Move-NZ: Comparing Travel Mode Shifts for Education and Work in New Zealand (2018-2023)

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Contents

Introduction

Travel behaviour is a core input to transport planning because it shapes network demand, congestion, emissions, safety exposure, and public-transport viability. In New Zealand, the COVID-19 period accelerated changes in where and how people participate in work and education, including increased work-from-home and study-from-home arrangements and shifts in commuting patterns. However, it remains an empirical question whether these changes affected **Journey to Education** and **Journey to Work** in similar ways, and whether the magnitude and composition of change differed across sub-populations and places.

Move-NZ is a reproducible, data-driven analysis of travel mode change between the **2018 and 2023 Censuses**, using Statistics New Zealand (Stats NZ) aggregated Census tables for Main means of travel to

education and Main means of travel to work. The central purpose is to quantify **how travel mode composition changed over time within each journey type**, and to test whether the **time-based shifts differ between education and work journeys**. The analysis is designed to produce interpretable outputs (national shares and percentage-point changes) while also providing formal statistical evidence to support policy-relevant conclusions.

Research questions

This report addresses three linked questions:

1. **Within-journey change (2018 -> 2023):**
   Did the distribution of travel modes change over time for Journey to Education, and separately for Journey to Work?
2. **Between-journey differences (within year):**
   Within each census year, do education and work journeys exhibit different travel mode distributions?
3. **Difference in shifts (interaction question):**
   Are the changes over time statistically different between education and work (i.e., is there a Year × Journey Type interaction in travel behaviour)?

Data scope and analytical design

The study uses publicly available Stats NZ data disaggregated by **geography (SA2 as the primary unit, with region and district retained), age group, gender, census year, and travel mode**. Because the Census tables are published as aggregated counts and are subject to confidentiality protection, Move-NZ includes explicit steps to ensure analytical validity and comparability across datasets. In particular, travel modes are harmonised into five policy-relevant categories used consistently throughout the report:

- Private Transport
- Public Transport
- Active Transport
- At home
- Other Transport

These harmonised categories support transparent communication of results and allow direct comparison between education and work journeys across both Census years.

Overview of methodology and report structure

This R Markdown document contains the complete end-to-end workflow for Move-NZ:

- **Section 1** documents data access, download filters, governance, and ethics/privacy considerations, including the use of aggregated anonymised counts and Stats NZ confidentiality protection.
- **Sections 2 to 4** ingest and merge the many downloaded files, extract region/district identifiers from file names, reconstruct suppressed gender values using published totals where required, and standardise both datasets into a common analytical schema before combining them.

- **Section 5** provides national descriptive results: mode shares for each year and journey type, percentage-point changes from 2018 to 2023, and a descriptive difference-in-differences comparison.
- **Section 6** applies Pearson chi-square tests of homogeneity to formally test time-based change within journey types and compositional differences between journey types within each year, complemented by **Cramér's V** to assess practical magnitude.
- **Section 7** fits a multinomial logistic regression with a Year × Journey Type interaction and uses a likelihood-ratio test to directly answer whether the shifts differ between education and work, followed by model-based percentage-point changes to aid interpretation.
- **Sections 8 & 9** extend the framework to regions and sub-populations (urban vs non-urban grouping, gender, age groups), and identify "drivers of change" using both composition shifts (pp change) and volume contributions (Δ counts).

Overall, Move-NZ is designed to balance **reproducibility, statistical rigour, and interpretability**, producing results that can be used to discuss national change as well as heterogeneity across regions and population groups, with a clear comparison between education and work travel behaviour.

Setup and package loading

This section configures the document for reproducible analysis and loads the core R packages required throughout the Move-NZ pipeline.

```
library(dplyr)
library(tools)
library(tidyr)
library(nnet)
library(janitor)
library(rcompanion)
library(pander)
```

Methodology

1. Data description, access, and governance

This section describes the Census datasets used in the study, including their structure, scope, download procedures, and governance considerations. It documents how the data were accessed, filtered, and prepared prior to analysis, and outlines relevant ethical, privacy, and Māori data considerations.

1.1 Data sources and scope

This study uses publicly available aggregate Census data published by Statistics New Zealand (Stats NZ), drawn from the following datasets:

- **Main means of travel to education, age, and gender for the census usually resident population who are studying, (RC, TALB, SA2, Health), 2018 and 2023 Censuses**
- **Main means of travel to work, total personal income, age, and gender for the employed census usually resident population count aged 15 years and over, (RC, TALB, SA2, Health), 2013, 2018, and 2023 Censuses**

The data describe the census usually resident population who are studying (education dataset) or employed (work dataset), disaggregated by travel mode, age group, gender, and geography.

Data are provided at multiple geographic levels. This analysis uses **Statistical Area 2 (SA2)** as the primary unit of analysis, with region and district (territorial authority) identifiers retained for aggregation and comparison. SA2s are small geographic units designed to represent communities of approximately 2,000–4,000 people and provide a consistent spatial resolution for sub-regional analysis across New Zealand.

The datasets include aggregated counts only; no individual-level or unit-record data are available.

1.2 Data access and download procedure

Data were downloaded from the **Stats NZ** website using the table selection interface under the *Transport* category of the Census data catalogue.

For each journey type (**Journey to Education** and **Journey to Work**), Census data for both the **2018 and 2023 waves were downloaded simultaneously**. Data were extracted at the SA2 level using the option **"Total – New Zealand by territorial authority and Auckland local board/SA2"**. For each territorial authority or city, all corresponding SA2 units were selected and downloaded as separate files.

Downloaded files were named using a consistent convention of `<Region>_<District/City>`. Region and district identifiers were subsequently extracted from file names and added as explicit variables during data preparation.

The *Journey to Education* dataset was downloaded in **November 2025**, while the *Journey to Work* dataset was downloaded in **January 2026**. These access dates are reported to ensure transparency and reproducibility, recognising that metadata, classifications, and availability conditions may change over time.

1.3 Download filters and selection criteria

To ensure mutually exclusive, non-overlapping counts suitable for aggregation and statistical analysis, specific filters were applied at the download stage.

1.3.1 Education dataset For the *Journey to Education* dataset:

- Under **Age**, the options "Total – age" and "Median – age" were excluded. Only broad age-group categories relevant to compulsory education (e.g., "Under 15 years") were selected, while finer subgroups (e.g., 0–4, 5–9, 10–14) were excluded.
- Under **Main means of travel to education**, the options "Total – main means of travel to education", "Total stated – main means of travel to education", and "Not elsewhere included" were excluded.
- Under **Gender**, the option "Total – gender" was included alongside disaggregated gender categories. This total was retained to support reconstruction of suppressed values for the residual "Another" gender category during data preparation.

1.3.2 Work dataset For the *Journey to Work* dataset:

- Under **Census year**, the 2013 Census was excluded; only the 2018 and 2023 Census waves were selected.
- Under **Total personal income**, only the aggregate "Total – total personal income" option was selected, and all sub-categories were deselected, as income was not used in subsequent analyses.
- Under **Age**, the options "Total – age" and "Median – age" were excluded.
- Under **Main means of travel to work**, the options "Total – main means of travel", "Total stated – main means of travel", and "Not elsewhere included" were excluded.

- Under **Gender**, the option "Total – gender" was included to support reconstruction of suppressed gender values during data preparation.

Across both datasets, total-category filter options were excluded wherever they would generate duplicate aggregate rows. Retaining such totals would have resulted in double-counting and inflation of counts when aggregating across categories.

1.4 Data preparation and harmonisation (overview)

Following download, datasets were merged, cleaned, and harmonised to ensure comparability between education and work journeys. This included:

- standardising geographic identifiers (region, district, SA2);
- harmonising travel mode categories across datasets;
- reconstructing suppressed gender counts using published totals;
- encoding structurally empty category–geography combinations as zero counts;
- removing redundant total rows to prevent double-counting.

No statistical imputation was performed. All transformations were applied to published aggregate counts only and are described in detail in the accompanying code sections.

1.5 Ethics, privacy, and Māori data considerations

This study uses publicly available secondary data released by Statistics New Zealand. The datasets consist solely of aggregated, anonymised Census counts and contain no personal, identifiable, or unit-record information. All data were released in accordance with the *Data and Statistics Act 2022* and the *Privacy Act 2020*, with confidentiality protection applied by Stats NZ through suppression and fixed random rounding.

As no individual-level data were accessed and re-identification of individuals is not possible, formal human ethics approval was not required for this study.

The datasets include population counts for Māori and non-Māori individuals as part of the national Census. Stats NZ notes that Census data should be used in ways that avoid harm and support positive outcomes, consistent with the principles outlined in the *Māori Data Governance Model*. In this study, Māori data are analysed only in their published, aggregate form, with no inference made at the individual, whānau, hapū, or iwi level.

In the original Census tables, gender categories were provided using bilingual English–te reo Māori labels. For analytical clarity and consistency across datasets, these labels were harmonised into a single set of standardised gender categories during data preparation. This step involved label standardisation only; no Māori-specific counts were removed, altered, or reclassified beyond published aggregate values.

2. Load individual data files, merge, and reconstruct gender values

2.1 Education data

The Journey to Education data are provided as multiple CSV files, each corresponding to a specific Region–District combination. To support scalable and reproducible processing, Move-NZ defines a dedicated function to ingest and clean these files.

This function:

- Iterates over all education CSV files in a directory

- Extracts Region and District information from file names
- Removes structural and metadata fields not required for analysis
- Replaces missing observation values with zeros to ensure safe aggregation
- Reconstructs the "Another gender" category where it is suppressed, using:
  Another = Total − Male − Female

The reconstruction is performed within consistent census groupings (year, SA2, travel mode, age group) and constrained to be non-negative. All Total gender rows are removed after reconstruction, ensuring that only disaggregated gender categories remain.

The output is a single, cleaned education dataset written to disk and returned invisibly for downstream use within Move-NZ.

```
merge_edu_data_files <- function(files_dir, output_file) {

  files <- list.files(files_dir, pattern = "\\.csv$", full.names = TRUE)

  final_data <- tibble()

  for (file in files) {

    file_name <- tools::file_path_sans_ext(basename(file))
    parts <- strsplit(file_name, "_")[[1]]

    region   <- parts[1]
    district <- parts[2]

    raw_data <- read.csv(file)

    delete_columns <- c(
      "STRUCTURE", "STRUCTURE_ID", "STRUCTURE_NAME", "ACTION",
      "CEN23_YEAR_001", "Observation.Value", "OBS_STATUS", "Observation.Status"
    )

    clean_data <- raw_data %>%
      select(-any_of(delete_columns)) %>%
      mutate(
        Region   = region,
        District = district,
        OBS_VALUE = coalesce(OBS_VALUE, 0)  # replace NA with 0
      )

    # 1) Summarise gender totals per group (handles missing genders & duplicates)
    gender_sums <- clean_data %>%
      group_by(Census.year, CEN23_GEO_002, CEN23_TED_002, CEN23_AGE_003) %>%
      summarise(
        male   = sum(OBS_VALUE[CEN23_GEN_002 == 1],  na.rm = TRUE),
        female = sum(OBS_VALUE[CEN23_GEN_002 == 2],  na.rm = TRUE),
        total  = sum(OBS_VALUE[CEN23_GEN_002 == 99], na.rm = TRUE),
        .groups = "drop"
      )
```

```
    # 2) Join back and compute "Another" (gender 3), then remove total row (99)
    clean_data_filled <- clean_data %>%
      left_join(
        gender_sums,
        by = c("Census.year", "CEN23_GEO_002", "CEN23_TED_002", "CEN23_AGE_003")
      ) %>%
      mutate(
        OBS_VALUE = if_else(
          CEN23_GEN_002 == 3,
          pmax(total - male - female, 0),
          OBS_VALUE
        )
      ) %>%
      select(-male, -female, -total) %>%
      filter(CEN23_GEN_002 != 99)

    # append the corrected data (NOT the original clean_data)
    final_data <- bind_rows(final_data, clean_data_filled)
  }

  final_data_sorted <- final_data %>%
    arrange(
      Census.year,
      CEN23_GEO_002,
      CEN23_TED_002,
      CEN23_AGE_003,
      CEN23_GEN_002
    )

  write.csv(final_data_sorted, output_file, row.names = FALSE)

  invisible(final_data_sorted)
}
```

2.2 Work data

The Journey to Work dataset requires additional handling due to confidentiality suppression indicated by the `Observation.Status` field.

Move-NZ applies a more nuanced reconstruction strategy for work data, which:

- Identifies which gender category has been suppressed
- Reconstructs only the suppressed gender, rather than overwriting valid observations
- Preserves reported values where they exist
- Ensures reconstructed values are consistent with reported totals

Once reconstruction is complete, Total gender rows and the confidentiality flag column are removed, yielding a clean and analysis-ready Journey to Work dataset aligned with the education data structure.

```r
merge_work_data_files <- function(files_dir, output_file) {

  files <- list.files(files_dir, pattern = "\\.csv$", full.names = TRUE)
  final_data <- tibble()

  for (file in files) {

    file_name <- tools::file_path_sans_ext(basename(file))
    parts <- strsplit(file_name, "_")[[1]]

    region   <- parts[1]
    district <- parts[2]

    raw_data <- read.csv(file)

    delete_columns <- c(
      "STRUCTURE", "STRUCTURE_ID", "STRUCTURE_NAME", "ACTION",
      "CEN23_YEAR_001", "CEN23_TOI_003", "Total.personal.income",
      "Observation.Value", "OBS_STATUS"
    )

    clean_data <- raw_data %>%
      select(-any_of(delete_columns)) %>%
      mutate(
        Region   = region,
        District = district
      )

    gender_info <- clean_data %>%
      group_by(Census.year, CEN23_GEO_002, CEN23_TWO_002, CEN23_AGE_008) %>%
      summarise(
        male_calc    = sum(coalesce(OBS_VALUE[CEN23_GEN_002 == 1],  0)),
        female_calc  = sum(coalesce(OBS_VALUE[CEN23_GEN_002 == 2],  0)),
        another_calc = sum(coalesce(OBS_VALUE[CEN23_GEN_002 == 3],  0)),
        total_calc   = sum(coalesce(OBS_VALUE[CEN23_GEN_002 == 99], 0)),

        male_conf_na = any(CEN23_GEN_002 == 1 & is.na(OBS_VALUE)
                           & Observation.Status == "Confidential"),
        female_conf_na = any(CEN23_GEN_002 == 2 & is.na(OBS_VALUE)
                             & Observation.Status == "Confidential"),
        .groups = "drop"
      )

    clean_data_filled <- clean_data %>%
      left_join(
        gender_info,
        by = c("Census.year", "CEN23_GEO_002", "CEN23_TWO_002", "CEN23_AGE_008")
      ) %>%
      mutate(
        OBS_VALUE = case_when(
          CEN23_GEN_002 == 1 &
            is.na(OBS_VALUE) &
            Observation.Status == "Confidential" &
```

```
            male_conf_na ~ pmax(total_calc - female_calc - another_calc, 0),

          CEN23_GEN_002 == 2 &
            !male_conf_na &
            is.na(OBS_VALUE) &
            Observation.Status == "Confidential" &
            female_conf_na ~ pmax(total_calc - male_calc - another_calc, 0),

          CEN23_GEN_002 == 3 &
            !male_conf_na & !female_conf_na &
            is.na(OBS_VALUE) ~ pmax(total_calc - male_calc - female_calc, 0),

          TRUE ~ OBS_VALUE
        )
      ) %>%
      select(
        -male_calc, -female_calc, -another_calc,
        -total_calc, -male_conf_na, -female_conf_na
      )

    final_data <- bind_rows(final_data, clean_data_filled)
  }

  # FINAL CLEANUP STEP (as requested)
  final_data_sorted <- final_data %>%
    filter(CEN23_GEN_002 != 99) %>%
    select(-Observation.Status) %>%
    arrange(
      Census.year,
      CEN23_GEO_002,
      CEN23_TWO_002,
      CEN23_AGE_008,
      CEN23_GEN_002
    )

  write.csv(final_data_sorted, output_file, row.names = FALSE)

  invisible(final_data_sorted)
}
```

2.3 Generate consolidated Education and Work datasets

The two data-ingestion functions are now executed to generate the core Move-NZ datasets:

- `edu_data.csv` for **Journey to Education**
- `work_data.csv` for **Journey to Work**

Each dataset represents a harmonised aggregation of all regional census files and serves as the authoritative input for all subsequent transformations and analyses.

```
# NOTE:
# This block is commented out because the merged files are already generated
# and saved to disk. If you are running this code for the first time,
# uncomment the lines below and execute them to generate the output files.

# merge_edu_data_files("./data/raw/education", "./data/interim/edu_data.csv")
# merge_work_data_files("./data/raw/work", "./data/interim/work_data.csv")
```

2.4 Load and inspect the Education and Work dataset

The consolidated education and work datasets are loaded from disk and inspected to verify:

- Column names and structure
- Data types
- Successful merging across regions and districts

This step acts as a validation checkpoint before applying further transformations.

```
# NOTE:
# This block is commented out because the data is transformed and written to disk
# in later steps of the pipeline. If you are running this code for the first time,
# uncomment the lines below to load and inspect the raw input datasets.

# # load the travel to education dataset
# edu_data <- read.csv("./data/interim/edu_data.csv")
# # #
# colnames(edu_data)
# str(edu_data)
# #
# # # load the travel to work dataset
# work_data <- read.csv("./data/interim/work_data.csv")
# # #
# colnames(work_data)
# str(work_data)
```

3. Transform the Merged datasets

3.1 Transform Education dataset

To prepare the education data for comparison and modelling, Move-NZ applies a series of systematic transformations:

1. Renaming variables to concise, analysis-friendly names
2. Grouping detailed travel modes into five high-level categories:
    - Private Transport
    - Public Transport
    - Active Transport

- At home
- Other Transport

3. Removing `Total-gender` rows, which are not analytically required
4. Standardising `gender` labels (Male, Female, Other)
5. Adding a `journey_type` indicator to distinguish education from work journeys
6. Reordering columns to enforce a consistent schema
7. Replacing missing counts with zero to ensure robust aggregation
8. Harmonising `age_group` labels
9. Correcting UTF-8 encoding issues in region names to avoid duplication

At the end of this step, the education dataset is fully standardised and ready for merging.

```
### transform the travel to education dataset

transform_edu_data <- function(edu_data){
  ## 1. Rename columns
  edu_data <- edu_data %>%
    rename(census_year = Census.year,
           sa2_code = CEN23_GEO_002,
           sa2 = Area,
           mode_code = CEN23_TED_002,
           mode = Main.means.of.travel.to.education,
           age_group_code = CEN23_AGE_003,
           age_group = Age,
           gender_code = CEN23_GEN_002,
           gender = Gender,
           count = OBS_VALUE,
           region = Region,
           district = District
           )


  ## 2. Add travel_category column, by categorising the travel modes into 5 types

  edu_data <- edu_data %>%
    mutate(
      travel_category = case_when(
        mode %in% c(
          "Passenger in a car, truck or van",
          "Drive a car, truck or van"
        ) ~ "Private Transport",

        mode %in% c(
          "Bicycle",
          "Walk or jog"
        ) ~ "Active Transport",

        mode %in% c(
          "Public bus",
```

```
        "Train",
        "Ferry",
        "School bus"
      ) ~ "Public Transport",

      mode == "Study at home" ~ "At home",

      mode == "Other" ~ "Other Transport",

      TRUE ~ NA_character_
    )
  )


## 3. remove the Total - gender values as these are not needed
edu_data <- edu_data %>%
  filter(gender != "Total - gender")


## 4. replace the male female and other values in gender column
edu_data <- edu_data %>%
  mutate(
    gender = recode(gender,
                    "Male / Tāne" = "Male",
                    "Female / Wahine" = "Female",
                    "Another gender / He ira kē anō" = "Other")
  )


## 5. Add journey_type column to indicate it is Journey to Education releated data
edu_data$journey_type <- "Education"

## 6. Reorder the columns
edu_data <- edu_data %>%
  select(
    journey_type,
    census_year,
    region,
    district,
    sa2_code,
    sa2,
    mode_code,
    mode,
    travel_category,
    age_group_code,
    age_group,
    gender_code,
    gender,
    count
  )


## 7. Replace NA in student_count to 0
```

```
  edu_data <- edu_data %>%
    mutate(
      count = coalesce(count, 0)
    )


  # 8. Rename the age groups from '65 years and over' to 'Over 64 years'

  edu_data <- edu_data %>%
    mutate(
      age_group = recode(age_group,
                         "65 years and over" = "Over 64 years")
    )

  # 9. UTF-8 encoding on region values
  edu_data <- edu_data %>%
    mutate(
      region = recode(region,
                         "Manawatū-Whanganui Region" = "Manawatu-Whanganui Regions",
                "Manawatū-Whanganui Region"  = "Manawatu-Whanganui Regions")
    )
  edu_data
}
```

3.2 Transform Work dataset

The work dataset undergoes transformations parallel to those applied to education data to guarantee comparability within Move-NZ.

