin Bus (Urban Bus) | 11,850,000 | 8,791,000 | 8,900,000 | 9,229,000 | 8,563,000 | 10,508,000 | 11,489,000 | 9,997,000 | 11,111,000 | |

| Table 43 | CO₂ Emissions Intensity by fuel type (gCO₂/kWh) based on conversion factors from the Sustainable Energy Authority of Ireland [9]. |
|----------|--------------------------------------------------|
| gCO₂/kWh | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| Diesel | 263.9 | 263.9 | 263.9 | 263.9 | 263.9 | 263.9 | 263.9 | 263.9 | 263.9 | 263.9 |
Table 44
Energy Intensity per passenger kilometer by Fuel Type - Dublin Bus (kWh/km) calculated from fuel consumption (Table 40, Table 41, Table 42) And per passenger kilometres (Table 36).

|         | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---------|------|------|------|------|------|------|------|------|------|------|
| Diesel  | 0.1921 | 0.2446 | 0.2344 | 0.1812 | 0.1585 | 0.1580 | 0.2400 | 0.2348 | 0.1363 |

Table 45
Energy Intensity by Fuel Type - Bus Éireann (kWh/km) calculated from fuel consumption (Tables 40–42) and passenger kilometres (Table 36).

|         | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---------|------|------|------|------|------|------|------|------|------|
| Diesel  | 0.2585 | 0.3262 | 0.3161 | 0.2422 | 0.2215 | 0.2234 | 0.3301 | 0.3182 | 0.1724 |

Table 46
Energy Intensity by Fuel Type – Irish Rail (kWh/km) calculated from fuel consumption (Tables 40–42) and passenger kilometres (Table 36).

|         | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---------|------|------|------|------|------|------|------|------|------|------|
| Diesel  | 0.191 | 0.201 | 0.197 | 0.194 | 0.180 | 0.178 | 0.183 | 0.191 | 0.197 |

Table 47
Energy Intensity by Fuel Type – Luas (kWh/km) calculated from fuel consumption (Tables 40–42) and passenger kilometres (Table 36).

|         | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---------|------|------|------|------|------|------|------|------|------|
| Electricity | 0.0639 | 0.0485 | 0.0496 | 0.0481 | 0.0434 | 0.0457 | 0.0515 | 0.0454 | 0.0424 |

Table 48
CO₂ Emissions Intensity by Dublin Bus (gCO₂/km) based on calculation of energy intensity per passenger kilometer (Table 44) and CO₂ Emissions intensity by fuel type (Table 43).

|         | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---------|------|------|------|------|------|------|------|------|------|
| Diesel  | 50.68 | 64.54 | 61.86 | 47.82 | 41.84 | 41.70 | 63.33 | 61.98 | 35.98 |

Table 49
CO₂ Emissions Intensity of Bus Éireann (gCO₂/km) based on calculation of energy intensity per passenger kilometer (Table 45) and CO₂ emissions intensity by fuel type (Table 56).

|         | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---------|------|------|------|------|------|------|------|------|------|
| Diesel  | 68.22 | 86.09 | 83.42 | 63.92 | 58.45 | 58.95 | 87.10 | 83.98 | 45.49 |

Table 50
CO₂ Emissions Intensity of Irish Rail (gCO₂/km) based on calculation of energy intensity per passenger kilometer (Table 46) and CO₂ Emissions Intensity by fuel type (Table 43).

|         | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---------|------|------|------|------|------|------|------|------|------|
| Diesel  | 50.47 | 52.92 | 51.99 | 51.14 | 47.61 | 47.09 | 48.23 | 50.41 | 52.02 |
Table 51
CO₂ Emissions Intensity of the Luas (gCO₂/km) based on calculation of energy intensity per passenger kilometer (Table 47) and CO₂ Emissions intensity by fuel type (Table 44).