These steps include:

1. Variable renaming
2. Travel-mode categorisation using the same five categories
3. Removal of `Total-gender` rows
4. Gender label standardisation
5. Addition of a `journey_type` = "Work" flag
6. Column reordering
7. Missing-value handling
8. `Age-group` harmonisation
9. UTF-8 region-name correction

Following this step, both datasets share an identical analytical structure.

```
# transform the travel to work dataset
transform_work_data <- function(work_data){
  # 1. Rename columns
  work_data <- work_data %>%
```

```
  rename(census_year = Census.year,
         sa2_code = CEN23_GEO_002,
         sa2 = Area,
         mode_code = CEN23_TWO_002,
         mode = Main.means.of.travel.to.work,
         age_group_code = CEN23_AGE_008,
         age_group = Age,
         gender_code = CEN23_GEN_002,
         gender = Gender,
         count = OBS_VALUE,
         region = Region,
         district = District
         )

# 2. Add work travel_category column, by categorising the travel modes into 5 types

work_data <- work_data %>%
  mutate(
    travel_category = case_when(
      mode == "Work at home" ~ "At home",

      mode %in% c(
        "Drive a private car, truck or van",
        "Drive a company car, truck or van",
        "Passenger in a car, truck, van or company bus"
      ) ~ "Private Transport",

      mode %in% c(
        "Public bus",
        "Train",
        "Ferry"
      ) ~ "Public Transport",

      mode %in% c(
        "Bicycle",
        "Walk or jog"
      ) ~ "Active Transport",

      mode %in% c(
        "Did not go to work today",
        "Other"
      ) ~ "Other Transport",

      TRUE ~ NA_character_
    )
  )

# 3. remove the Total - gender values as these are not needed
work_data <- work_data %>%
  filter(gender != "Total - gender")


# 4. replace the male femake and other values in gender column
```

```r
work_data <- work_data %>%
  mutate(
    gender = recode(gender,
                    "Male / Tāne" = "Male",
                    "Female / Wahine" = "Female",
                    "Another gender / He ira kē anō" = "Other")
  )

# 5. Add journey_type column to indicate it is Journey to Education rleated data
work_data$journey_type <- "Work"


# 6. Reoder the columns
work_data <- work_data %>%
  select(
    journey_type,
    census_year,
    region,
    district,
    sa2_code,
    sa2,
    mode_code,
    mode,
    travel_category,
    age_group_code,
    age_group,
    gender_code,
    gender,
    count
  )


# 7. Replace NA in employee_count to 0

work_data <- work_data %>%
  mutate(
    count = coalesce(count, 0)
  )


# 8. Rename the age groups from '65 years and over' to 'Over 64 years'

work_data <- work_data %>%
  mutate(
    age_group = recode(age_group,
                    "65 years and over" = "Over 64 years")
  )

# 9. UTF-8 encoding on region values
unique(work_data$region)
work_data <- work_data %>%
  mutate(
    region = recode(region,
```

```
                      "Manawatū-Whanganui Region" = "Manawatu-Whanganui Regions",
              "Manawatū-Whanganui Region" = "Manawatu-Whanganui Regions")
    )

  work_data
}
```

3.3 Apply standardised transformations to Education and Work datasets

The consolidated Education and Work datasets are passed through their respective transformation pipelines to ensure consistency, analytical readiness, and comparability across census years.

`transform_edu_data()` applies all predefined cleaning, harmonisation, and feature derivation steps to the Journey to Education dataset.

`transform_work_data()` performs the equivalent transformations for the Journey to Work dataset.

These transformations standardise variable names, recode travel modes into common categories, handle confidentiality suppression, and prepare the datasets for downstream descriptive analysis and statistical testing. The resulting transformed datasets (`edu_data` and `work_data`) form the final analytical base used throughout the remainder of the study.

```
# NOTE:
# These lines are commented out because the transformed datasets are saved
# to local disk and loaded from there for subsequent statistical analysis.
# If running this script for the first time, uncomment the lines below.

# edu_data <- transform_edu_data(edu_data)
# head(edu_data)
#
# work_data <- transform_work_data(work_data)
# head(work_data)
```

3.4 Write The Transformed Data To Files

```
# NOTE:
# Since the earlier blocks for loading, merging, and transforming the data
# are commented out, this export step is also commented.
# If this script is being run for the first time, uncomment the lines below
# to write the transformed datasets to disk.


# write.csv(edu_data, "./data/transformed/edu_data_transformed.csv", row.names = FALSE)
# write.csv(work_data, "./data/transformed/work_data_transformed.csv", row.names = FALSE)
```

3.5 Load the transformed Education and Work datasets

```
# NOTE:
# If this script is being run for the first time, these transformed data files
# may not yet exist on disk. In that case, uncomment and run the data loading,
```

```
# merging, and transformation blocks (Sections 2.3, 2.4, 3.3, and 3.4) first.
#
# Run those blocks and save the transformed datasets to avoid re-running the
# full preprocessing pipeline in future executions.

edu_data <- read.csv("./data/transformed/edu_data_transformed.csv")
work_data <- read.csv("./data/transformed/work_data_transformed.csv")
```

4. Combine Education and Work datasets into single dataset

4.1 Combine datasets

This section stacks the transformed Education and Work datasets and then runs **a consolidated validation checkpoint** (counts by year/journey type, missingness checks, and travel-category mapping coverage).

```
# Merge the Education and Work datasets

edu_work_data <- bind_rows(edu_data, work_data)
```

```
val_counts_by_journey_year <- edu_work_data %>%
  count(journey_type, census_year)

pander(
  val_counts_by_journey_year,
  caption = "Record counts by journey type and census year"
)
```

Table 1: Record counts by journey type and census year

journey_type	census_year	n
Education	2018	289920
Education	2023	289920
Work	2018	239184
Work	2023	239184

The table confirms that both Education and Work journeys are fully represented in each census year, with no evidence of record loss or duplication during dataset merging.

```
val_counts_by_year <- edu_work_data %>%
  count(census_year)

pander(
  val_counts_by_year,
  caption = "Record counts by census year"
)
```

Table 2: Record counts by census year

census_year	n
2018	529104
2023	529104

The identical counts arise because both census years are aggregated over the same harmonised set of geographic and categorical dimensions, resulting in equal numbers of grouped observations.

```
val_missingness <- edu_work_data %>%
  summarise(
    missing_travel_category = sum(is.na(travel_category)),
    missing_count           = sum(is.na(count))
  )

pander(
  val_missingness,
  caption = "Missing value summary for key variables"
)
```

Table 3: Missing value summary for key variables

missing_travel_category	missing_count
0	0

No missing values are observed in either travel category or count variables, confirming the completeness of key analytical fields

4.2 Compute total Journey to Education counts by census year

This step derives annual population totals for Journey to Education from the combined Education-Work dataset. The data are first restricted to education-related journeys and then aggregated at the census-year level.

For each census year, the total number of individuals is calculated by summing the corresponding counts across all travel modes and geographic units. These totals provide a consistent baseline for time-based comparison and are subsequently used as denominators in the calculation of mode shares and percentage-point changes between 2018 and 2023.

```
edu_totals <- edu_work_data %>%
  filter(journey_type == "Education") %>%
  group_by(census_year) %>%
  summarise(
    total_count = sum(count, na.rm = TRUE),
    .groups = "drop"
  )

pander(edu_totals,
         caption = "Total Journey to Education population counts by census year (2018 and 2023)"
)
```

Table 4: Total Journey to Education population counts by census year (2018 and 2023)

census_year	total_count
2018	1570383
2023	1633842

4.3 Exploratory Data Analysis (EDA) - Validation and Sanity Checks

This section performs lightweight exploratory checks to verify that the combined Education-Work dataset retains the expected structural coverage after data ingestion, harmonisation, and merging. The focus is on confirming dimensional completeness (geography, age groups, travel categories) rather than generating substantive results.

These checks ensure that subsequent descriptive and inferential analyses are based on a complete and internally consistent dataset.

4.3.1 Overall observation counts by journey type and census year This check confirms that both journey types are present in both census years and that no unexpected imbalance or data loss occurred during merging.

```
obs_counts <- edu_work_data %>%
  group_by(journey_type, census_year) %>%
  summarise(total_count = sum(count, na.rm = TRUE), .groups = "drop")

pander(
  obs_counts,
  caption = "Overall observation counts by journey type and census year"
)
```

Table 5: Overall observation counts by journey type and census year

journey_type	census_year	total_count
Education	2018	1570383
Education	2023	1633842
Work	2018	3293808
Work	2023	3495990

Interpretation

- Both Education and Work journeys are observed in 2018 and 2023.
- Work journeys dominate total counts, consistent with population coverage differences.
- No missing year-journey combinations are present.

4.3.2 Dataset dimensionality and overall coverage This step summarises the dimensional structure of the combined dataset, confirming that all key analytical dimensions (journey type, year, geography, age group, and travel category) are present and populated.

```
dim_coverage <- edu_work_data %>%
  summarise(
    n_rows               = n(),
    n_journey_types      = n_distinct(journey_type),
    n_years              = n_distinct(census_year),
    n_regions            = n_distinct(region),
    n_districts          = n_distinct(district),
    n_sa2_names           = n_distinct(sa2),
    n_age_groups         = n_distinct(age_group),
    n_travel_categories  = n_distinct(travel_category),
    n_modes              = n_distinct(mode)
  )

pander(
  dim_coverage,
  caption = "Dataset dimensionality and overall coverage across key analytical variables"
)
```

Table 6: Dataset dimensionality and overall coverage across key analytical variables (continued below)

n_rows	n_journey_types	n_years	n_regions	n_districts	n_sa2_names
1058208	2	2	17	68	2416

n_age_groups	n_travel_categories	n_modes
4	5	15

Interpretation

- The dataset contains observations for both journey types (Education and Work) across the expected census years.
- Regional, district, and SA2 coverage is preserved, indicating that no geographic levels were lost during merging.
- The number of travel categories matches the intended harmonised classification.
- Minor differences between SA2 codes and names are expected and do not affect analysis, as codes are used as the primary geographic key.

4.3.2 Structural coverage by journey type This check verifies that Education and Work datasets exhibit comparable structural coverage, while allowing for expected differences (e.g., age-group eligibility).

```r
dim_coverage_by_journey <- edu_work_data %>%
  group_by(journey_type) %>%
  summarise(
    n_rows               = n(),
    n_years              = n_distinct(census_year),
    n_regions            = n_distinct(region),
    n_districts          = n_distinct(district),
    n_age_groups         = n_distinct(age_group),
    n_travel_categories  = n_distinct(travel_category),
    n_modes              = n_distinct(mode),
    .groups = "drop"
  )

pander(
  dim_coverage_by_journey,
  caption = "Structural coverage of key analytical dimensions by journey type"
)
```

Table 8: Structural coverage of key analytical dimensions by journey type (continued below)

journey_type	n_rows	n_years	n_regions	n_districts	n_age_groups
Education	579840	2	17	68	4
Work	478368	2	17	68	3

n_travel_categories	n_modes
5	10
5	11

Interpretation

- Both journey types exhibit consistent geographic and travel-category coverage.
- Differences in age-group counts reflect expected population differences between Education and Work journeys.
- Structural comparability supports valid cross-journey and time-based comparisons in later sections.

4.3.3 Level inspection for key categorical variables This step inspects the unique levels of key categorical variables to confirm successful harmonisation and detect any unintended category duplication or labelling inconsistencies.

```r
level_inspection <- tibble(
  Variable = c("Journey Type", "Census Year", "Travel Category", "Age Group", "Gender"),
  Levels = c(
    paste(sort(unique(edu_work_data$journey_type)), collapse = ", "),
    paste(sort(unique(edu_work_data$census_year)), collapse = ", "),
    paste(sort(unique(edu_work_data$travel_category)), collapse = ", "),
    paste(sort(unique(edu_work_data$age_group)), collapse = ", "),
```

```
    paste(sort(unique(edu_work_data$gender)), collapse = ", ")
  )
)

pander(
  level_inspection,
  caption = "Observed levels of key categorical variables after data harmonisation"
)
```

Table 10: Observed levels of key categorical variables after data harmonisation

Variable	Levels
Journey Type	Education, Work
Census Year	2018, 2023
Travel Category	Active Transport, At home, Other Transport, Private Transport, Public Transport
Age Group	15-29 years, 30-64 years, Over 64 years, Under 15 years
Gender	Female, Male, Other

Interpretation

- All categorical variables contain only expected levels.
- Travel categories align with the defined harmonised classification.
- No spurious or misspelled category labels are present, confirming reliable grouping for subsequent analysis.

4.3.4 Distribution of counts across travel categories This step verifies that all five travel categories are populated and identifies their relative magnitudes prior to formal analysis.

```
cat_totals_shares <- edu_work_data %>%
  group_by(journey_type, travel_category) %>%
  summarise(total_count = sum(count, na.rm = TRUE), .groups = "drop") %>%
  group_by(journey_type) %>%
  mutate(
    share_pct = round(100 * total_count / sum(total_count), 2)
  ) %>%
  ungroup() %>%
  arrange(journey_type, desc(total_count))

pander(
  cat_totals_shares,
  caption = "Distribution of counts and percentage shares across travel
  categories within each journey type (pre-analysis sanity check)"
)
```

Table 11: Distribution of counts and percentage shares across travel categories within each journey type (pre-analysis sanity check)

journey_type	travel_category	total_count	share_pct
Education	Private Transport	1614597	50.39
Education	Active Transport	716037	22.35
Education	Public Transport	618891	19.31
Education	At home	210873	6.58
Education	Other Transport	43827	1.37
Work	Private Transport	4832841	71.18
Work	At home	989805	14.58
Work	Public Transport	452559	6.67
Work	Active Transport	420390	6.19
Work	Other Transport	94203	1.39

Interpretation

- All travel categories contain non-zero counts.
- Private Transport dominates both journey types.
- "At home" represents a substantial share, particularly for Work, motivating time-based comparison.

4.3.5 Year-wise composition check (Education vs Work) This check ensures that travel-category composition varies meaningfully across years and journey types, justifying subsequent percentage-point and chi-square analyses.

```
year_comp <- edu_work_data %>%
  filter(census_year %in% c(2018, 2023)) %>%
  group_by(journey_type, census_year, travel_category) %>%
  summarise(count = sum(count, na.rm = TRUE), .groups = "drop") %>%
  group_by(journey_type, census_year) %>%
  mutate(
    share_pct = round(100 * count / sum(count), 2)
  ) %>%
  ungroup()

pander(
  year_comp,
  caption = "Year-wise travel-category composition (percentage shares) by journey type"
)
```

Table 12: Year-wise travel-category composition (percentage shares) by journey type

journey_type	census_year	travel_category	count	share_pct
Education	2018	Active Transport	371289	23.64
Education	2018	At home	80028	5.1
Education	2018	Other Transport	21528	1.37
Education	2018	Private Transport	783675	49.9
Education	2018	Public Transport	313863	19.99

journey_type	census_year	travel_category	count	share_pct
Education	2023	Active Transport	344748	21.1
Education	2023	At home	130845	8.01
Education	2023	Other Transport	22299	1.36
Education	2023	Private Transport	830922	50.86
Education	2023	Public Transport	305028	18.67
Work	2018	Active Transport	223728	6.79
Work	2018	At home	367290	11.15
Work	2018	Other Transport	48069	1.46
Work	2018	Private Transport	2405145	73.02
Work	2018	Public Transport	249576	7.58
Work	2023	Active Transport	196662	5.63
Work	2023	At home	622515	17.81
Work	2023	Other Transport	46134	1.32
Work	2023	Private Transport	2427696	69.44
Work	2023	Public Transport	202983	5.81

Interpretation

- Travel mode shares differ clearly between Education and Work.
- Shares change between 2018 and 2023, especially for "At home".
- These patterns justify formal hypothesis testing in Section 6.

4.3.6 Zero and missing count diagnostics This diagnostic ensures that zero counts reflect true absence rather than missing data and that no NA values remain after transformation.

```
zero_missing_diag <- edu_work_data %>%
  summarise(
    zero_counts         = sum(count == 0, na.rm = TRUE),
    missing_counts      = sum(is.na(count)),
    missing_categories  = sum(is.na(travel_category))
  )

pander(
  zero_missing_diag,
  caption = "Diagnostics for zero values and missingness in key analytical variables"
)
```

Table 13: Diagnostics for zero values and missingness in key analytical variables

zero_counts	missing_counts	missing_categories
752411	0	0

Interpretation

- Zero counts are present but expected due to disaggregation.
- No missing counts or travel categories remain.
- The dataset is safe for aggregation, reshaping, and chi-square testing.

4.3.7 Identify unmapped travel modes across journey types This step performs a validation check to identify travel modes that have not been successfully mapped to a standardised travel category. The combined Education–Work dataset is filtered to retain only records where the derived travel_category is missing.

Distinct combinations of journey type and original travel mode are then extracted and ordered for review. This output is used as a quality-assurance mechanism to verify the completeness of the travel-mode categorisation scheme and to identify any residual or unexpected modes that may require additional recoding prior to analysis.

```
unmapped_modes <- edu_work_data %>%
  filter(is.na(travel_category)) %>%
  distinct(journey_type, mode) %>%
  arrange(journey_type, mode)

unmapped_modes
```

```
## [1] journey_type mode
## <0 rows> (or 0-length row.names)
```

5. National-Level Travel Mode Composition and Time-Based Change (2018-2023)

This section summarises national travel behaviour for Journey to Education and Journey to Work by

(i) computing travel category shares,

(ii) quantifying absolute changes between 2018 and 2023 using percentage-point differences, and

(iii) contrasting the size of those changes between journey types using a descriptive difference-in-differences metric.

Together, these outputs provide an interpretable, policy-relevant overview of how the composition of travel modes has shifted over time and how those shifts differ between education and work travel.

5.1 National mode shares by journey type and census year

This code aggregates Census counts by journey type, year, and travel category, and converts those totals into within-year shares. The resulting table (`shares_nz`) provides the national composition of travel categories for Education and Work in each census year, forming the baseline for all subsequent change calculations.

```
shares_nz <- edu_work_data %>%
  group_by(journey_type, census_year, travel_category) %>%
  summarise(count = sum(count, na.rm = TRUE), .groups = "drop") %>%
  group_by(journey_type, census_year) %>%
  mutate(
    share_pct = round(100 * count / sum(count), 2)
  ) %>%
  ungroup()

pander(
  shares_nz,
  caption = "National travel mode shares (%) by journey type and census year"
)
```

Table 14: National travel mode shares (%) by journey type and census year

journey_type	census_year	travel_category	count	share_pct
Education	2018	Active Transport	371289	23.64
Education	2018	At home	80028	5.1
Education	2018	Other Transport	21528	1.37
Education	2018	Private Transport	783675	49.9
Education	2018	Public Transport	313863	19.99
Education	2023	Active Transport	344748	21.1
Education	2023	At home	130845	8.01
Education	2023	Other Transport	22299	1.36
Education	2023	Private Transport	830922	50.86
Education	2023	Public Transport	305028	18.67
Work	2018	Active Transport	223728	6.79
Work	2018	At home	367290	11.15
Work	2018	Other Transport	48069	1.46
Work	2018	Private Transport	2405145	73.02
Work	2018	Public Transport	249576	7.58
Work	2023	Active Transport	196662	5.63
Work	2023	At home	622515	17.81
Work	2023	Other Transport	46134	1.32
Work	2023	Private Transport	2427696	69.44
Work	2023	Public Transport	202983	5.81

5.2 Percentage-point change in mode shares from 2018 to 2023

This code reshapes the national share table into a wide format (2018 vs 2023 side-by-side) and computes percentage-point (pp) changes for each travel category within each journey type. Percentage-point change is used to capture absolute compositional shifts, enabling straightforward interpretation of increases and decreases in mode share over time.

```
pp_change_nz <- shares_nz %>%
  select(journey_type, census_year, travel_category, share_pct) %>%
  pivot_wider(
    id_cols      = c(journey_type, travel_category),
    names_from   = census_year,
    values_from  = share_pct,
    names_prefix = "y"
  ) %>%
  mutate(
    y2018 = round(y2018, 2),
    y2023 = round(y2023, 2),
    pp_change_2018_2023 = round(y2023 - y2018, 2)
  ) %>%
  arrange(journey_type, travel_category)

pander(
  pp_change_nz,
  caption = "Percentage-point change in national travel mode shares between
  2018 and 2023, by journey type"
)
```

Table 15: Percentage-point change in national travel mode shares between 2018 and 2023, by journey type

journey_type	travel_category	y2018	y2023	pp_change_2018_2023
Education	Active Transport	23.64	21.1	-2.54
Education	At home	5.1	8.01	2.91
Education	Other Transport	1.37	1.36	-0.01
Education	Private Transport	49.9	50.86	0.96
Education	Public Transport	19.99	18.67	-1.32
Work	Active Transport	6.79	5.63	-1.16
Work	At home	11.15	17.81	6.66
Work	Other Transport	1.46	1.32	-0.14
Work	Private Transport	73.02	69.44	-3.58
Work	Public Transport	7.58	5.81	-1.77

5.3 Data validation check: confirm one record per group

This diagnostic check confirms that `shares_nz` contains a single aggregated row for each (Journey Type × Census Year × Travel Category) combination. Any output returned by this block would indicate duplicate group records and signal that upstream aggregation or categorisation requires review before interpreting results.

```
dup_check <- shares_nz %>%
  count(journey_type, census_year, travel_category) %>%
  filter(n > 1)

dup_check
```

(No rows to display.)

5.4 Descriptive difference-in-differences: comparing shifts between Education and Work

This code compares the size of change between journey types by computing a descriptive difference-in-differences metric for each travel category. Specifically, it subtracts the Work percentage-point change from the Education percentage-point change. Positive values indicate that Education experienced a larger increase (or smaller decrease) than Work for that category between 2018 and 2023; negative values indicate the opposite.

```
did_nz <- pp_change_nz %>%
  select(journey_type, travel_category, pp_change_2018_2023) %>%
  pivot_wider(names_from = journey_type, values_from = pp_change_2018_2023) %>%
  mutate(
    diff_in_diff_pp = round(Education - Work, 2)
  ) %>%
  arrange(travel_category)

pander(
  did_nz,
  caption = "Descriptive difference-in-differences: Education vs Work
  percentage-point shifts (2018-2023), by travel category"
)
```

Table 16: Descriptive difference-in-differences: Education vs Work percentage-point shifts (2018–2023), by travel category **Interpretation**

travel_category	Education	Work	diff_in_diff_pp
Active Transport	-2.54	-1.16	-1.38
At home	2.91	6.66	-3.75
Other Transport	-0.01	-0.14	0.13
Private Transport	0.96	-3.58	4.54
Public Transport	-1.32	-1.77	0.45

The descriptive difference-in-differences results indicate that travel mode shifts between 2018 and 2023 differed meaningfully between education and work journeys. Education experienced a larger relative increase in private transport (+4.54 pp compared with work), while at-home travel increased much more for work than for education (−3.75 pp DiD). Declines in active transport were also more pronounced for education, whereas public transport fell slightly less for education than for work. Changes in other transport were negligible for both journey types.

Overall, these patterns suggest systematic differences in post-2018 modal reallocation between education and work, motivating the formal inferential analysis that follows.

6. Statistical Analysis 1: Time-Based and Cross-Journey Comparisons of Travel Mode Distributions

This section applies Pearson chi-square tests of homogeneity to formally assess whether observed differences in travel mode distributions are statistically significant. The analysis addresses two core inferential questions:

1. Within-journey time-based change:

Do travel mode distributions for a given journey type differ between the 2018 and 2023 Censuses?

2. Between-journey compositional differences:

Do education and work journeys exhibit different travel mode distributions within the same census year, and has the strength of this difference changed over time?

All tests are conducted on aggregated Census counts and are interpreted in conjunction with effect size measures to distinguish statistical significance from practical relevance.

6.1 Statistical Test 1: Change Over Time Within Each Journey Type

Purpose and hypotheses:

For each journey type (Education and Work), a chi-square test of homogeneity is used to assess whether we have significant evidence that data distribution of travel categories differs between 2018 and 2023.

- H_0 **(null hypothesis):**
  The travel mode distribution is the same in 2018 and 2023.
- H_1 **(alternative hypothesis):**
  The travel mode distribution differs between 2018 and 2023.

This test is appropriate under the following conditions:

- Observations are counts of individuals in mutually exclusive categories
- Expected cell counts are large (satisfied given Census-scale data)
- Samples from different years are treated as independent cross-sections

There are no substantive reasons to doubt these assumptions in this setting.

6.1.1 Chi-square test implementation for within-journey time-based shifts This code constructs a contingency table of census year by travel category for a single journey type and applies Pearson's chi-square test of homogeneity.

```
test_time_shift <- function(df_one_journey) {

  tab <- df_one_journey %>%
    filter(census_year %in% c(2018, 2023)) %>%
    group_by(census_year, travel_category) %>%
    summarise(n = sum(count, na.rm = TRUE), .groups = "drop") %>%
    pivot_wider(names_from = travel_category, values_from = n, values_fill = 0) %>%
    arrange(census_year)

  mat <- as.matrix(tab %>% select(-census_year))
  rownames(mat) <- tab$census_year

  out <- chisq.test(mat, correct = FALSE)

  list(table = mat, test = out)
}

res_edu_time  <- edu_work_data %>% filter(journey_type == "Education") %>% test_time_shift()
res_work_time <- edu_work_data %>% filter(journey_type == "Work") %>% test_time_shift()

# tested contingency tables
res_edu_time$table
```

```
##      Active Transport At home Other Transport Private Transport
## 2018           371289   80028           21528            783675
## 2023           344748  130845           22299            830922
##      Public Transport
## 2018           313863
## 2023           305028
```

```
res_work_time$table
```

```
##      Active Transport At home Other Transport Private Transport
## 2018           223728  367290           48069           2405145
## 2023           196662  622515           46134           2427696
##      Public Transport
## 2018           249576
## 2023           202983
```

```r
# Show test objects
edu_test_tbl <- tibble(
  Statistic = "Chi-square",
  Value     = round(unname(res_edu_time$test$statistic), 2),
  df        = unname(res_edu_time$test$parameter),
  p_value   = format.pval(res_edu_time$test$p.value, digits = 3, eps = 1e-16)
)

pander(
  edu_test_tbl,
  caption = "Pearson chi-square test for time-based changes in travel mode distribution (Education)"
)
```

Table 17: Pearson chi-square test for time-based changes in travel mode distribution (Education)

Statistic	Value	df	p_value
Chi-square	13501	4	<1e-16

```r
work_test_tbl <- tibble(
  Statistic = "Chi-square",
  Value     = round(unname(res_work_time$test$statistic), 2),
  df        = unname(res_work_time$test$parameter),
  p_value   = format.pval(res_work_time$test$p.value, digits = 3, eps = 1e-16)
)

pander(
  work_test_tbl,
  caption = "Pearson chi-square test for time-based changes in travel mode distribution (Work)"
)
```

Table 18: Pearson chi-square test for time-based changes in travel mode distribution (Work)

Statistic	Value	df	p_value
Chi-square	66534	4	<1e-16

Interpretation of output

For both Journey to Education and Journey to Work, the chi-square tests return extremely large test statistics with p-values smaller than 2.2×10^{-16}. This provides overwhelming evidence against the null hypothesis.

Answer to the research question: Yes, there is statistically significant evidence that travel behaviour in 2018 and 2023 originated from different underlying models for both education and work journeys. Each journey type experienced a clear and significant time-based shift in travel mode composition.

6.1.2 Summary of within-journey time-based tests This table summarises the chi-square statistics, degrees of freedom, and p-values for the within-journey comparisons.

```r
chi_summary <- tibble(
  Journey = c("Education", "Work"),
  Chi_square = c(
    unname(res_edu_time$test$statistic),
    unname(res_work_time$test$statistic)
  ),
  df = c(
    unname(res_edu_time$test$parameter),
    unname(res_work_time$test$parameter)
  ),
  p_value = c(
    res_edu_time$test$p.value,
    res_work_time$test$p.value
  )
) %>%
  mutate(
    Chi_square = round(Chi_square, 0),
    p_value_fmt = format.pval(p_value, digits = 3, eps = 1e-16)
  ) %>%
  select(Journey, Chi_square, df, p_value_fmt)

pander(
  chi_summary,
  caption = "Summary of within-journey chi-square tests comparing travel mode distributions between 2018
)
```

Table 19: Summary of within-journey chi-square tests comparing travel mode distributions between 2018 and 2023 **Interpretation of output**

Journey	Chi_square	df	p_value_fmt
Education	13501	4	<1e-16
Work	66534	4	<1e-16

Both journey types show strong evidence of time-based change in travel mode distributions, with particularly large departures from stability observed for work travel.

6.2 Constructing Category-Wise Changes Between 2018 and 2023

To complement the global chi-square tests, category-wise changes in counts are computed to identify which travel categories increased or decreased for each journey type.

```r
shift_tab <- edu_work_data %>%
  filter(census_year %in% c(2018, 2023)) %>%
  group_by(journey_type, census_year, travel_category) %>%
  summarise(n = sum(count, na.rm = TRUE), .groups = "drop") %>%
  pivot_wider(names_from = census_year, values_from = n, names_prefix = "y", values_fill = 0) %>%
  mutate(delta = y2023 - y2018) %>%
  select(journey_type, travel_category, delta) %>%
  pivot_wider(names_from = travel_category, values_from = delta, values_fill = 0)
```

```
pander(shift_tab,
       caption = "Category-wise changes in travel counts between 2018 and
       2023 (2023 - 2018), by journey type"
)
```

Table 20: Category-wise changes in travel counts between 2018 and 2023 (2023 − 2018), by journey type (continued below)

journey_type	Active Transport	At home	Other Transport
Education	-26541	50817	771
Work	-27066	255225	-1935

Private Transport	Public Transport
47247	-8835
22551	-46593

Interpretation of output

The table reveals substantial increases in At home travel for both journey types, alongside declines in Active and Public Transport. The magnitude and direction of changes differ between education and work, motivating formal comparison of change profiles.

6.3 Comparing Change Profiles Between Education and Work

Purpose and hypotheses

This analysis assesses whether education and work journeys experienced different patterns of reallocation across travel categories between 2018 and 2023.

- H_0: The magnitudes of category-wise changes are distributed identically for Education and Work.
- H_1: The distributions differ.

```
shift_mat <- as.matrix(shift_tab %>% select(-journey_type))
rownames(shift_mat) <- shift_tab$journey_type

chisq_shift <- chisq.test(abs(shift_mat))

chisq_shift_tbl <- tibble(
  Test      = "Pearson's chi-squared test",
  Chi_square = round(unname(chisq_shift$statistic), 2),
  df        = unname(chisq_shift$parameter),
  p_value   = format.pval(chisq_shift$p.value, digits = 3, eps = 1e-16)
)

pander(
  chisq_shift_tbl,
  caption = "Pearson's chi-squared test comparing the magnitude of category-wise
  change profiles between Education and Work (2018-2023)"
)
```

Table 22: Pearson's chi-squared test comparing the magnitude of category-wise change profiles between Education and Work (2018–2023)

Test	Chi_square	df	p_value
Pearson's chi-squared test	91461	4	<1e-16

Interpretation of output

The highly significant result indicates that education and work journeys did not merely change over time, but did so in systematically different ways across travel categories.

6.4 Statistical Test 2: Education vs Work Comparisons Within a Single Census Year

Purpose and hypotheses

This test evaluates whether education and work journeys share the same travel mode distribution within a given census year.

```
test_edu_vs_work_by_year <- function(data, year_value) {

  tab <- data %>%
    filter(census_year == year_value) %>%
    group_by(journey_type, travel_category) %>%
    summarise(n = sum(count, na.rm = TRUE), .groups = "drop") %>%
    pivot_wider(
      names_from  = travel_category,
      values_from = n,
      values_fill = 0
    ) %>%
    arrange(journey_type)

  mat <- as.matrix(tab %>% select(-journey_type))
  rownames(mat) <- tab$journey_type

  list(
    table = mat,
    test  = chisq.test(mat)
  )
}
```

```
res_edu_work_2018 <- test_edu_vs_work_by_year(edu_work_data, 2018)

chi_edu_work_2018 <- tibble(
  Test = "Pearson's chi-squared test",
  Chi_square = round(unname(res_edu_work_2018$test$statistic), 2),
  df = unname(res_edu_work_2018$test$parameter),
  p_value = format.pval(res_edu_work_2018$test$p.value, digits = 3, eps = 1e-16)
)
```

```
pander(
  chi_edu_work_2018,
  caption = "Pearson's chi-squared test comparing Education and Work
  travel mode distributions in 2018"
)
```

6.4.1 Education vs Work travel mode distribution in 2018

Table 23: Pearson's chi-squared test comparing Education and Work travel mode distributions in 2018 **Interpretation of output**

Test	Chi_square	df	p_value
Pearson's chi-squared test	517341	4	<1e-16

Education and work travel had statistically distinct mode distributions in 2018.

```
res_edu_work_2023 <- test_edu_vs_work_by_year(edu_work_data, 2023)

chi_edu_work_2023 <- tibble(
  Test = "Pearson's chi-squared test",
  Chi_square = round(unname(res_edu_work_2023$test$statistic), 2),
  df = unname(res_edu_work_2023$test$parameter),
  p_value = format.pval(res_edu_work_2023$test$p.value, digits = 3, eps = 1e-16)
)

pander(
  chi_edu_work_2023,
  caption = "Pearson's chi-squared test comparing Education and Work
  travel mode distributions in 2023"
)
```

6.4.2 Education vs Work travel mode distribution in 2023

Table 24: Pearson's chi-squared test comparing Education and Work travel mode distributions in 2023 **Interpretation of output**

Test	Chi_square	df	p_value
Pearson's chi-squared test	572042	4	<1e-16

The distinction between education and work travel persisted in 2023, indicating stable structural differences post-COVID.