|           | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|-----------|------|------|------|------|------|------|------|------|------|
| Electricity | 40.63 | 25.71 | 24.24 | 25.49 | 20.30 | 20.78 | 23.92 | 21.81 | 18.51 |

Table 52
CO₂ Emissions Intensity of private vehicles by fuel type (gCO₂/km), source: Irish Car Stock Model. [4,14].

|         | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Diesel  | 179.35 | 180.07 | 182.36 | 185.70 | 184.62 | 182.36 | 179.44 | 175.76 | 174.56 | 174.49 | 173.71 | 172.36 | 173.48 |

Table 53
CO₂ Emissions Intensity of Electric vehicles by fuel type (gCO₂/km) calculated from CO₂ Emissions intensity of electricity (Table 43) and the energy intensity of electric vehicles (Table 31).

|         | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---------|------|------|------|------|------|------|------|------|------|------|
| Electricity | 96.58 | 96.58 | 80.53 | 74.33 | 70.66 | 73.02 | 66.36 |

Table 54
CO₂ Emissions Intensity of Plug in Hybrids by fuel type (gCO₂/km) calculated from CO₂ Emissions intensity of fuels (Table 43) and the energy intensity of Plug-in hybrid vehicles (Table 32).

|         | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---------|------|------|------|------|------|------|------|------|------|------|
| Electricity | 57.95 | 57.95 | 48.32 | 44.60 | 48.34 | 42.61 | 41.49 | 42.40 | 43.81 | 39.82 |

Table 55
CO₂ Emissions Intensity of Hybrids by fuel type (gCO₂/km) calculated from the CO₂ Emissions intensity of fuels and the energy intensity of hybrid vehicles (Table 30).

|         | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---------|------|------|------|------|------|------|------|------|------|------|
| Electricity | 38.63 | 38.63 | 32.21 | 29.73 | 32.22 | 28.41 | 27.66 | 28.27 | 29.21 | 26.55 |

Table 56
CO₂ Emissions Intensity of private vehicles by fuel type per passenger kilometer (gCO₂/pkm) based on CO₂ Emissions intensity per vehicle kilometer (Tables 52–55), and occupancy of private vehicles (Table 61).

|         | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---------|------|------|------|------|------|------|------|------|------|------|
| Diesel  | 120.4 | 120.9 | 122.4 | 122.7 | 121.9 | 124.6 | 125.4 | 123.9 | 122.4 | 120.4 |
Table 57
Energy intensity of private vehicles by fuel type (kWh/pkm).

|        | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|--------|------|------|------|------|------|------|------|------|------|------|
| Diesel | 0.456| 0.458| 0.464| 0.465| 0.462| 0.472| 0.474| 0.470| 0.464| 0.456|

Table 58
Synthesized CO₂ Emissions intensity by mode type (gCO₂/pkm) based on the CO₂ Emissions intensity of cars (Table 56) and public transport (Tables 48–51).

|        | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|--------|------|------|------|------|------|------|------|------|------|------|------|
| Private car –Driver | 121.7 | 122.2 | 123.2 | 123.3 | 122.8 | 124.1 | 124.1 | 122.5 | 121.2 | 119.5 | 119.5 |

1.4. Passenger kilometre calculation assumptionsa

Table 59
Average distance by kilometer grouping for mode types.

|        | 2009  | 2012  | 2013  | 2014  | 2016  | 2019  |
|--------|-------|-------|-------|-------|-------|-------|
| km     | km    | km    | km    | km    | km    | km    |
| <2 km  | 1     | 1     | 1     | 1     | 1     | 1     |

Table 60
Private vehicle kilometres from the Car Stock Model.

|        | 2009         | 2012         | 2013         | 2014         | 2016         | 2019         |
|--------|--------------|--------------|--------------|--------------|--------------|--------------|
| vkm    | 32,873,713,915 | 29,535,056,173 | 31,821,299,194 | 32,323,075,433 | 36,171,159,701 | 36,195,324,272 |