6.5 Effect Size Assessment Using Cramér's V

While the chi-square tests in the preceding sections establish whether differences in travel mode distributions are statistically significant, they do not convey the magnitude of those differences. This distinction is

particularly important when working with Census data, where very large sample sizes can lead to extremely small p-values even for relatively modest deviations.

To address this limitation, Cramér's V is computed as a standardised measure of association between journey type and travel category for each census year. By quantifying effect size on a scale from 0 (no association) to 1 (perfect association), Cramér's V enables assessment of the practical relevance of observed differences, complementing the hypothesis-testing results with an interpretable measure of strength.

```
cramers_v_2018 <- rcompanion::cramerV(res_edu_work_2018$table)
cramers_v_2023 <- rcompanion::cramerV(res_edu_work_2023$table)

# Convert to a tidy table for reporting
cramers_v_tbl <- tibble(
  Census_year = c(2018, 2023),
  Cramers_V = round(c(cramers_v_2018, cramers_v_2023), 4)
)

pander(
  cramers_v_tbl,
  caption = "Cramér's V effect size for the association between journey type
  and travel category (Education vs Work), by census year"
)
```

Table 25: Cramér's V effect size for the association between journey type and travel category (Education vs Work), by census year
Interpretation of output

Census_year	Cramers_V
2018	0.3261
2023	0.3339

Cramér's V values of approximately 0.33 in both years indicate a moderate to strong association between journey type and travel category, confirming that differences are not only statistically significant but also practically meaningful.

6.6 Summary of Education vs Work Differences by Census Year

This section consolidates the results of the year-specific chi-square tests and corresponding effect sizes into a single summary table. Presenting the test statistics, degrees of freedom, p-values, and Cramér's V side by side facilitates a clear comparison of the existence, strength, and stability of differences between education and work travel behaviour across census years.

By jointly reporting statistical significance and effect size, this summary provides a balanced interpretation that distinguishes between changes driven by large sample sizes and those reflecting substantively meaningful differences. It also offers a concise reference point for subsequent discussion of how and why travel behaviour differs by journey purpose and how these differences evolved between 2018 and 2023.

```
chi_edu_work_summary <- tibble(
  Census_Year = c(2018, 2023),
  Chi_square  = c(
    unname(res_edu_work_2018$test$statistic),
    unname(res_edu_work_2023$test$statistic)
```

```
  ),
  df = c(
    unname(res_edu_work_2018$test$parameter),
    unname(res_edu_work_2023$test$parameter)
  ),
  p_value = c(
    res_edu_work_2018$test$p.value,
    res_edu_work_2023$test$p.value
  ),
  Cramers_V = c(
    cramers_v_2018,
    cramers_v_2023
  )
) %>%
  mutate(
    Chi_square = round(Chi_square, 0),
    Cramers_V  = round(Cramers_V, 3),
    p_value_fmt = format.pval(p_value, digits = 3, eps = 1e-16)
  ) %>%
  select(Census_Year, Chi_square, df, p_value_fmt, Cramers_V)

pander(
  chi_edu_work_summary,
  caption = "Summary of Education vs Work travel mode differences by census
  year: chi-square tests and Cramér's V effect sizes"
)
```

Table 26: Summary of Education vs Work travel mode differences by census year: chi-square tests and Cramér's V effect sizes

Census_Year	Chi_square	df	p_value_fmt	Cramers_V
2018	517341	4	<1e-16	0.326
2023	572042	4	<1e-16	0.334

Interpretation of output

Across both census years, education and work journeys differ in statistically significant and practically meaningful ways. The consistency of effect sizes suggests that journey purpose remains a stable determinant of travel behaviour, even as overall travel patterns changed between 2018 and 2023.

7. Statistical Analysys 2: Do Time-Based Shifts Differ Between Education and Work?

While the previous section established that travel mode distributions changed significantly over time within each journey type, this section addresses a more stringent question:

Are the 2018 to 2023 shifts themselves statistically different between Journey to Education and Journey to Work?

To answer this, a multinomial logistic regression is fitted with travel category as the outcome and a `Year × Journey Type` interaction. A likelihood-ratio test (LRT) is then used to formally assess whether allowing the time-based effect to differ by journey type significantly improves model fit.

7.1 Preparing Aggregated Counts for Multinomial Modelling

Multinomial regression is fitted to aggregated Census counts, treating travel category as a multinomial outcome and using counts as frequency weights. This preserves the full information content of the Census while avoiding artificial replication of individual-level records.

```
model_data <- edu_work_data %>%
  filter(census_year %in% c(2018, 2023)) %>%
  group_by(journey_type, census_year, travel_category) %>%
  summarise(n = sum(count, na.rm = TRUE), .groups = "drop") %>%
  mutate(
    year = factor(census_year),
    journey_type = factor(journey_type),
    travel_category = factor(travel_category) %>% droplevels()
  )

pander(model_data,
         caption = "Aggregated Census counts for multinomial modelling,
       by journey type, census year, and travel category"
)
```

Table 27: Aggregated Census counts for multinomial modelling, by journey type, census year, and travel category

journey_type	census_year	travel_category	n	year
Education	2018	Active Transport	371289	2018
Education	2018	At home	80028	2018
Education	2018	Other Transport	21528	2018
Education	2018	Private Transport	783675	2018
Education	2018	Public Transport	313863	2018
Education	2023	Active Transport	344748	2023
Education	2023	At home	130845	2023
Education	2023	Other Transport	22299	2023
Education	2023	Private Transport	830922	2023
Education	2023	Public Transport	305028	2023
Work	2018	Active Transport	223728	2018
Work	2018	At home	367290	2018
Work	2018	Other Transport	48069	2018
Work	2018	Private Transport	2405145	2018
Work	2018	Public Transport	249576	2018
Work	2023	Active Transport	196662	2023
Work	2023	At home	622515	2023
Work	2023	Other Transport	46134	2023
Work	2023	Private Transport	2427696	2023
Work	2023	Public Transport	202983	2023

Interpretation of output

The resulting dataset contains one row per combination of journey type, census year, and travel category, with n representing the number of individuals in that category. This structure is appropriate for multinomial modelling with frequency weights and ensures consistent category definitions across years and journey types.

7.2 Multinomial Model Specification and Interaction Test

Purpose and hypotheses

Two nested multinomial logistic regression models are estimated:

- **Baseline model (m0)**:
  Allows main effects of `year` and `journey type`.
- **Interaction model (m1)**:
  Allows the effect of `year` to differ by `journey type` via a `Year × Journey Type` interaction.

The hypotheses tested via a likelihood-ratio test are:

- H_0: The time-based shift in travel mode distribution is the same for Education and Work.
- H_1: The time-based shift differs between Education and Work.

```
baseline_mode <- "Private Transport"

model_data <- edu_work_data %>%
  filter(census_year %in% c(2018, 2023),
         journey_type %in% c("Education", "Work")) %>%
  mutate(
    census_year = factor(census_year),
    journey_type = factor(journey_type),
    travel_category = factor(travel_category)
  )

# Set baseline for travel_category (reference outcome)
if (baseline_mode %in% levels(model_data$travel_category)) {
  model_data$travel_category <- relevel(model_data$travel_category, ref = baseline_mode)
} else {
  warning("Baseline travel_category not found. Check the exact level names in travel_category.")
  print(levels(model_data$travel_category))
}

model_data$census_year  <- relevel(model_data$census_year, ref = "2018")
model_data$journey_type <- relevel(model_data$journey_type, ref = "Work")


m0 <- nnet::multinom(travel_category ~ census_year + journey_type,
                     weights = count, data = model_data, trace = FALSE)

m1 <- nnet::multinom(travel_category ~ census_year * journey_type,
                     weights = count, data = model_data, trace = FALSE)

lrt <- anova(m0, m1, test = "Chisq")

pander(lrt, caption = "Likelihood ratio tests of Multinomial Models:")
```

Table 28: Likelihood ratio tests of Multinomial Models: (continued below)

Model	Resid. df	Resid. Dev	Test	Df	LR stat.
census_year + journey_type	4232820	20533275		NA	NA
census_year * journey_type	4232816	20531955	1 vs 2	4	1320

Pr(Chi)
NA
0

```
### Likelihood-ratio test for Year × Journey Type interaction

p <- lrt$`Pr(Chi)`[2]
format.pval(p, digits = 3, eps = 1e-16)
```

```
## [1] "<1e-16"
```

```
lr_stat <- 2 * (logLik(m1) - logLik(m0))
df_diff <- attr(logLik(m1), "df") - attr(logLik(m0), "df")
p_val   <- pchisq(lr_stat, df = df_diff, lower.tail = FALSE)

pander(
  data.frame(
    LR_stat = as.numeric(lr_stat),
    df      = df_diff,
    p_value = p_val
  ),
  caption = "Likelihood-ratio test for the Year × Journey Type interaction
  in the multinomial logistic regression model"
)
```

Table 30: Likelihood-ratio test for the Year × Journey Type interaction in the multinomial logistic regression model

LR_stat	df	p_value
1320	4	1.406e-284

Interpretation of output

The likelihood-ratio test comparing the additive multinomial model with the interaction model yields a large LR statistic (1320.18 on 4 degrees of freedom) and a p-value effectively equal to zero. This indicates that allowing the time-based effect to differ by journey type results in a substantially improved model fit.

Conclusion

There is strong statistical evidence that the 2018-2023 shift in travel mode distribution differs between Journey to Education and Journey to Work when all travel categories are considered jointly.

7.3 Model-Based Percentage-Point Changes in Travel Mode Shares

While the interaction test provides a formal inferential result, it does not directly convey how travel behaviour changed. To obtain interpretable effect sizes, predicted probabilities from the fitted multinomial model are converted into percentage-point changes for each travel category, journey type, and census year.

```
# Define the category set
cat_levels <- c("Private Transport", "Public Transport",
                "Active Transport", "At home", "Other Transport")

# Build prediction grid
pred_grid <- tidyr::expand_grid(
  census_year  = factor(c(2018, 2023), levels = levels(model_data$census_year)),
  journey_type = factor(c("Education", "Work"), levels = levels(model_data$journey_type))
)

# Predict probabilities
pred_probs_wide <- predict(m1, newdata = pred_grid, type = "probs") %>%
  as_tibble()

missing_cats <- setdiff(cat_levels, names(pred_probs_wide))
if (length(missing_cats) > 0) {
  stop("These categories are missing from predicted probabilities: ",
       paste(missing_cats, collapse = ", "),
       "\nCheck levels(model_data$travel_category).")
}

pred_probs <- pred_probs_wide %>%
  dplyr::select(dplyr::all_of(cat_levels)) %>%
  dplyr::bind_cols(pred_grid) %>%
  tidyr::pivot_longer(
    cols      = dplyr::all_of(cat_levels),
    names_to  = "travel_category",
    values_to = "prob"
  ) %>%
  dplyr::mutate(prob_pct = round(100 * prob, 2))

# Percentage-point change from 2018 to 2023
pred_pp <- pred_probs %>%
  dplyr::select(journey_type, census_year, travel_category, prob_pct) %>%
  tidyr::pivot_wider(
    names_from  = census_year,
    values_from = prob_pct,
    names_prefix = "y"
  ) %>%
  dplyr::mutate(pp_change_2018_2023 = y2023 - y2018) %>%
  dplyr::arrange(
  factor(journey_type, levels = c("Education", "Work")),
  travel_category
)

pander(
  pred_pp,
  caption = "Model-based predicted travel mode shares (%) in 2018 and 2023,
```

```
  and percentage-point change (2023 - 2018), by journey type and travel category"
)
```

Table 31: Model-based predicted travel mode shares (%) in 2018 and 2023, and percentage-point change (2023 - 2018), by journey type and travel category

journey_type	travel_category	y2018	y2023	pp_change_2018_2023
Education	Active Transport	23.64	21.1	-2.54
Education	At home	5.1	8.01	2.91
Education	Other Transport	1.37	1.37	0
Education	Private Transport	49.9	50.86	0.96
Education	Public Transport	19.99	18.67	-1.32
Work	Active Transport	6.79	5.63	-1.16
Work	At home	11.15	17.81	6.66
Work	Other Transport	1.46	1.32	-0.14
Work	Private Transport	73.02	69.44	-3.58
Work	Public Transport	7.58	5.81	-1.77

Interpretation of output

Model-based predictions show that both journey types experienced increases in at-home travel, but the increase is much larger for work journeys. Education travel exhibits relatively modest shifts, including a slight increase in private transport, whereas work travel shows a pronounced decline in private transport alongside a large rise in working from home.

Unlike Section 5, which reports observed Census shares, the percentage-point changes reported here are derived from predicted probabilities of the fitted multinomial model and therefore represent model-implied effects rather than raw empirical changes.

Conclusion

The predicted percentage-point changes confirm that education and work journeys underwent qualitatively and quantitatively different time-based reallocations of travel modes, providing an interpretable explanation for the significant interaction detected in the multinomial regression.

8. Extensions to Regions and Sub-Populations

The Move-NZ analytical framework is fully extensible beyond national aggregates. The same descriptive and inferential methods used earlier can be applied to regional and sub-population breakdowns, including region, urban versus non-urban classification, gender, and age group. This section demonstrates that extensibility using regional and urban-non-urban examples, combining descriptive percentage-point shifts with supporting statistical tests.

8.1 Regional Time-Based Change in Education Travel

As an initial regional extension, chi-square tests of homogeneity are applied separately within each region for Journey to Education to assess whether travel mode distributions changed between 2018 and 2023.

```
region_tests_edu <- edu_work_data %>%
  filter(journey_type == "Education", census_year %in% c(2018, 2023)) %>%
  group_by(region) %>%
```

```
  group_map(~{
    tab <- .x %>%
      group_by(census_year, travel_category) %>%
      summarise(n = sum(count, na.rm = TRUE), .groups = "drop") %>%
      pivot_wider(names_from = travel_category, values_from = n, values_fill = 0) %>%
      arrange(census_year)

    mat <- as.matrix(tab %>% select(-census_year))
    rownames(mat) <- tab$census_year

    tst <- suppressWarnings(chisq.test(mat))
    tibble(
      region = .y$region,
      statistic = unname(tst$statistic),
      df = unname(tst$parameter),
      p_value = unname(tst$p.value)
    )
  }) %>%
  bind_rows() %>%
  arrange(p_value)

pander(
  region_tests_edu %>%
    dplyr::mutate(
      statistic = formatC(statistic, format = "f", digits = 2),
      p_value   = formatC(p_value, format = "e", digits = 2)
    ) %>%
    dplyr::select(region, statistic, df, p_value),
  caption = "Region-wise Pearson chi-square tests of homogeneity for
  changes in Education travel mode distributions between 2018 and 2023"
)
```

Table 32: Region-wise Pearson chi-square tests of homogeneity for changes in Education travel mode distributions between 2018 and 2023

region	statistic	df	p_value
Auckland Region	8436.39	4	0.00e+00
Wellington Region	1479.95	4	3.19e-319
Canterbury Region	1050.14	4	4.86e-226
Waikato Region	1008.46	4	5.25e-217
Manawatu-Whanganui Region	722.42	4	4.88e-155
Bay of Plenty Region	634.14	4	6.33e-136
Hawke's Bay Region	446.62	4	2.33e-95
Northland Region	412.35	4	5.95e-88
Otago Region	305.88	4	5.85e-65
Gisborne Region	255.75	4	3.75e-54
Taranaki Region	186.50	4	2.99e-39
Southland Region	156.96	4	6.55e-33
West Coast Region	128.23	4	9.31e-27
Nelson Region	105.11	4	8.04e-22
Marlborough Region	57.33	4	1.06e-11

region	statistic	df	p_value
Tasman Region	42.20	4	1.52e-08
Area Outside Region	9.97	4	4.09e-02

Interpretation of output

All regions show extremely small p-values, indicating statistically significant changes in education travel mode distributions between 2018 and 2023. The magnitude of the chi-square statistics varies by region, reflecting differences in the scale and composition of change.

Conclusion

There is strong evidence that education travel behaviour changed over time in every region considered. Subsequent analysis therefore focuses on how those changes differ across regions rather than on whether change occurred.

8.2 Defining Urban and Non-Urban Region Groups

To facilitate comparison across spatial contexts, regions are grouped into top urban and top non-urban sets. This allows regional heterogeneity to be summarised while preserving meaningful contrasts.

```
urban_regions <- c(
  "Auckland Region",
  "Waikato Region",
  "Bay of Plenty Region",
  "Wellington Region",
  "Canterbury Region"
)

nonurban_regions <- c(
  "Gisborne Region",
  "West Coast Region",
  "Southland Region",
  "Tasman Region",
  "Marlborough Region"
)

edu_work_data_top5 <- edu_work_data %>%
  mutate(
    urban_group = case_when(
      region %in% urban_regions    ~ "Urban (Top 5)",
      region %in% nonurban_regions ~ "Non-Urban (Top 5)",
      TRUE                         ~ "Other"
    )
  )
```

8.3 Region-Level Shares and Percentage-Point Shifts

8.3.1 Shares by Region, Journey Type, Year, and Category This block computes region-level travel mode shares for education and work journeys in 2018 and 2023, forming the basis for all subsequent regional comparisons.

```r
region_shares <- edu_work_data_top5 %>%
  filter(region %in% c(urban_regions, nonurban_regions),
         census_year %in% c(2018, 2023)) %>%
  group_by(urban_group, region, journey_type, census_year, travel_category) %>%
  summarise(count = sum(count, na.rm = TRUE), .groups = "drop") %>%
  group_by(urban_group, region, journey_type, census_year) %>%
  mutate(share = count / sum(count)) %>%
  ungroup()
```

8.3.2 Percentage-Point Changes (2018 to 2023) by Region and Journey Type Shares are converted into percentage-point changes to quantify absolute shifts in travel mode composition over time.

```r
region_pp_change <- region_shares %>%
  mutate(share_pct = 100 * share) %>%
  select(urban_group, region, journey_type, census_year, travel_category, share_pct) %>%
  pivot_wider(names_from = census_year, values_from = share_pct, names_prefix = "y") %>%
  mutate(
    pp_change_2018_2023 = y2023 - y2018,
    across(c(y2018, y2023, pp_change_2018_2023), ~ round(.x, 2))
  ) %>%
  arrange(urban_group, region, journey_type, travel_category)

region_pp_change
```

urban_group	region	journey_type	travel_category	y2018	y2023	pp_change_2018_2023
Non-Urban (Top 5)	Gisborne Region	Education	Active Transport	20.64	14.30	-6.34
Non-Urban (Top 5)	Gisborne Region	Education	At home	6.02	8.78	2.76
Non-Urban (Top 5)	Gisborne Region	Education	Other Transport	1.85	1.33	-0.52
Non-Urban (Top 5)	Gisborne Region	Education	Private Transport	55.19	60.43	5.24
Non-Urban (Top 5)	Gisborne Region	Education	Public Transport	16.30	15.16	-1.14
Non-Urban (Top 5)	Gisborne Region	Work	Active Transport	6.06	4.88	-1.17
Non-Urban (Top 5)	Gisborne Region	Work	At home	15.05	16.40	1.35
Non-Urban (Top 5)	Gisborne Region	Work	Other Transport	1.51	1.19	-0.32
Non-Urban (Top 5)	Gisborne Region	Work	Private Transport	76.93	77.25	0.32
Non-Urban (Top 5)	Gisborne Region	Work	Public Transport	0.45	0.27	-0.18
Non-Urban (Top 5)	Marlborough Region	Education	Active Transport	25.61	25.05	-0.56
Non-Urban (Top 5)	Marlborough Region	Education	At home	8.85	11.93	3.08
Non-Urban (Top 5)	Marlborough Region	Education	Other Transport	1.94	1.34	-0.60
Non-Urban (Top 5)	Marlborough Region	Education	Private Transport	50.86	48.97	-1.89
Non-Urban (Top 5)	Marlborough Region	Education	Public Transport	12.74	12.71	-0.03
Non-Urban (Top 5)	Marlborough Region	Work	Active Transport	9.17	7.84	-1.32
Non-Urban (Top 5)	Marlborough Region	Work	At home	15.65	16.71	1.06
Non-Urban (Top 5)	Marlborough Region	Work	Other Transport	1.42	0.96	-0.46
Non-Urban (Top 5)	Marlborough Region	Work	Private Transport	73.60	74.30	0.69
Non-Urban (Top 5)	Marlborough Region	Work	Public Transport	0.16	0.19	0.03
Non-Urban (Top 5)	Southland Region	Education	Active Transport	21.11	18.24	-2.87
Non-Urban (Top 5)	Southland Region	Education	At home	6.05	8.59	2.54
Non-Urban (Top 5)	Southland Region	Education	Other Transport	1.21	0.98	-0.23
Non-Urban (Top 5)	Southland Region	Education	Private Transport	52.20	53.23	1.03
Non-Urban (Top 5)	Southland Region	Education	Public Transport	19.43	18.96	-0.47
Non-Urban (Top 5)	Southland Region	Work	Active Transport	6.26	5.71	-0.55

(continued)

urban_group	region	journey_type	travel_category	y2018	y2023	pp_change_2018_2023
Non-Urban (Top 5)	Southland Region	Work	At home	17.28	17.01	-0.27
Non-Urban (Top 5)	Southland Region	Work	Other Transport	2.16	2.05	-0.11
Non-Urban (Top 5)	Southland Region	Work	Private Transport	73.86	74.78	0.92
Non-Urban (Top 5)	Southland Region	Work	Public Transport	0.44	0.45	0.01
Non-Urban (Top 5)	Tasman Region	Education	Active Transport	24.98	23.46	-1.52
Non-Urban (Top 5)	Tasman Region	Education	At home	8.47	10.77	2.30
Non-Urban (Top 5)	Tasman Region	Education	Other Transport	1.59	1.28	-0.31
Non-Urban (Top 5)	Tasman Region	Education	Private Transport	43.33	43.42	0.08
Non-Urban (Top 5)	Tasman Region	Education	Public Transport	21.63	21.08	-0.55
Non-Urban (Top 5)	Tasman Region	Work	Active Transport	8.31	8.08	-0.23
Non-Urban (Top 5)	Tasman Region	Work	At home	18.27	20.83	2.57
Non-Urban (Top 5)	Tasman Region	Work	Other Transport	1.55	1.53	-0.02
Non-Urban (Top 5)	Tasman Region	Work	Private Transport	71.46	69.20	-2.26
Non-Urban (Top 5)	Tasman Region	Work	Public Transport	0.42	0.36	-0.05
Non-Urban (Top 5)	West Coast Region	Education	Active Transport	25.19	19.94	-5.25
Non-Urban (Top 5)	West Coast Region	Education	At home	9.47	13.79	4.32
Non-Urban (Top 5)	West Coast Region	Education	Other Transport	1.06	0.69	-0.37
Non-Urban (Top 5)	West Coast Region	Education	Private Transport	43.03	47.91	4.88
Non-Urban (Top 5)	West Coast Region	Education	Public Transport	21.25	17.68	-3.57
Non-Urban (Top 5)	West Coast Region	Work	Active Transport	10.20	8.53	-1.67
Non-Urban (Top 5)	West Coast Region	Work	At home	20.30	19.22	-1.08
Non-Urban (Top 5)	West Coast Region	Work	Other Transport	1.48	1.33	-0.15
Non-Urban (Top 5)	West Coast Region	Work	Private Transport	67.90	70.79	2.89
Non-Urban (Top 5)	West Coast Region	Work	Public Transport	0.12	0.12	0.00
Urban (Top 5)	Auckland Region	Education	Active Transport	22.47	20.33	-2.14
Urban (Top 5)	Auckland Region	Education	At home	3.97	6.99	3.02
Urban (Top 5)	Auckland Region	Education	Other Transport	1.32	1.42	0.10
Urban (Top 5)	Auckland Region	Education	Private Transport	49.78	50.63	0.85
Urban (Top 5)	Auckland Region	Education	Public Transport	22.45	20.63	-1.83
Urban (Top 5)	Auckland Region	Work	Active Transport	5.37	4.24	-1.13
Urban (Top 5)	Auckland Region	Work	At home	8.77	18.15	9.37
Urban (Top 5)	Auckland Region	Work	Other Transport	1.32	1.21	-0.12
Urban (Top 5)	Auckland Region	Work	Private Transport	73.76	68.65	-5.11
Urban (Top 5)	Auckland Region	Work	Public Transport	10.78	7.76	-3.02
Urban (Top 5)	Bay of Plenty Region	Education	Active Transport	21.17	17.88	-3.29
Urban (Top 5)	Bay of Plenty Region	Education	At home	6.12	8.90	2.77
Urban (Top 5)	Bay of Plenty Region	Education	Other Transport	1.19	1.03	-0.16
Urban (Top 5)	Bay of Plenty Region	Education	Private Transport	53.22	52.82	-0.40
Urban (Top 5)	Bay of Plenty Region	Education	Public Transport	18.30	19.38	1.08
Urban (Top 5)	Bay of Plenty Region	Work	Active Transport	5.12	4.25	-0.87
Urban (Top 5)	Bay of Plenty Region	Work	At home	14.47	17.50	3.03
Urban (Top 5)	Bay of Plenty Region	Work	Other Transport	1.29	1.16	-0.13
Urban (Top 5)	Bay of Plenty Region	Work	Private Transport	77.94	76.02	-1.92
Urban (Top 5)	Bay of Plenty Region	Work	Public Transport	1.18	1.07	-0.11
Urban (Top 5)	Canterbury Region	Education	Active Transport	26.78	26.38	-0.40
Urban (Top 5)	Canterbury Region	Education	At home	5.51	8.22	2.72
Urban (Top 5)	Canterbury Region	Education	Other Transport	1.81	1.69	-0.11
Urban (Top 5)	Canterbury Region	Education	Private Transport	50.56	50.47	-0.09
Urban (Top 5)	Canterbury Region	Education	Public Transport	15.35	13.23	-2.12
Urban (Top 5)	Canterbury Region	Work	Active Transport	8.06	7.49	-0.56
Urban (Top 5)	Canterbury Region	Work	At home	12.41	15.69	3.28
Urban (Top 5)	Canterbury Region	Work	Other Transport	1.51	1.67	0.16

(continued)

urban_group	region	journey_type	travel_category	y2018	y2023	pp_change_2018_2023
Urban (Top 5)	Canterbury Region	Work	Private Transport	75.17	72.38	-2.78
Urban (Top 5)	Canterbury Region	Work	Public Transport	2.85	2.76	-0.09
Urban (Top 5)	Waikato Region	Education	Active Transport	21.15	17.78	-3.37
Urban (Top 5)	Waikato Region	Education	At home	5.86	8.54	2.68
Urban (Top 5)	Waikato Region	Education	Other Transport	1.08	1.04	-0.04
Urban (Top 5)	Waikato Region	Education	Private Transport	55.61	57.49	1.87
Urban (Top 5)	Waikato Region	Education	Public Transport	16.29	15.15	-1.14
Urban (Top 5)	Waikato Region	Work	Active Transport	5.72	4.52	-1.20
Urban (Top 5)	Waikato Region	Work	At home	14.97	18.34	3.37
Urban (Top 5)	Waikato Region	Work	Other Transport	1.69	1.38	-0.31
Urban (Top 5)	Waikato Region	Work	Private Transport	76.31	74.49	-1.82
Urban (Top 5)	Waikato Region	Work	Public Transport	1.31	1.27	-0.05
Urban (Top 5)	Wellington Region	Education	Active Transport	28.54	23.85	-4.68
Urban (Top 5)	Wellington Region	Education	At home	5.98	9.26	3.27
Urban (Top 5)	Wellington Region	Education	Other Transport	1.64	1.60	-0.04
Urban (Top 5)	Wellington Region	Education	Private Transport	41.98	42.41	0.43
Urban (Top 5)	Wellington Region	Education	Public Transport	21.86	22.88	1.01
Urban (Top 5)	Wellington Region	Work	Active Transport	12.90	10.74	-2.17
Urban (Top 5)	Wellington Region	Work	At home	9.10	19.05	9.95
Urban (Top 5)	Wellington Region	Work	Other Transport	1.85	1.59	-0.25
Urban (Top 5)	Wellington Region	Work	Private Transport	58.15	53.16	-4.99
Urban (Top 5)	Wellington Region	Work	Public Transport	18.01	15.46	-2.55

Interpretation of output

The results reveal substantial regional variation in both the magnitude and direction of percentage-point changes between 2018 and 2023. Across non-urban regions, including Gisborne, Southland, and West Coast, education journeys consistently exhibit declines in active transport, often accompanied by stable or increasing private transport shares, while changes in work journeys are generally smaller in magnitude. In contrast, urban regions such as Auckland, Wellington, and Canterbury display more mixed patterns, characterised by pronounced increases in study-from-home and comparatively muted shifts across other travel modes. Overall, these results indicate that while time-based changes are widespread, their composition differs systematically by both regional context and journey type.

Conclusion

Although time-based changes in travel behaviour are evident nationwide, their composition differs systematically by both region and journey type. Education journeys-particularly in urban areas exhibit more pronounced shifts, including substantial increases in study-from-home and corresponding declines in active transport, while work journeys display comparatively smaller and more stable changes. These findings highlight the importance of spatially and contextually disaggregated analysis when interpreting national travel trends.

8.4 Comparing Education and Work Shifts Within Each Region (Difference-in-Differences)

A descriptive difference-in-differences metric is used to compare how education and work travel changed relative to one another within each region.

```
region_did <- region_pp_change %>%
  select(urban_group, region, journey_type, travel_category, pp_change_2018_2023) %>%
  pivot_wider(names_from = journey_type, values_from = pp_change_2018_2023) %>%
  mutate(diff_in_diff_pp = round(Education - Work, 2)) %>%
```

```
  arrange(urban_group, region, travel_category)

region_did
```

urban_group	region	travel_category	Education	Work	diff_in_diff_pp
Non-Urban (Top 5)	Gisborne Region	Active Transport	-6.34	-1.17	-5.17
Non-Urban (Top 5)	Gisborne Region	At home	2.76	1.35	1.41
Non-Urban (Top 5)	Gisborne Region	Other Transport	-0.52	-0.32	-0.20
Non-Urban (Top 5)	Gisborne Region	Private Transport	5.24	0.32	4.92
Non-Urban (Top 5)	Gisborne Region	Public Transport	-1.14	-0.18	-0.96
Non-Urban (Top 5)	Marlborough Region	Active Transport	-0.56	-1.32	0.76
Non-Urban (Top 5)	Marlborough Region	At home	3.08	1.06	2.02
Non-Urban (Top 5)	Marlborough Region	Other Transport	-0.60	-0.46	-0.14
Non-Urban (Top 5)	Marlborough Region	Private Transport	-1.89	0.69	-2.58
Non-Urban (Top 5)	Marlborough Region	Public Transport	-0.03	0.03	-0.06
Non-Urban (Top 5)	Southland Region	Active Transport	-2.87	-0.55	-2.32
Non-Urban (Top 5)	Southland Region	At home	2.54	-0.27	2.81
Non-Urban (Top 5)	Southland Region	Other Transport	-0.23	-0.11	-0.12
Non-Urban (Top 5)	Southland Region	Private Transport	1.03	0.92	0.11
Non-Urban (Top 5)	Southland Region	Public Transport	-0.47	0.01	-0.48
Non-Urban (Top 5)	Tasman Region	Active Transport	-1.52	-0.23	-1.29
Non-Urban (Top 5)	Tasman Region	At home	2.30	2.57	-0.27
Non-Urban (Top 5)	Tasman Region	Other Transport	-0.31	-0.02	-0.29
Non-Urban (Top 5)	Tasman Region	Private Transport	0.08	-2.26	2.34
Non-Urban (Top 5)	Tasman Region	Public Transport	-0.55	-0.05	-0.50
Non-Urban (Top 5)	West Coast Region	Active Transport	-5.25	-1.67	-3.58
Non-Urban (Top 5)	West Coast Region	At home	4.32	-1.08	5.40
Non-Urban (Top 5)	West Coast Region	Other Transport	-0.37	-0.15	-0.22
Non-Urban (Top 5)	West Coast Region	Private Transport	4.88	2.89	1.99
Non-Urban (Top 5)	West Coast Region	Public Transport	-3.57	0.00	-3.57
Urban (Top 5)	Auckland Region	Active Transport	-2.14	-1.13	-1.01
Urban (Top 5)	Auckland Region	At home	3.02	9.37	-6.35
Urban (Top 5)	Auckland Region	Other Transport	0.10	-0.12	0.22
Urban (Top 5)	Auckland Region	Private Transport	0.85	-5.11	5.96
Urban (Top 5)	Auckland Region	Public Transport	-1.83	-3.02	1.19
Urban (Top 5)	Bay of Plenty Region	Active Transport	-3.29	-0.87	-2.42
Urban (Top 5)	Bay of Plenty Region	At home	2.77	3.03	-0.26
Urban (Top 5)	Bay of Plenty Region	Other Transport	-0.16	-0.13	-0.03
Urban (Top 5)	Bay of Plenty Region	Private Transport	-0.40	-1.92	1.52
Urban (Top 5)	Bay of Plenty Region	Public Transport	1.08	-0.11	1.19
Urban (Top 5)	Canterbury Region	Active Transport	-0.40	-0.56	0.16
Urban (Top 5)	Canterbury Region	At home	2.72	3.28	-0.56
Urban (Top 5)	Canterbury Region	Other Transport	-0.11	0.16	-0.27
Urban (Top 5)	Canterbury Region	Private Transport	-0.09	-2.78	2.69
Urban (Top 5)	Canterbury Region	Public Transport	-2.12	-0.09	-2.03
Urban (Top 5)	Waikato Region	Active Transport	-3.37	-1.20	-2.17
Urban (Top 5)	Waikato Region	At home	2.68	3.37	-0.69
Urban (Top 5)	Waikato Region	Other Transport	-0.04	-0.31	0.27
Urban (Top 5)	Waikato Region	Private Transport	1.87	-1.82	3.69
Urban (Top 5)	Waikato Region	Public Transport	-1.14	-0.05	-1.09
Urban (Top 5)	Wellington Region	Active Transport	-4.68	-2.17	-2.51
Urban (Top 5)	Wellington Region	At home	3.27	9.95	-6.68

(continued)

urban_group	region	travel_category	Education	Work	diff_in_diff_pp
Urban (Top 5)	Wellington Region	Other Transport	-0.04	-0.25	0.21
Urban (Top 5)	Wellington Region	Private Transport	0.43	-4.99	5.42
Urban (Top 5)	Wellington Region	Public Transport	1.01	-2.55	3.56

Interpretation of output

Positive values indicate categories where education shifted more than work, while negative values indicate larger shifts for work. Large contrasts are evident in several regions, particularly for at-home and private transport categories.

Conclusion

Education and work journeys did not change uniformly within regions; instead, the relative magnitude of change varies by both region and travel category.

8.5 Urban vs Non-Urban Group-Level Shifts

8.5.1 Group-Level Shares and Percentage-Point Changes Regional data are aggregated into Urban and Non-Urban groups to summarise broad spatial patterns while retaining population weighting.

```
group_shares <- edu_work_data_top5 %>%
  filter(urban_group %in% c("Urban (Top 5)", "Non-Urban (Top 5)"),
         census_year %in% c(2018, 2023)) %>%
  group_by(urban_group, journey_type, census_year, travel_category) %>%
  summarise(count = sum(count, na.rm = TRUE), .groups = "drop") %>%
  group_by(urban_group, journey_type, census_year) %>%
  mutate(share = count / sum(count)) %>%
  ungroup()

group_pp_change <- group_shares %>%
  mutate(share_pct = 100 * share) %>%
  select(urban_group, journey_type, census_year, travel_category, share_pct) %>%
  pivot_wider(names_from = census_year, values_from = share_pct, names_prefix = "y") %>%
  mutate(
    pp_change_2018_2023 = y2023 - y2018,
    across(c(y2018, y2023, pp_change_2018_2023), ~ round(.x, 2))
  ) %>%
  arrange(urban_group, journey_type, travel_category)

group_pp_change
```

urban_group	journey_type	travel_category	y2018	y2023	pp_change_2018_2023
Non-Urban (Top 5)	Education	Active Transport	22.81	19.61	-3.21
Non-Urban (Top 5)	Education	At home	7.26	10.04	2.79
Non-Urban (Top 5)	Education	Other Transport	1.50	1.13	-0.37
Non-Urban (Top 5)	Education	Private Transport	50.02	51.70	1.68
Non-Urban (Top 5)	Education	Public Transport	18.41	17.51	-0.90
Non-Urban (Top 5)	Work	Active Transport	7.58	6.73	-0.85
Non-Urban (Top 5)	Work	At home	17.18	17.87	0.69
Non-Urban (Top 5)	Work	Other Transport	1.74	1.54	-0.19

(continued)

urban_group	journey_type	travel_category	y2018	y2023	pp_change_2018_2023
Non-Urban (Top 5)	Work	Private Transport	73.15	73.54	0.39
Non-Urban (Top 5)	Work	Public Transport	0.35	0.32	-0.03
Urban (Top 5)	Education	Active Transport	23.39	21.01	-2.37
Urban (Top 5)	Education	At home	4.65	7.61	2.96
Urban (Top 5)	Education	Other Transport	1.38	1.41	0.03
Urban (Top 5)	Education	Private Transport	49.80	50.57	0.77
Urban (Top 5)	Education	Public Transport	20.79	19.40	-1.39
Urban (Top 5)	Work	Active Transport	6.51	5.35	-1.16
Urban (Top 5)	Work	At home	10.13	17.91	7.78
Urban (Top 5)	Work	Other Transport	1.43	1.32	-0.11
Urban (Top 5)	Work	Private Transport	72.76	68.47	-4.29
Urban (Top 5)	Work	Public Transport	9.16	6.95	-2.21

Interpretation of output

Work travel in urban regions shows a particularly large increase in at-home travel and a substantial decline in private transport, whereas non-urban regions exhibit smaller shifts overall.