Table 61
Private vehicle occupancy rates.

|        | 2009–2019 |
|--------|-----------|
| People | 1.49      |

Table 62
Private vehicle passenger kilometres from the Irish Car Stock Model [4,8].

|        | 2009         |
|--------|--------------|
| pkm    | 48,981,833,733 |
Table 63
Average distance by kilometre grouping for trip purpose.

|        | 2009 km | 2012 km | 2013 km | 2014 km | 2016 km | 2019 km |
|--------|---------|---------|---------|---------|---------|---------|
| <2 km  | 1       | 1       | 1       | 1       | 1       | 1       |

Table 64
Adjustment factor for distance based on trip purpose.

|        | 2009 | 2012 | 2013 | 2014 | 2016 | 2019 |
|--------|------|------|------|------|------|------|
| Work   | 1    | 1    | 1    | 1    | 1    | 1    |
| Education | 0.888888889 | 0.888888889 | 0.888888889 | 0.888888889 | 0.888888889 | 0.888888889 |

Table 65
Vehicle Kilometres by fuel type of private cars (km).

| Fuel Type     | 2001         |
|---------------|--------------|
| PETROL        | 20,379,511,457 |
| DIESEL        | 4,721,440,677  |
| HYBRID        | -            |
| PLUGIN        | -            |
| ELECTRIC      | -            |
| Private Vehicle | 25,100,952,134 |

Table 66
Number of journeys by trip purpose, calculated by Table 22, reason of journeys by percentage and total journeys per year, Table 12.

|        | 2009          | 2012          | 2013          | 2014          | 2016          | 2019          |
|--------|---------------|---------------|---------------|---------------|---------------|---------------|
| Number of journeys |               |               |               |               |               |               |
| Work   | 1,001,885,893 | 728,108,245   | 786,528,458   | 735,025,500   | 902,205,246   | 1,267,291,680 |

Table 67
Average distance of journeys by trip purpose, calculated by dividing Table 66: Number of journeys by trip purpose by Table 72: Interpolation of Passenger Kilometres by trip purpose.

| Average distance of journeys by trip purpose | 2009 % | 2012 % | 2013 % | 2014 % | 2016 % | 2019 % |
|---------------------------------------------|-------|-------|-------|-------|-------|-------|
| Work                                       | 21.3  | 21.7  | 15.5  | 25.3  | 25.9  | 15.4  |
1.5. Passenger Kilometres by distance and mode

**Table 68**
Sample row entry from Passenger kilometres by trip distance and mode type with additional reference row for Table references within the Data in Brief.

| Title | Value description | Unit | Value | Data in Brief reference |
|-------|-------------------|------|-------|-------------------------|
| Passenger kilometres by trip distance and mode type | Year | | 2009 | |
| | Trip distance | km | <2 km | |
| | Mode Type | | Private car - Driver | |
| | Decimal distribution of journey distance for all regions, 2009–2019 | % | 22 | Table 3 |
| | Distribution of journeys by mode of travel and distance < 2 km, 2009–2019 | % | 40 | Table 4 |
| | Distribution of journeys by mode of travel and distance 2–4 km, 2009–2019 | % | 0 | Table 5 |
| | Distribution of journeys by mode of travel and distance 4–6 km, 2009–2019 | % | 0 | Table 6 |
| | Distribution of journeys by mode of travel and distance 6–8 km, 2009–2019 | % | 0 | Table 7 |
| | Distribution of journeys by mode of travel and distance >8 km, 2009–2019 | % | 0 | Table 8 |
| Average Journey Length | km | | 1.00 | Table 14 |
| Mode distance adjustment factor | | | 1.00 | Table 15 |
| Number of journeys | | | 4,007,543,571 | Table 12 |
| Total Passenger Kilometres for the journey grouping | pkm | | 352,663,834 | Calculation based on Eq. (4). |
| Total Vehicle Kilometres (for that year) | vkm | | 32,873,713,915 | Table 13 |