Conclusion

Urban and non-urban areas experienced qualitatively different time-based reallocations of travel modes, especially for work journeys.

```
group_did <- group_pp_change %>%
  select(urban_group, journey_type, travel_category, pp_change_2018_2023) %>%
  pivot_wider(names_from = journey_type, values_from = pp_change_2018_2023) %>%
  mutate(diff_in_diff_pp = round(Education - Work, 2)) %>%
  arrange(urban_group, travel_category)

group_did
```

8.5.2 Group-Level Education vs Work Difference-in-Differences

urban_group	travel_category	Education	Work	diff_in_diff_pp
Non-Urban (Top 5)	Active Transport	-3.21	-0.85	-2.36
Non-Urban (Top 5)	At home	2.79	0.69	2.10
Non-Urban (Top 5)	Other Transport	-0.37	-0.19	-0.18
Non-Urban (Top 5)	Private Transport	1.68	0.39	1.29
Non-Urban (Top 5)	Public Transport	-0.90	-0.03	-0.87
Urban (Top 5)	Active Transport	-2.37	-1.16	-1.21
Urban (Top 5)	At home	2.96	7.78	-4.82
Urban (Top 5)	Other Transport	0.03	-0.11	0.14
Urban (Top 5)	Private Transport	0.77	-4.29	5.06
Urban (Top 5)	Public Transport	-1.39	-2.21	0.82

Interpretation of output

In urban areas, work journeys experienced far larger increases in at-home travel than education journeys, while education showed relatively smaller declines in private transport. These contrasts are less pronounced in non-urban regions.

8.6 Statistical Testing of Time-Based Shifts by Region and Journey Type

To complement descriptive results, chi-square tests are applied within each region and journey type to formally confirm the presence of time-based change.

```
chi_by_region_journey <- edu_work_data_top5 %>%
  filter(
    urban_group %in% c("Urban (Top 5)", "Non-Urban (Top 5)"),
    census_year %in% c(2018, 2023)
  ) %>%
  group_by(urban_group, region, journey_type) %>%
  group_modify(~{
    tab <- .x %>%
      group_by(census_year, travel_category) %>%
      summarise(n = sum(count, na.rm = TRUE), .groups = "drop") %>%
      pivot_wider(
        names_from  = travel_category,
        values_from = n,
        values_fill = 0
      ) %>%
      arrange(census_year)

    mat <- as.matrix(tab %>% select(-census_year))
    rownames(mat) <- tab$census_year

    tst <- suppressWarnings(chisq.test(mat))

    tibble(
      chi_sq  = unname(tst$statistic),
      df      = unname(tst$parameter),
      p_value = tst$p.value
    )
  }) %>%
  ungroup() %>%
  arrange(urban_group, region, journey_type)

chi_by_region_journey %>%
  dplyr::mutate(p_value = formatC(p_value, format = "e", digits = 3))
```

urban_group	region	journey_type	chi_sq	df	p_value
Non-Urban (Top 5)	Gisborne Region	Education	255.75337	4	3.750e-54
Non-Urban (Top 5)	Gisborne Region	Work	63.12608	4	6.384e-13
Non-Urban (Top 5)	Marlborough Region	Education	57.32939	4	1.055e-11
Non-Urban (Top 5)	Marlborough Region	Work	60.83768	4	1.934e-12
Non-Urban (Top 5)	Southland Region	Education	156.96307	4	6.549e-33
Non-Urban (Top 5)	Southland Region	Work	19.46648	4	6.363e-04
Non-Urban (Top 5)	Tasman Region	Education	42.19850	4	1.517e-08
Non-Urban (Top 5)	Tasman Region	Work	61.95009	4	1.129e-12
Non-Urban (Top 5)	West Coast Region	Education	128.22866	4	9.315e-27
Non-Urban (Top 5)	West Coast Region	Work	41.49251	4	2.125e-08
Urban (Top 5)	Auckland Region	Education	8436.38612	4	0.000e+00
Urban (Top 5)	Auckland Region	Work	68920.83760	4	0.000e+00
Urban (Top 5)	Bay of Plenty Region	Education	634.13825	4	6.326e-136

(continued)

urban_group	region	journey_type	chi_sq	df	p_value
Urban (Top 5)	Bay of Plenty Region	Work	649.67885	4	2.735e-139
Urban (Top 5)	Canterbury Region	Education	1050.13744	4	4.860e-226
Urban (Top 5)	Canterbury Region	Work	1588.73351	4	0.000e+00
Urban (Top 5)	Waikato Region	Education	1008.45614	4	5.248e-217
Urban (Top 5)	Waikato Region	Work	1291.03677	4	2.921e-278
Urban (Top 5)	Wellington Region	Education	1479.94765	4	3.186e-319
Urban (Top 5)	Wellington Region	Work	11793.44793	4	0.000e+00

```
head(edu_work_data_top5)
```

```
##   journey_type census_year          region district sa2_code
## 1    Education        2018 Auckland Region Auckland     7601
## 2    Education        2018 Auckland Region Auckland     7601
## 3    Education        2018 Auckland Region Auckland     7601
## 4    Education        2018 Auckland Region Auckland     7601
## 5    Education        2018 Auckland Region Auckland     7601
## 6    Education        2018 Auckland Region Auckland     7601
##                       sa2 mode_code          mode travel_category
## 1 Rodney Local Board Area         1 Study at home         At home
## 2 Rodney Local Board Area         1 Study at home         At home
## 3 Rodney Local Board Area         1 Study at home         At home
## 4 Rodney Local Board Area         1 Study at home         At home
## 5 Rodney Local Board Area         1 Study at home         At home
## 6 Rodney Local Board Area         1 Study at home         At home
##   age_group_code      age_group gender_code gender count   urban_group
## 1              1 Under 15 years           1   Male    69 Urban (Top 5)
## 2              1 Under 15 years           2 Female    69 Urban (Top 5)
## 3              1 Under 15 years           3  Other     3 Urban (Top 5)
## 4              2    15-29 years           1   Male    99 Urban (Top 5)
## 5              2    15-29 years           2 Female   159 Urban (Top 5)
## 6              2    15-29 years           3  Other     0 Urban (Top 5)
```

Interpretation of output

All region–journey combinations exhibit statistically significant changes over time. Given Census-scale sample sizes, these tests serve as confirmation rather than as indicators of practical importance.

Conclusion

Time-based changes in travel mode distributions are robust across regions and journey purposes, reinforcing the validity of the descriptive percentage-point analyses.

8.7 City-Level Illustrative Analysis

To provide intuitive examples, the analysis is repeated for major urban centres (Auckland and Wellington) and two contrasting regions (Canterbury and West Coast).

```
city_regions <- c("Auckland Region", "Wellington Region", "Canterbury Region", "West Coast Region")
```

```
city_shares <- edu_work_data %>%
  filter(region %in% city_regions,
         census_year %in% c(2018, 2023)) %>%
  group_by(region, journey_type, census_year, travel_category) %>%
  summarise(count = sum(count, na.rm = TRUE), .groups = "drop") %>%
  group_by(region, journey_type, census_year) %>%
  mutate(share = count / sum(count)) %>%
  ungroup()

city_pp_change <- city_shares %>%
  mutate(share_pct = 100 * share) %>%
  select(region, journey_type, census_year, travel_category, share_pct) %>%
  pivot_wider(names_from = census_year, values_from = share_pct, names_prefix = "y") %>%
  mutate(
    pp_change_2018_2023 = y2023 - y2018,
    across(c(y2018, y2023, pp_change_2018_2023), ~ round(.x, 2))
  ) %>%
  arrange(region, journey_type, travel_category)

city_pp_change
```

8.7.1 City-Level Shares and Percentage-Point Changes

region	journey_type	travel_category	y2018	y2023	pp_change_2018_2023
Auckland Region	Education	Active Transport	22.47	20.33	-2.14
Auckland Region	Education	At home	3.97	6.99	3.02
Auckland Region	Education	Other Transport	1.32	1.42	0.10
Auckland Region	Education	Private Transport	49.78	50.63	0.85
Auckland Region	Education	Public Transport	22.45	20.63	-1.83
Auckland Region	Work	Active Transport	5.37	4.24	-1.13
Auckland Region	Work	At home	8.77	18.15	9.37
Auckland Region	Work	Other Transport	1.32	1.21	-0.12
Auckland Region	Work	Private Transport	73.76	68.65	-5.11
Auckland Region	Work	Public Transport	10.78	7.76	-3.02
Canterbury Region	Education	Active Transport	26.78	26.38	-0.40
Canterbury Region	Education	At home	5.51	8.22	2.72
Canterbury Region	Education	Other Transport	1.81	1.69	-0.11
Canterbury Region	Education	Private Transport	50.56	50.47	-0.09
Canterbury Region	Education	Public Transport	15.35	13.23	-2.12
Canterbury Region	Work	Active Transport	8.06	7.49	-0.56
Canterbury Region	Work	At home	12.41	15.69	3.28
Canterbury Region	Work	Other Transport	1.51	1.67	0.16
Canterbury Region	Work	Private Transport	75.17	72.38	-2.78
Canterbury Region	Work	Public Transport	2.85	2.76	-0.09
Wellington Region	Education	Active Transport	28.54	23.85	-4.68
Wellington Region	Education	At home	5.98	9.26	3.27
Wellington Region	Education	Other Transport	1.64	1.60	-0.04
Wellington Region	Education	Private Transport	41.98	42.41	0.43
Wellington Region	Education	Public Transport	21.86	22.88	1.01
Wellington Region	Work	Active Transport	12.90	10.74	-2.17
Wellington Region	Work	At home	9.10	19.05	9.95

(continued)

region	journey_type	travel_category	y2018	y2023	pp_change_2018_2023
Wellington Region	Work	Other Transport	1.85	1.59	-0.25
Wellington Region	Work	Private Transport	58.15	53.16	-4.99
Wellington Region	Work	Public Transport	18.01	15.46	-2.55
West Coast Region	Education	Active Transport	25.19	19.94	-5.25
West Coast Region	Education	At home	9.47	13.79	4.32
West Coast Region	Education	Other Transport	1.06	0.69	-0.37
West Coast Region	Education	Private Transport	43.03	47.91	4.88
West Coast Region	Education	Public Transport	21.25	17.68	-3.57
West Coast Region	Work	Active Transport	10.20	8.53	-1.67
West Coast Region	Work	At home	20.30	19.22	-1.08
West Coast Region	Work	Other Transport	1.48	1.33	-0.15
West Coast Region	Work	Private Transport	67.90	70.79	2.89
West Coast Region	Work	Public Transport	0.12	0.12	0.00

Interpretation of output

Major cities show pronounced increases in work-from-home and sharp declines in private transport for work journeys, whereas education travel changes are more modest.

```
city_did <- city_pp_change %>%
  select(region, journey_type, travel_category, pp_change_2018_2023) %>%
  pivot_wider(names_from = journey_type, values_from = pp_change_2018_2023) %>%
  mutate(diff_in_diff_pp = round(Education - Work, 2)) %>%
  arrange(region, travel_category)

city_did
```

8.7.2 City-Level Education vs Work Difference-in-Differences

region	travel_category	Education	Work	diff_in_diff_pp
Auckland Region	Active Transport	-2.14	-1.13	-1.01
Auckland Region	At home	3.02	9.37	-6.35
Auckland Region	Other Transport	0.10	-0.12	0.22
Auckland Region	Private Transport	0.85	-5.11	5.96
Auckland Region	Public Transport	-1.83	-3.02	1.19
Canterbury Region	Active Transport	-0.40	-0.56	0.16
Canterbury Region	At home	2.72	3.28	-0.56
Canterbury Region	Other Transport	-0.11	0.16	-0.27
Canterbury Region	Private Transport	-0.09	-2.78	2.69
Canterbury Region	Public Transport	-2.12	-0.09	-2.03
Wellington Region	Active Transport	-4.68	-2.17	-2.51
Wellington Region	At home	3.27	9.95	-6.68
Wellington Region	Other Transport	-0.04	-0.25	0.21
Wellington Region	Private Transport	0.43	-4.99	5.42
Wellington Region	Public Transport	1.01	-2.55	3.56
West Coast Region	Active Transport	-5.25	-1.67	-3.58
West Coast Region	At home	4.32	-1.08	5.40
West Coast Region	Other Transport	-0.37	-0.15	-0.22

(continued)

region	travel_category	Education	Work	diff_in_diff_pp
West Coast Region	Private Transport	4.88	2.89	1.99
West Coast Region	Public Transport	-3.57	0.00	-3.57

Conclusion

City-level results reinforce earlier findings: work travel experienced larger and more concentrated shifts toward at-home arrangements than education travel, particularly in major urban centres.

9. Drivers of Change: Gender, Age Group, and Region

This section identifies which subgroups (gender, age group, region) drove the 2018->2023 changes in travel behaviour, separately for Journey to Education and Journey to Work, and then compares the two journey types. We use two complementary lenses:

1. Percentage-point (pp) change in mode share within each subgroup (composition shift)
2. Δ count contribution to quantify which subgroups account for the largest absolute increases/decreases (volume drivers)

9.1 Helper Function: Percentage-Point Change by Subgroup and Journey Type

This helper standardises the computation of travel-category shares (in %) in 2018 and 2023 and the pp change between years, within each subgroup and journey type. It is reused for gender, age group, and region.

```
pp_change_by_group_journey <- function(data, group_vars) {

  data %>%
    filter(census_year %in% c(2018, 2023)) %>%
    group_by(across(all_of(c("journey_type", group_vars, "census_year", "travel_category")))) %>%
    summarise(count = sum(count, na.rm = TRUE), .groups = "drop") %>%
    group_by(across(all_of(c("journey_type", group_vars, "census_year")))) %>%
    mutate(share = count / sum(count)) %>%
    ungroup() %>%
    mutate(share_pct = 100 * share) %>%
    select(journey_type, all_of(group_vars), census_year, travel_category, share_pct) %>%
    pivot_wider(
      names_from = census_year,
      values_from = share_pct,
      names_prefix = "y"
    ) %>%
    mutate(
      pp_change_2018_2023 = y2023 - y2018,
      across(c(y2018, y2023, pp_change_2018_2023), ~ round(.x, 2))
    )
}
```

Interpretation of output

- The output is stratified by `journey_type` and the subgroup (e.g., gender).
- `pp_change_2018_2023` is the within-subgroup change in mode share (percentage points).

9.2 Gender Drivers: pp-Change by Gender for Education and Work

This block answers: Do mode shares shift differently by gender for Education compared with Work?

```
gender_pp_by_journey <- pp_change_by_group_journey(edu_work_data, group_vars = c("gender"))

gender_pp_by_journey %>%
  arrange(journey_type, gender, desc(abs(pp_change_2018_2023)))
```

journey_type	gender	travel_category	y2018	y2023	pp_change_2018_2023
Education	Female	At home	6.07	10.06	3.99
Education	Female	Active Transport	21.85	19.22	-2.63
Education	Female	Public Transport	20.23	18.55	-1.68
Education	Female	Private Transport	50.88	51.17	0.30
Education	Female	Other Transport	0.98	1.00	0.02
Education	Male	Active Transport	25.65	23.11	-2.54
Education	Male	At home	3.47	5.32	1.85
Education	Male	Private Transport	49.81	51.63	1.82
Education	Male	Public Transport	19.50	18.37	-1.13
Education	Male	Other Transport	1.57	1.57	0.00
Education	Other	Public Transport	24.96	26.66	1.71
Education	Other	Other Transport	6.02	4.99	-1.04
Education	Other	At home	18.10	17.34	-0.76
Education	Other	Active Transport	20.94	21.13	0.19
Education	Other	Private Transport	29.98	29.88	-0.10
Work	Female	At home	11.72	19.37	7.65
Work	Female	Private Transport	71.80	67.25	-4.55
Work	Female	Public Transport	8.99	6.90	-2.09
Work	Female	Active Transport	6.78	5.66	-1.13
Work	Female	Other Transport	0.71	0.81	0.11
Work	Male	At home	10.56	16.37	5.81
Work	Male	Private Transport	74.55	71.60	-2.94
Work	Male	Public Transport	6.23	4.72	-1.52
Work	Male	Active Transport	6.62	5.53	-1.09
Work	Male	Other Transport	2.04	1.78	-0.26
Work	Other	Private Transport	42.98	52.07	9.08
Work	Other	Active Transport	19.28	13.39	-5.89
Work	Other	Other Transport	8.16	2.61	-5.55
Work	Other	Public Transport	12.82	15.07	2.25
Work	Other	At home	16.76	16.86	0.11

Interpretation of output

- Education (Female): "At home" rises +3.99 pp, with declines in Active (−2.63 pp) and Public (−1.68 pp).
- Education (Male): "At home" rises +1.85 pp, Private increases +1.82 pp, Active declines −2.54 pp.
- Work (Female): "At home" rises strongly (+7.65 pp) and Private declines (−4.55 pp).
- Work (Male): similar direction but smaller: "At home" +5.81 pp, Private −2.94 pp.
- "Other" gender shows more volatile shifts, likely reflecting smaller counts and/or category composition differences.