1.6. Passenger kilometres by distance and purpose

**Table 69**
Sample entry row passenger kilometres by trip distance and purpose with additional reference row for Table references within the Data in Brief.

| Title | Value description | Unit | Value | Data in Brief reference |
|-------|-------------------|------|-------|-------------------------|
| Passenger kilometres by distance and trip purpose | Year | | 2009 | |
| | Trip distance | km | <2 km | |
| | Trip purpose | | Work | |
| | Distribution of journey distance for all regions, 2009–2019 | % | 22 | Table 3 |
| | Distribution of journeys by mode of travel and distance < 2 km, 2009–2019 | % | 13 | Table 16 |
| | Distribution of journeys by purpose of travel and distance 2–4 km, 2009–2019 | % | 0 | Table 17 |
| | Distribution of journeys by purpose of travel and distance 4–6 km, 2009–2019 | % | 0 | Table 18 |
| | Distribution of journeys by purpose of travel and distance 6–8 km, 2009–2019 | % | 0 | Table 19 |
| | Distribution of journeys by purpose of travel and distance >8 km, 2009–2019 | % | 0 | Table 20 |
| Average Journey Length | | | 1.00 | Table 21 |
| Trip purpose distance adjustment factor | | | 1.00 | Table 64 |
| Number of journeys | | | 4,007,543,571 | Table 12 |
| Total Passenger Kilometres | | | 114,615,746 | Calculation based on Eq. (3). |
| Total Vehicle Kilometres | | | 32,873,713,915 | Table 13 |
1.7. Emissions by trip mode, purpose, and distance

Table 70
Sample entry row of emissions by trip mode, purpose, and distance with additional reference row for Table references within the Data in Brief.

| Title | Value description | Unit | Value | Data in Brief reference |
|-------|-------------------|------|-------|-------------------------|
| Passenger kilometres by mode type, trip purpose and distance | Year | | 2009 | |
| | Mode Type | | Private car - Driver | |
| | Purpose | | Work | |
| | Trip Distance | | <2 km | |
| | Passenger Kilometres for that mode type across all purpose | | 41,186,265,415 | |
| | Percentage of journeys by trip purpose | | | 24 | % |
| | Passenger Kilometres by purpose and mode type | | | 10,028,855,628 | pkm |
| Average distance based on mode type | | Km | 1 | |
| Average distance based on trip purpose type | | Km | | Table 59 |
| Average distance based on trip purpose and mode type | | Km | 1 | |
| Distance weighting | | | 0.02108148 | |
| Calibration factor | | | 1 | |
| Passenger Kilometres by distance category, mode type and trip purpose | | Pkm | 211423118.6 | |
| % Pkm for that year by distance, mode type and trip purpose category | | | 0.003464316 | % |
| CO₂ Emissions intensity by mode type | | gCO₂/pkm | 121.68 | |
| Emissions from category | | gCO₂ | 25726686424 | |
| Emissions from category | | MTCO₂ | 0.025726886 | |

1.8. Passenger kilometre tables

Table 71
Interpolation of Passenger Kilometres by mode type (2009–2019).

| 2009 | |
|------|------|
| Bus | 2,807,733,663 |
| Cycle | 223,983,168 |
| Lorry/Motorcycle/Other | 5,875,413,924 |
| Private car - Driver | 41,186,265,415 |
| Private car - Passenger | 7,789,254,560 |
| Rail/Dart/Luas | 2,755,466,733 |
| Taxi/hackney | - |
| Walk | 157,552,740 |
| Total | 60,795,670,202 |
Table 72
Interpolation of Passenger Kilometres by trip purpose.

| Purpose                        | Value                  |
|--------------------------------|------------------------|
| Companion / escort journey     | 4,912,442,902          |
| Education                      | 2,294,831,660          |
| Entertainment / leisure / sports| 3,875,062,196          |
| Other                          | 5,507,218,474          |
| Personal business              | 4,968,776,942          |
| Shopping                       | 10,147,549,168         |
| To eat or drink                | 736,414,184            |
| Visit family / friends         | 7,027,564,286          |
| Work                           | 21,336,198,042         |
| Total                          | 60,806,057,855         |

Table 73
Interpolation of passenger kilometres by trip distance.

| Distance | Value                  |
|----------|------------------------|
| <2 km    | 1,281,662,701          |
| 2-4 km   | 3,844,988,102          |
| 4-6 km   | 6,408,313,503          |
| 6-8 km   | 8,971,638,904          |
| 8+ km    | 40,289,066,993         |
| Total    | 60,795,670,202         |

1.9. Emissions intensity

Table 74
Sample row from Emissions Intensity Table, with Table references for each entry.

| Title                  | Value description                  | Unit          | Value             | Data in Brief reference |
|------------------------|------------------------------------|---------------|-------------------|-------------------------|
| Emissions intensity    | Year                               | 2010          | Mass transport    | Tables 60, 39           |
|                        | Mode                               | Irish Rail (Heavy Rail) |                  |                         |
|                        | Fuel Type                          | Diesel        |                   |                         |
|                        | Vehicle Kilometres                 | vkm           | 15,950,000        |                         |
|                        | Occupancy                          | vkm/pkm       | 152.8             | Tables 35, 61           |
|                        | Passenger Kilometres               | km            | 2,436,460,870     | Table 36,               |
|                        | CO₂ Emissions Intensity            | gCO₂/pkm      | 50.47378412       | Tables 48–53            |
|                        | Total CO₂ Emissions                | gCO₂          | 122,977,400,000   | Calculation based on Eq. (10) |
|                        | Total CO₂ Emissions                | MTCO₂         | 0.12              |                         |
|                        | Energy Intensity                   | kWh/100pkm    | 19.13             | Tabled 45–47, 57, Eq. (10) |
|                        | Energy Consumption                 | kWh           | 466,000,000       | Calculation based on Eq. (8) |
|                        | Energy Consumption (MWH)            | MWh           | 466,000           |                         |
1.10. Emissions tables

**Table 75**
Total emissions by trip purpose (MTCO₂).

| Purpose                        | 2009   |
|--------------------------------|--------|
| Companion/Escort Journey       | 1.08   |
| Education                      | 0.21   |
| Entertainment/leisure/sports   | 0.47   |
| Other                          | 0.21   |
| Personal Business              | 0.40   |
| Shopping                       | 1.39   |
| To eat or drink                | 0.08   |
| Visit family/friends           | 0.67   |
| Work                           | 1.45   |
| Grand Total                    | 5.96   |

**Table 76**
Emissions by trip distance category (MTCO₂).

| Distance Category | 2009   |
|-------------------|--------|
| <2 km             | 0.125635|
| 2–4 km            | 0.376906|
| 4–6 km            | 0.628176|
| 6–8 km            | 0.879447|
| 8+ km             | 3.949344|

**Table 77**
Emissions by mode type (MTCO₂).

|       | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|-------|------|------|------|------|------|------|------|------|------|------|------|
| Bus   | 0.00 | 0.05 | 0.11 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 |

2. Experimental Design, Materials and Methods

This section will discuss the methods used to acquire the secondary data and calculate the primary data used in the IPTEM V2.9 spreadsheet.

2.1. Acquisition of secondary data

This section outlines the steps required to acquire, process, and analyse the data referenced in this article.

The National Travel Survey conducted by the CSO [7] forms a key source of secondary data for the “CSO Tables” sheet in IPTEM V2.9. The data was extracted from the interactive data tool available from the Central Statistics Office [3].