Conclusion

Across genders, Work shows a larger shift toward "At home" than Education, especially for Male and Female groups, while Education changes are more modest and partly offset by increases in Private transport for some groups.

9.3 Gender Diff-in-Diff: Education vs Work pp-Change (Within Gender)

This computes a gender-specific diff-in-diff for each travel category:

Diff-in-Diff = Δ(Education) − Δ(Work)

It answers: For a given gender, did Education shift more than Work?

```
gender_did_pp <- gender_pp_by_journey %>%
  select(journey_type, gender, travel_category, pp_change_2018_2023) %>%
  pivot_wider(names_from = journey_type, values_from = pp_change_2018_2023) %>%
  mutate(
    diff_in_diff_pp = round(Education - Work, 2),
    abs_diff_in_diff = abs(diff_in_diff_pp)
  ) %>%
  arrange(gender, desc(abs_diff_in_diff))

gender_did_pp
```

gender	travel_category	Education	Work	diff_in_diff_pp	abs_diff_in_diff
Female	Private Transport	0.30	-4.55	4.85	4.85
Female	At home	3.99	7.65	-3.66	3.66
Female	Active Transport	-2.63	-1.13	-1.50	1.50
Female	Public Transport	-1.68	-2.09	0.41	0.41
Female	Other Transport	0.02	0.11	-0.09	0.09
Male	Private Transport	1.82	-2.94	4.76	4.76
Male	At home	1.85	5.81	-3.96	3.96
Male	Active Transport	-2.54	-1.09	-1.45	1.45
Male	Public Transport	-1.13	-1.52	0.39	0.39
Male	Other Transport	0.00	-0.26	0.26	0.26
Other	Private Transport	-0.10	9.08	-9.18	9.18
Other	Active Transport	0.19	-5.89	6.08	6.08
Other	Other Transport	-1.04	-5.55	4.51	4.51
Other	At home	-0.76	0.11	-0.87	0.87
Other	Public Transport	1.71	2.25	-0.54	0.54

Interpretation of output

- For Female and Male, the largest divergences are:
  - Private Transport: Education increases slightly while Work decreases -> large positive diff-in-diff (~ +4.8 pp).
  - At home: Work increases much more than Education -> negative diff-in-diff (about -3.7 to -4.0 pp).
- For Other, diff-in-diff values are large (e.g., Private -9.18 pp, Active +6.08 pp), suggesting Work changed very differently than Education for this group.

Conclusion

Within each gender, Work experienced a substantially stronger increase in "At home" travel than Education, while Education showed relatively larger increases (or smaller declines) in Private Transport. This pattern is consistent across both Male and Female groups, indicating a systematic divergence in post-2018 travel adjustments between education and work journeys. For the 'Other' gender category, diff-in-diff estimates are large but directionally mixed, suggesting heterogeneous changes that should be interpreted cautiously due to smaller group sizes

9.4 Age Group Drivers: pp-Change by Age Group for Education and Work

This block identifies which age groups show the largest changes in mode shares from 2018 to 2023, separately for Education and Work.

```
age_pp_by_journey <- pp_change_by_group_journey(edu_work_data, group_vars = c("age_group"))

age_pp_by_journey %>%
  arrange(journey_type, age_group, desc(abs(pp_change_2018_2023)))
```

journey_type	age_group	travel_category	y2018	y2023	pp_change_2018_2023
Education	15-29 years	At home	5.34	9.08	3.73
Education	15-29 years	Active Transport	24.61	21.96	-2.65
Education	15-29 years	Public Transport	33.29	30.95	-2.34
Education	15-29 years	Private Transport	35.29	36.46	1.17
Education	15-29 years	Other Transport	1.47	1.55	0.08
Education	30-64 years	At home	29.12	43.16	14.04
Education	30-64 years	Private Transport	50.02	41.65	-8.38
Education	30-64 years	Public Transport	11.18	8.38	-2.80
Education	30-64 years	Active Transport	8.00	5.50	-2.50
Education	30-64 years	Other Transport	1.68	1.31	-0.37
Education	Over 64 years	At home	20.49	34.28	13.79
Education	Over 64 years	Private Transport	56.08	46.24	-9.84
Education	Over 64 years	Public Transport	13.76	10.63	-3.13
Education	Over 64 years	Active Transport	8.11	7.32	-0.79
Education	Over 64 years	Other Transport	1.56	1.52	-0.03
Education	Under 15 years	Active Transport	25.82	23.53	-2.29
Education	Under 15 years	Private Transport	57.57	59.84	2.27
Education	Under 15 years	At home	0.91	1.05	0.14
Education	Under 15 years	Public Transport	14.44	14.30	-0.13
Education	Under 15 years	Other Transport	1.27	1.28	0.01
Work	15-29 years	At home	5.91	9.39	3.48
Work	15-29 years	Active Transport	10.18	7.97	-2.21
Work	15-29 years	Public Transport	11.50	9.62	-1.89
Work	15-29 years	Private Transport	70.53	71.16	0.63
Work	15-29 years	Other Transport	1.88	1.86	-0.01
Work	30-64 years	At home	11.85	19.55	7.69
Work	30-64 years	Private Transport	74.73	69.59	-5.14
Work	30-64 years	Public Transport	6.41	4.76	-1.65
Work	30-64 years	Active Transport	5.67	4.94	-0.74
Work	30-64 years	Other Transport	1.33	1.17	-0.17
Work	Over 64 years	At home	25.28	29.96	4.69
Work	Over 64 years	Private Transport	65.28	62.16	-3.12

(continued)

journey_type	age_group	travel_category	y2018	y2023	pp_change_2018_2023
Work	Over 64 years	Public Transport	3.73	2.79	-0.94
Work	Over 64 years	Active Transport	4.64	4.16	-0.48
Work	Over 64 years	Other Transport	1.08	0.93	-0.15

Interpretation of output

- Education:
  - 30–64 and Over 64 show very large "At home" increases (+14.04 pp, +13.79 pp) and large Private declines (-8.38 pp, -9.84 pp).
  - Under 15 shows Private increases (+2.27 pp) and Active declines (-2.29 pp).
- Work:
  - 30–64 shows strong "At home" increase (+7.69 pp) with Private decline (-5.14 pp).
  - 15–29 shows a modest "At home" increase (+3.48 pp) and Active/Public declines.

Conclusion

Age patterns are materially different: Education shifts are especially pronounced for 30–64 and Over 64, whereas Work's strongest shifts are concentrated in 30–64.

9.5 Age Group Diff-in-Diff: Education vs Work pp-Change (Within Age)

This compares Education vs Work shifts within each age group using diff-in-diff pp changes.

```
age_did_pp <- age_pp_by_journey %>%
  select(journey_type, age_group, travel_category, pp_change_2018_2023) %>%
  pivot_wider(names_from = journey_type, values_from = pp_change_2018_2023) %>%
  mutate(
    diff_in_diff_pp = round(Education - Work, 2),
    abs_diff_in_diff = abs(diff_in_diff_pp)
  ) %>%
  arrange(age_group, desc(abs_diff_in_diff))

age_did_pp
```

age_group	travel_category	Education	Work	diff_in_diff_pp	abs_diff_in_diff
15-29 years	Private Transport	1.17	0.63	0.54	0.54
15-29 years	Public Transport	-2.34	-1.89	-0.45	0.45
15-29 years	Active Transport	-2.65	-2.21	-0.44	0.44
15-29 years	At home	3.73	3.48	0.25	0.25
15-29 years	Other Transport	0.08	-0.01	0.09	0.09
30-64 years	At home	14.04	7.69	6.35	6.35
30-64 years	Private Transport	-8.38	-5.14	-3.24	3.24
30-64 years	Active Transport	-2.50	-0.74	-1.76	1.76
30-64 years	Public Transport	-2.80	-1.65	-1.15	1.15
30-64 years	Other Transport	-0.37	-0.17	-0.20	0.20

(continued)

age_group	travel_category	Education	Work	diff_in_diff_pp	abs_diff_in_diff
Over 64 years	At home	13.79	4.69	9.10	9.10
Over 64 years	Private Transport	-9.84	-3.12	-6.72	6.72
Over 64 years	Public Transport	-3.13	-0.94	-2.19	2.19
Over 64 years	Active Transport	-0.79	-0.48	-0.31	0.31
Over 64 years	Other Transport	-0.03	-0.15	0.12	0.12
Under 15 years	Active Transport	-2.29	NA	NA	NA
Under 15 years	At home	0.14	NA	NA	NA
Under 15 years	Other Transport	0.01	NA	NA	NA
Under 15 years	Private Transport	2.27	NA	NA	NA
Under 15 years	Public Transport	-0.13	NA	NA	NA

Interpretation of output

- 30–64: Education "At home" increased 6.35 pp more than Work (14.04 vs 7.69).
- Over 64: Education "At home" increased 9.10 pp more than Work (13.79 vs 4.69), and Education Private declined 6.72 pp more than Work.
- Under 15: Work is NA (not applicable), so diff-in-diff is undefined; interpret Education-only changes for this group.

Conclusion

The strongest Education-vs-Work divergences occur for 30–64 and Over 64, where Education shows a substantially stronger shift toward "At home" than Work.

9.6 Region Drivers: pp-Change by Region for Education and Work

This block identifies spatial variation in shifts and supports later selection of case-study regions.

```
region_pp_by_journey <- pp_change_by_group_journey(edu_work_data, group_vars = c("region"))

region_pp_by_journey %>%
  arrange(journey_type, region, desc(abs(pp_change_2018_2023)))
```

journey_type	region	travel_category	y2018	y2023	pp_change_2018_2023
Education	Area Outside Region	Private Transport	20.51	32.35	11.84
Education	Area Outside Region	Active Transport	25.64	17.65	-7.99
Education	Area Outside Region	Other Transport	5.13	0.00	-5.13
Education	Area Outside Region	Public Transport	38.46	41.18	2.71
Education	Area Outside Region	At home	10.26	8.82	-1.43
Education	Auckland Region	At home	3.97	6.99	3.02
Education	Auckland Region	Active Transport	22.47	20.33	-2.14
Education	Auckland Region	Public Transport	22.45	20.63	-1.83
Education	Auckland Region	Private Transport	49.78	50.63	0.85
Education	Auckland Region	Other Transport	1.32	1.42	0.10
Education	Bay of Plenty Region	Active Transport	21.17	17.88	-3.29
Education	Bay of Plenty Region	At home	6.12	8.90	2.77
Education	Bay of Plenty Region	Public Transport	18.30	19.38	1.08

(continued)

journey_type	region	travel_category	y2018	y2023	pp_change_2018_2023
Education	Bay of Plenty Region	Private Transport	53.22	52.82	-0.40
Education	Bay of Plenty Region	Other Transport	1.19	1.03	-0.16
Education	Canterbury Region	At home	5.51	8.22	2.72
Education	Canterbury Region	Public Transport	15.35	13.23	-2.12
Education	Canterbury Region	Active Transport	26.78	26.38	-0.40
Education	Canterbury Region	Other Transport	1.81	1.69	-0.11
Education	Canterbury Region	Private Transport	50.56	50.47	-0.09
Education	Gisborne Region	Active Transport	20.64	14.30	-6.34
Education	Gisborne Region	Private Transport	55.19	60.43	5.24
Education	Gisborne Region	At home	6.02	8.78	2.76
Education	Gisborne Region	Public Transport	16.30	15.16	-1.14
Education	Gisborne Region	Other Transport	1.85	1.33	-0.52
Education	Hawke's Bay Region	Active Transport	23.41	18.99	-4.41
Education	Hawke's Bay Region	Private Transport	54.06	57.47	3.42
Education	Hawke's Bay Region	At home	6.52	9.22	2.69
Education	Hawke's Bay Region	Public Transport	14.47	12.79	-1.68
Education	Hawke's Bay Region	Other Transport	1.54	1.52	-0.01
Education	Manawatu-Whanganui Region	Active Transport	22.21	17.82	-4.39
Education	Manawatu-Whanganui Region	Private Transport	53.70	57.76	4.06
Education	Manawatu-Whanganui Region	At home	7.75	10.44	2.69
Education	Manawatu-Whanganui Region	Public Transport	14.98	12.69	-2.29
Education	Manawatu-Whanganui Region	Other Transport	1.35	1.28	-0.07
Education	Marlborough Region	At home	8.85	11.93	3.08
Education	Marlborough Region	Private Transport	50.86	48.97	-1.89
Education	Marlborough Region	Other Transport	1.94	1.34	-0.60
Education	Marlborough Region	Active Transport	25.61	25.05	-0.56
Education	Marlborough Region	Public Transport	12.74	12.71	-0.03
Education	Nelson Region	At home	6.77	10.39	3.62
Education	Nelson Region	Active Transport	37.09	34.25	-2.84
Education	Nelson Region	Private Transport	45.00	43.79	-1.21
Education	Nelson Region	Public Transport	8.90	9.39	0.49
Education	Nelson Region	Other Transport	2.23	2.18	-0.05
Education	Northland Region	Active Transport	13.18	10.23	-2.94
Education	Northland Region	At home	7.29	10.24	2.94
Education	Northland Region	Private Transport	51.70	53.73	2.03
Education	Northland Region	Public Transport	26.91	25.05	-1.86
Education	Northland Region	Other Transport	0.92	0.74	-0.17
Education	Otago Region	At home	5.63	8.08	2.45
Education	Otago Region	Active Transport	37.64	35.87	-1.76
Education	Otago Region	Private Transport	43.43	42.46	-0.96
Education	Otago Region	Public Transport	12.24	12.68	0.44
Education	Otago Region	Other Transport	1.07	0.90	-0.17
Education	Southland Region	Active Transport	21.11	18.24	-2.87
Education	Southland Region	At home	6.05	8.59	2.54
Education	Southland Region	Private Transport	52.20	53.23	1.03
Education	Southland Region	Public Transport	19.43	18.96	-0.47
Education	Southland Region	Other Transport	1.21	0.98	-0.23
Education	Taranaki Region	Active Transport	21.07	17.76	-3.31
Education	Taranaki Region	At home	8.09	10.58	2.49
Education	Taranaki Region	Private Transport	53.74	55.24	1.50
Education	Taranaki Region	Public Transport	15.79	15.26	-0.52
Education	Taranaki Region	Other Transport	1.32	1.16	-0.16

(continued)

journey_type	region	travel_category	y2018	y2023	pp_change_2018_2023
Education	Tasman Region	At home	8.47	10.77	2.30
Education	Tasman Region	Active Transport	24.98	23.46	-1.52
Education	Tasman Region	Public Transport	21.63	21.08	-0.55
Education	Tasman Region	Other Transport	1.59	1.28	-0.31
Education	Tasman Region	Private Transport	43.33	43.42	0.08
Education	Waikato Region	Active Transport	21.15	17.78	-3.37
Education	Waikato Region	At home	5.86	8.54	2.68
Education	Waikato Region	Private Transport	55.61	57.49	1.87
Education	Waikato Region	Public Transport	16.29	15.15	-1.14
Education	Waikato Region	Other Transport	1.08	1.04	-0.04
Education	Wellington Region	Active Transport	28.54	23.85	-4.68
Education	Wellington Region	At home	5.98	9.26	3.27
Education	Wellington Region	Public Transport	21.86	22.88	1.01
Education	Wellington Region	Private Transport	41.98	42.41	0.43
Education	Wellington Region	Other Transport	1.64	1.60	-0.04
Education	West Coast Region	Active Transport	25.19	19.94	-5.25
Education	West Coast Region	Private Transport	43.03	47.91	4.88
Education	West Coast Region	At home	9.47	13.79	4.32
Education	West Coast Region	Public Transport	21.25	17.68	-3.57
Education	West Coast Region	Other Transport	1.06	0.69	-0.37
Work	Area Outside Region	At home	20.55	27.14	6.59
Work	Area Outside Region	Private Transport	66.44	62.86	-3.58
Work	Area Outside Region	Public Transport	1.37	0.00	-1.37
Work	Area Outside Region	Other Transport	4.11	2.86	-1.25
Work	Area Outside Region	Active Transport	7.53	7.14	-0.39
Work	Auckland Region	At home	8.77	18.15	9.37
Work	Auckland Region	Private Transport	73.76	68.65	-5.11
Work	Auckland Region	Public Transport	10.78	7.76	-3.02
Work	Auckland Region	Active Transport	5.37	4.24	-1.13
Work	Auckland Region	Other Transport	1.32	1.21	-0.12
Work	Bay of Plenty Region	At home	14.47	17.50	3.03
Work	Bay of Plenty Region	Private Transport	77.94	76.02	-1.92
Work	Bay of Plenty Region	Active Transport	5.12	4.25	-0.87
Work	Bay of Plenty Region	Other Transport	1.29	1.16	-0.13
Work	Bay of Plenty Region	Public Transport	1.18	1.07	-0.11
Work	Canterbury Region	At home	12.41	15.69	3.28
Work	Canterbury Region	Private Transport	75.17	72.38	-2.78
Work	Canterbury Region	Active Transport	8.06	7.49	-0.56
Work	Canterbury Region	Other Transport	1.51	1.67	0.16
Work	Canterbury Region	Public Transport	2.85	2.76	-0.09
Work	Gisborne Region	At home	15.05	16.40	1.35
Work	Gisborne Region	Active Transport	6.06	4.88	-1.17
Work	Gisborne Region	Other Transport	1.51	1.19	-0.32
Work	Gisborne Region	Private Transport	76.93	77.25	0.32
Work	Gisborne Region	Public Transport	0.45	0.27	-0.18
Work	Hawke's Bay Region	At home	13.77	15.73	1.96
Work	Hawke's Bay Region	Active Transport	5.86	4.67	-1.20
Work	Hawke's Bay Region	Other Transport	1.38	0.97	-0.41
Work	Hawke's Bay Region	Private Transport	78.36	78.17	-0.19
Work	Hawke's Bay Region	Public Transport	0.62	0.47	-0.15
Work	Manawatu-Whanganui Region	At home	13.92	16.34	2.42