The open-source Irish Car Stock Model formed the basis of on the secondary data included in the “Irish Car Stock Model V2.4” spreadsheet [4]. The Irish Car Stock Model as described in Daly and Ó Gallachóir develops a picture of private car energy demand in Ireland [8]. The study documents the method and data needed to create a bottom-up private vehicle technology stock for Ireland. A Data in Brief corresponding to the Irish Car Stock Model is available [5].
Figures for the energy consumption, vehicle kilometres and passenger numbers for public transport operators in Ireland were extracted manually from Annual Reports by Luas [13], Bus Éireann [12], Irish Rail [11], and Dublin Bus [10]. These figures were referred to in “Occupancy, Energy Consumption and Emissions” sheet.

2.2. Equations for primary data

In this section, equations for the calculation of the primary data listed in the IPTEM V2.9 model are defined. The equations are previously referenced in the Data Description section as the method used to calculate values in table entries.

The CSO distance categorization does not account for mode types that typically service distances on the shorter end of the distance grouping. Distance weighting factors based on mode are calculated by comparing average distance travelled by that mode with the “Private car – driver” mode as shown in (xxx).

Eq. (1): Distance weighting

\[
\text{Distance Weighting}_{mode, year} = \frac{\text{Average distance of all journeys}_{mode, year}}{\text{Average distance for private car – driver}_{year}}
\]

The distribution of journeys by distance is recorded by the National Travel Survey over the period of 2009–2019.

Average values for reasons of journeys by mode type are based on aggregate values from Dublin and the rest of the country. As approximately 1 in 4 people in Ireland are Dublin based, a weighting of 0.25 is given to the Dublin statistics, and a weighting of 0.75 is given to the rest-of-country figures. The equation for this is outlined below:

Eq. (2): Average value for reason of journey by mode type

\[
\text{Average reason of journey by mode type} = 0.25(\% \text{ Reason for journey by mode type}_{\text{Dublin}}) + 0.75(\% \text{ Reason for journey by mode type}_{\text{Rest of Country}})
\]

Total Passenger Kilometres for a given distance and mode category is calculated as a function of the share of journeys by distance and the share of journeys that are of that mode type, then applying the average distance by the kilometer grouping and applying weighting factors based on the mode type as calculated in Eq. (1).

Eq. (3): Total Passenger Kilometres

\[
\text{Total Pkm by distance and mode category} = \% \text{ distribution of journey distance} \times \text{Percentage of journeys}_{mode} \times \text{average distance by distance grouping}_{mode} \times \text{weighting factor}_{mode} \times \text{number of journeys}
\]

Passenger kilometres for the intermittent years that were not surveyed (2010, 2011, 2015, 2017, 2018) are interpolated.

To calculate total passenger kilometres by distance and trip purpose, the method used in Distance weighting factors based on trip mode are applied to adjust the average distance calculated to reflect the average journey lengths given for a given trip mode [1]. Weighting factors based on trip purpose are also applied and calculated by comparing the average distance of journeys by trip purpose.

Passenger kilometres by trip purpose was calculated as shown in Eq. (4).
Eq. (4): Passenger kilometres by trip purpose

\[
\text{Passenger kilometres by trip purpose} = \text{percentage distribution of journey distance} \\
\times \text{percentage distribution of journeys by trip purpose and distance} \\
\times \text{average distance by kilometre grouping for trip purpose} \\
\times \text{adjustment factor based on trip purpose} \times \text{total number of journeys}
\]

Weighting factors based on trip purpose are also applied to adjust the average distance calculated to capture the varying average journey lengths for certain trip purposes [1]. Only figures from 2009 are available as average distances based on trip purpose are given from the 2009 National Travel Survey.

Average distance based on trip purpose and mode type is based on the average distance based on trip purpose type (Table 21) and average distance based on mode type (Table 59). As the average distance based on trip purpose is only calculated from the 2009 National Travel Survey, these figures are used for all journeys up to 2019.

Eq. (5): Average distance based on trip purpose and mode type

\[
\text{Average distance based on trip purpose and mode type} = \frac{\text{Average distance}_{\text{trip purpose}} + \text{Average distance}_{\text{mode type}}}{2}
\]

The share of passenger kilometres for that year by distance, mode type and trip purpose, as listed in Table 69: Sample entry row passenger kilometres by trip distance and purpose with additional reference row for Table references within the Data in Brief. The share is based on comparing the passenger kilometres from the listed mode type, trip purpose and distance entry to the entire passenger kilometres calculated for that year.

Eq. (6): Share of passenger kilometres by distance, mode and trip purpose

\[
\text{% Pkm for that year by distance, mode and trip purpose} = \frac{\text{Passenger kilometres by distance, mode, trip purpose}}{\text{Total Passenger Kilometres}}
\]

The energy intensity of each mode type per passenger kilometre (Pkm) was calculated as follows in Eq. (7).

Eq. (7): Energy Intensity of mode type per passenger kilometre

\[
\text{Energy Intensity} \left( \frac{\text{kWh}}{\text{Pkm}} \right) = \frac{\text{Energy Intensity per kWh}_{\text{f,t}} \times \text{Energy Consumption per year}_{\text{f,t}}}{\text{Pkm}_{\text{t}}}
\]

Where:
- \( f \) is the fuel type
- \( t \) represents the transit provider.

Energy consumption of a given journey type by mode, trip purpose or trip distance is calculated as a function of the mode type's energy intensity and the passenger kilometres serviced by the journey's passenger kilometres for the specified trip purpose, distance, and mode.

Eq. (8): Energy Consumption of a given journey purpose, distance and mode

\[
\text{Energy Consumption}_{\text{purpose, distance, mode}} = \text{Energy Intensity}_{\text{mode}} \left( \frac{\text{kWh}}{\text{Pkm}} \right) \times \text{Passenger Kilometres}_{\text{purpose, distance, mode}} \text{ (Pkm)}
\]
The CO₂ emissions intensity of each mode type per passenger kilometre (Pkm) was then calculated as follows:

Eq. (9): CO₂ Emissions Intensity per passenger kilometre by mode type

\[ \text{CO₂ Emissions Intensity (gCO₂ pkm)} = \frac{\text{CO₂ emissions intensity per kW} \times \text{Energy consumption per year}}{\text{Pkm}_t} \]

Where:
- \( f \) is the fuel type
- \( t \) represents the transit provider.

CO₂ emissions intensity per kWh were based on the Sustainable Energy Authority of Ireland conversion rates [9].

Annual energy consumption values for private vehicles were derived from the Irish Car Stock Model [4], annual energy consumption values for bus, heavy rail and light rail were derived from national public transport annual reports [10–13].

Total CO₂ emissions (Table 75) is calculated as a function of the passenger kilometres by the given mode type, trip purpose and trip distance and the CO₂ emissions intensity of the given mode type, trip purpose and passenger kilometre category (Tables 48–51).

The equation for total CO₂ emissions is outlined in Eq. (10).

Eq. (10): Total Emissions by journey mode type, trip purpose or journey distance

\[ \text{TotalCO₂ Emissions (gCO₂)} = \text{Emissions Intensity (gCO₂ pkm)} \times \text{Passenger Kilometres (pkm)} \]

**Ethics statements**

The authors have no conflicts of interest to declare. Ethics approval was not required for this data in brief.

**Declaration of Competing Interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

**Data Availability**

IPTEM V2.9 (Original data) (Zenodo).

**CRediT Author Statement**

**Vera O’Riordan:** Conceptualization, Methodology, Data curation, Writing – original draft; **Fionn Rogan:** Supervision, Writing – review & editing; **Tomás Mac Uidhir:** Writing – review & editing; **Hannah Daly:** Supervision, Writing – review & editing.

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Supplementary Materials

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