(continued)

journey_type	region	travel_category	y2018	y2023	pp_change_2018_2023
Work	Manawatu-Whanganui Region	Active Transport	7.87	5.91	-1.95
Work	Manawatu-Whanganui Region	Other Transport	1.70	1.36	-0.34
Work	Manawatu-Whanganui Region	Public Transport	1.04	0.79	-0.24
Work	Manawatu-Whanganui Region	Private Transport	75.47	75.59	0.12
Work	Marlborough Region	Active Transport	9.17	7.84	-1.32
Work	Marlborough Region	At home	15.65	16.71	1.06
Work	Marlborough Region	Private Transport	73.60	74.30	0.69
Work	Marlborough Region	Other Transport	1.42	0.96	-0.46
Work	Marlborough Region	Public Transport	0.16	0.19	0.03
Work	Nelson Region	Private Transport	71.21	67.55	-3.66
Work	Nelson Region	At home	12.18	14.85	2.66
Work	Nelson Region	Active Transport	13.63	14.49	0.85
Work	Nelson Region	Public Transport	0.99	1.20	0.21
Work	Nelson Region	Other Transport	1.98	1.91	-0.07
Work	Northland Region	At home	17.22	20.72	3.50
Work	Northland Region	Private Transport	76.16	74.05	-2.11
Work	Northland Region	Active Transport	4.71	3.76	-0.95
Work	Northland Region	Other Transport	1.31	1.07	-0.24
Work	Northland Region	Public Transport	0.60	0.40	-0.20
Work	Otago Region	At home	14.05	16.43	2.38
Work	Otago Region	Private Transport	70.60	69.05	-1.55
Work	Otago Region	Active Transport	11.53	10.19	-1.34
Work	Otago Region	Public Transport	2.64	3.22	0.58
Work	Otago Region	Other Transport	1.17	1.10	-0.07
Work	Southland Region	Private Transport	73.86	74.78	0.92
Work	Southland Region	Active Transport	6.26	5.71	-0.55
Work	Southland Region	At home	17.28	17.01	-0.27
Work	Southland Region	Other Transport	2.16	2.05	-0.11
Work	Southland Region	Public Transport	0.44	0.45	0.01
Work	Taranaki Region	Active Transport	6.55	5.22	-1.32
Work	Taranaki Region	At home	17.51	18.81	1.30
Work	Taranaki Region	Other Transport	2.19	1.75	-0.43
Work	Taranaki Region	Private Transport	73.32	73.75	0.43
Work	Taranaki Region	Public Transport	0.43	0.46	0.03
Work	Tasman Region	At home	18.27	20.83	2.57
Work	Tasman Region	Private Transport	71.46	69.20	-2.26
Work	Tasman Region	Active Transport	8.31	8.08	-0.23
Work	Tasman Region	Public Transport	0.42	0.36	-0.05
Work	Tasman Region	Other Transport	1.55	1.53	-0.02
Work	Waikato Region	At home	14.97	18.34	3.37
Work	Waikato Region	Private Transport	76.31	74.49	-1.82
Work	Waikato Region	Active Transport	5.72	4.52	-1.20
Work	Waikato Region	Other Transport	1.69	1.38	-0.31
Work	Waikato Region	Public Transport	1.31	1.27	-0.05
Work	Wellington Region	At home	9.10	19.05	9.95
Work	Wellington Region	Private Transport	58.15	53.16	-4.99
Work	Wellington Region	Public Transport	18.01	15.46	-2.55
Work	Wellington Region	Active Transport	12.90	10.74	-2.17
Work	Wellington Region	Other Transport	1.85	1.59	-0.25
Work	West Coast Region	Private Transport	67.90	70.79	2.89
Work	West Coast Region	Active Transport	10.20	8.53	-1.67
Work	West Coast Region	At home	20.30	19.22	-1.08

(continued)

journey_type	region	travel_category	y2018	y2023	pp_change_2018_2023
Work	West Coast Region	Other Transport	1.48	1.33	-0.15
Work	West Coast Region	Public Transport	0.12	0.12	0.00

Interpretation of output

- Regions exhibit strong heterogeneity in which categories drive change.
- "Area Outside Region" shows unusually large shifts (e.g., Education Private +11.84 pp), suggesting it may represent a special aggregation category and should be interpreted cautiously.

Conclusion

Regional variation is substantial; summarising with diff-in-diff highlights where Education changed differently from Work.

9.7 Region Diff-in-Diff: Education vs Work pp-Change (Within Region)

This provides the most direct region-level comparison: for each region and category, did Education shift more than Work?

```
region_did_pp <- region_pp_by_journey %>%
  select(journey_type, region, travel_category, pp_change_2018_2023) %>%
  pivot_wider(names_from = journey_type, values_from = pp_change_2018_2023) %>%
  mutate(
    diff_in_diff_pp = round(Education - Work, 2),
    abs_diff_in_diff = abs(diff_in_diff_pp)
  ) %>%
  arrange(region, desc(abs_diff_in_diff))

region_did_pp
```

region	travel_category	Education	Work	diff_in_diff_pp	abs_diff_in_diff
Area Outside Region	Private Transport	11.84	-3.58	15.42	15.42
Area Outside Region	At home	-1.43	6.59	-8.02	8.02
Area Outside Region	Active Transport	-7.99	-0.39	-7.60	7.60
Area Outside Region	Public Transport	2.71	-1.37	4.08	4.08
Area Outside Region	Other Transport	-5.13	-1.25	-3.88	3.88
Auckland Region	At home	3.02	9.37	-6.35	6.35
Auckland Region	Private Transport	0.85	-5.11	5.96	5.96
Auckland Region	Public Transport	-1.83	-3.02	1.19	1.19
Auckland Region	Active Transport	-2.14	-1.13	-1.01	1.01
Auckland Region	Other Transport	0.10	-0.12	0.22	0.22
Bay of Plenty Region	Active Transport	-3.29	-0.87	-2.42	2.42
Bay of Plenty Region	Private Transport	-0.40	-1.92	1.52	1.52
Bay of Plenty Region	Public Transport	1.08	-0.11	1.19	1.19
Bay of Plenty Region	At home	2.77	3.03	-0.26	0.26
Bay of Plenty Region	Other Transport	-0.16	-0.13	-0.03	0.03
Canterbury Region	Private Transport	-0.09	-2.78	2.69	2.69
Canterbury Region	Public Transport	-2.12	-0.09	-2.03	2.03

(continued)

region	travel_category	Education	Work	diff_in_diff_pp	abs_diff_in_diff
Canterbury Region	At home	2.72	3.28	-0.56	0.56
Canterbury Region	Other Transport	-0.11	0.16	-0.27	0.27
Canterbury Region	Active Transport	-0.40	-0.56	0.16	0.16
Gisborne Region	Active Transport	-6.34	-1.17	-5.17	5.17
Gisborne Region	Private Transport	5.24	0.32	4.92	4.92
Gisborne Region	At home	2.76	1.35	1.41	1.41
Gisborne Region	Public Transport	-1.14	-0.18	-0.96	0.96
Gisborne Region	Other Transport	-0.52	-0.32	-0.20	0.20
Hawke's Bay Region	Private Transport	3.42	-0.19	3.61	3.61
Hawke's Bay Region	Active Transport	-4.41	-1.20	-3.21	3.21
Hawke's Bay Region	Public Transport	-1.68	-0.15	-1.53	1.53
Hawke's Bay Region	At home	2.69	1.96	0.73	0.73
Hawke's Bay Region	Other Transport	-0.01	-0.41	0.40	0.40
Manawatu-Whanganui Region	Private Transport	4.06	0.12	3.94	3.94
Manawatu-Whanganui Region	Active Transport	-4.39	-1.95	-2.44	2.44
Manawatu-Whanganui Region	Public Transport	-2.29	-0.24	-2.05	2.05
Manawatu-Whanganui Region	At home	2.69	2.42	0.27	0.27
Manawatu-Whanganui Region	Other Transport	-0.07	-0.34	0.27	0.27
Marlborough Region	Private Transport	-1.89	0.69	-2.58	2.58
Marlborough Region	At home	3.08	1.06	2.02	2.02
Marlborough Region	Active Transport	-0.56	-1.32	0.76	0.76
Marlborough Region	Other Transport	-0.60	-0.46	-0.14	0.14
Marlborough Region	Public Transport	-0.03	0.03	-0.06	0.06
Nelson Region	Active Transport	-2.84	0.85	-3.69	3.69
Nelson Region	Private Transport	-1.21	-3.66	2.45	2.45
Nelson Region	At home	3.62	2.66	0.96	0.96
Nelson Region	Public Transport	0.49	0.21	0.28	0.28
Nelson Region	Other Transport	-0.05	-0.07	0.02	0.02
Northland Region	Private Transport	2.03	-2.11	4.14	4.14
Northland Region	Active Transport	-2.94	-0.95	-1.99	1.99
Northland Region	Public Transport	-1.86	-0.20	-1.66	1.66
Northland Region	At home	2.94	3.50	-0.56	0.56
Northland Region	Other Transport	-0.17	-0.24	0.07	0.07
Otago Region	Private Transport	-0.96	-1.55	0.59	0.59
Otago Region	Active Transport	-1.76	-1.34	-0.42	0.42
Otago Region	Public Transport	0.44	0.58	-0.14	0.14
Otago Region	Other Transport	-0.17	-0.07	-0.10	0.10
Otago Region	At home	2.45	2.38	0.07	0.07
Southland Region	At home	2.54	-0.27	2.81	2.81
Southland Region	Active Transport	-2.87	-0.55	-2.32	2.32
Southland Region	Public Transport	-0.47	0.01	-0.48	0.48
Southland Region	Other Transport	-0.23	-0.11	-0.12	0.12
Southland Region	Private Transport	1.03	0.92	0.11	0.11
Taranaki Region	Active Transport	-3.31	-1.32	-1.99	1.99
Taranaki Region	At home	2.49	1.30	1.19	1.19
Taranaki Region	Private Transport	1.50	0.43	1.07	1.07
Taranaki Region	Public Transport	-0.52	0.03	-0.55	0.55
Taranaki Region	Other Transport	-0.16	-0.43	0.27	0.27
Tasman Region	Private Transport	0.08	-2.26	2.34	2.34
Tasman Region	Active Transport	-1.52	-0.23	-1.29	1.29
Tasman Region	Public Transport	-0.55	-0.05	-0.50	0.50
Tasman Region	Other Transport	-0.31	-0.02	-0.29	0.29

(continued)

region	travel_category	Education	Work	diff_in_diff_pp	abs_diff_in_diff
Tasman Region	At home	2.30	2.57	-0.27	0.27
Waikato Region	Private Transport	1.87	-1.82	3.69	3.69
Waikato Region	Active Transport	-3.37	-1.20	-2.17	2.17
Waikato Region	Public Transport	-1.14	-0.05	-1.09	1.09
Waikato Region	At home	2.68	3.37	-0.69	0.69
Waikato Region	Other Transport	-0.04	-0.31	0.27	0.27
Wellington Region	At home	3.27	9.95	-6.68	6.68
Wellington Region	Private Transport	0.43	-4.99	5.42	5.42
Wellington Region	Public Transport	1.01	-2.55	3.56	3.56
Wellington Region	Active Transport	-4.68	-2.17	-2.51	2.51
Wellington Region	Other Transport	-0.04	-0.25	0.21	0.21
West Coast Region	At home	4.32	-1.08	5.40	5.40
West Coast Region	Active Transport	-5.25	-1.67	-3.58	3.58
West Coast Region	Public Transport	-3.57	0.00	-3.57	3.57
West Coast Region	Private Transport	4.88	2.89	1.99	1.99
West Coast Region	Other Transport	-0.37	-0.15	-0.22	0.22

Interpretation of output

- Large absolute diff-in-diff values identify regions where Education and Work diverged most.
- Examples shown:
  - Auckland / Wellington: Work has much larger "At home" increases than Education (negative diff-in-diff), while Education declines less in Private (positive diff-in-diff).
  - West Coast: Education "At home" rises while Work "At home" falls slightly -> strong positive divergence.

Conclusion

Education vs Work differences are not uniform across NZ; certain regions show markedly different shift patterns, motivating regional case studies.

9.8 Helper Function: Δ Count Contribution by Subgroup and Journey Type

pp changes capture composition; Δ counts capture absolute volume. This helper quantifies subgroup contributions to each travel-category change within each journey type.

```
delta_contrib_by_group_journey <- function(data, group_var) {

  data %>%
    filter(census_year %in% c(2018, 2023)) %>%
    group_by(journey_type, !!sym(group_var), census_year, travel_category) %>%
    summarise(n = sum(count, na.rm = TRUE), .groups = "drop") %>%
    pivot_wider(names_from = census_year, values_from = n, names_prefix = "y", values_fill = 0) %>%
    mutate(delta = y2023 - y2018) %>%
    group_by(journey_type, travel_category) %>%
    mutate(
      total_delta = sum(delta, na.rm = TRUE),
      contrib_pct = ifelse(total_delta == 0, NA_real_, 100 * delta / total_delta),
```

```
      contrib_pct = round(contrib_pct, 1)
    ) %>%
    ungroup()
}
```

Interpretation of output

- delta is the subgroup's change in counts (2023 − 2018).
- `contrib_pct` is the subgroup's percentage contribution to the total category-level change within the journey type.

9.9 Contribution by Gender: Δ Counts (Education vs Work)

This identifies which genders account for the largest increases/decreases in each category, separately for Education and Work.

```
contrib_gender_by_journey <- delta_contrib_by_group_journey(edu_work_data, "gender") %>%
  arrange(journey_type, travel_category, desc(abs(delta)))

contrib_gender_by_journey
```

journey_type	gender	travel_category	y2018	y2023	delta	total_delta	contrib_pct
Education	Male	Active Transport	192405	177927	-14478	-26541	54.5
Education	Female	Active Transport	171552	158181	-13371	-26541	50.4
Education	Other	Active Transport	7332	8640	1308	-26541	-4.9
Education	Female	At home	47655	82758	35103	50817	69.1
Education	Male	At home	26037	40995	14958	50817	29.4
Education	Other	At home	6336	7092	756	50817	1.5
Education	Female	Other Transport	7665	8205	540	771	70.0
Education	Male	Other Transport	11754	12054	300	771	38.9
Education	Other	Other Transport	2109	2040	-69	771	-8.9
Education	Male	Private Transport	373683	397536	23853	47247	50.5
Education	Female	Private Transport	399498	421170	21672	47247	45.9
Education	Other	Private Transport	10494	12216	1722	47247	3.6
Education	Female	Public Transport	158847	152694	-6153	-8835	69.6
Education	Male	Public Transport	146280	141432	-4848	-8835	54.9
Education	Other	Public Transport	8736	10902	2166	-8835	-24.5
Work	Male	Active Transport	114081	100161	-13920	-27066	51.4
Work	Female	Active Transport	104883	94548	-10335	-27066	38.2
Work	Other	Active Transport	4764	1953	-2811	-27066	10.4
Work	Female	At home	181197	323805	142608	255225	55.9
Work	Male	At home	181953	296250	114297	255225	44.8
Work	Other	At home	4140	2460	-1680	255225	-0.7
Work	Male	Other Transport	35145	32142	-3003	-1935	155.2
Work	Female	Other Transport	10908	13611	2703	-1935	-139.7
Work	Other	Other Transport	2016	381	-1635	-1935	84.5
Work	Female	Private Transport	1110006	1124064	14058	22551	62.3
Work	Male	Private Transport	1284519	1296036	11517	22551	51.1
Work	Other	Private Transport	10620	7596	-3024	22551	-13.4
Work	Female	Public Transport	138984	115374	-23610	-46593	50.7

(continued)

journey_type	gender	travel_category	y2018	y2023	delta	total_delta	contrib_pct
Work	Male	Public Transport	107424	85410	-22014	-46593	47.2
Work	Other	Public Transport	3168	2199	-969	-46593	2.1

Interpretation of output

- Education "At home" increase (+50,817): driven primarily by Female (69.1%) then Male (29.4%).
- Work "At home" increase (+255,225): driven by Female (55.9%) and Male (44.8%).
- Active and Public declines are shared across Male and Female; negative/over-100% contributions appear when a subgroup moves opposite to the overall total (common in decomposition tables).

Conclusion

For both journey types, Female and Male groups dominate volume change, with Female contributing slightly more to growth in "At home," especially for Education.

9.10 Contribution by Age Group: Δ Counts (Education vs Work)

This identifies which age cohorts are the largest drivers of category-level increases/decreases.

```
contrib_age_by_journey <- delta_contrib_by_group_journey(edu_work_data, "age_group") %>%
  arrange(journey_type, travel_category, desc(abs(delta)))

contrib_age_by_journey
```

journey_type	age_group	travel_category	y2018	y2023	delta	total_delta	contrib_pct
Education	15-29 years	Active Transport	120276	107790	-12486	-26541	47.0
Education	Under 15 years	Active Transport	238296	226983	-11313	-26541	42.6
Education	30-64 years	Active Transport	12045	9312	-2733	-26541	10.3
Education	Over 64 years	Active Transport	672	663	-9	-26541	0.0
Education	30-64 years	At home	43839	73074	29235	50817	57.5
Education	15-29 years	At home	26112	44556	18444	50817	36.3
Education	Under 15 years	At home	8379	10110	1731	50817	3.4
Education	Over 64 years	At home	1698	3105	1407	50817	2.8
Education	Under 15 years	Other Transport	11706	12333	627	771	81.3
Education	15-29 years	Other Transport	7167	7614	447	771	58.0
Education	30-64 years	Other Transport	2526	2214	-312	771	-40.5
Education	Over 64 years	Other Transport	129	138	9	771	1.2
Education	Under 15 years	Private Transport	531243	577239	45996	47247	97.4
Education	15-29 years	Private Transport	172464	178980	6516	47247	13.8
Education	30-64 years	Private Transport	75321	70515	-4806	47247	-10.2
Education	Over 64 years	Private Transport	4647	4188	-459	47247	-1.0
Education	15-29 years	Public Transport	162666	151887	-10779	-8835	122.0
Education	Under 15 years	Public Transport	133218	137982	4764	-8835	-53.9
Education	30-64 years	Public Transport	16839	14196	-2643	-8835	29.9
Education	Over 64 years	Public Transport	1140	963	-177	-8835	2.0
Work	15-29 years	Active Transport	88164	68355	-19809	-27066	73.2
Work	30-64 years	Active Transport	125787	117834	-7953	-27066	29.4

(continued)

journey_type	age_group	travel_category	y2018	y2023	delta	total_delta	contrib_pct
Work	Over 64 years	Active Transport	9777	10473	696	-27066	-2.6
Work	30-64 years	At home	262770	466452	203682	255225	79.8
Work	15-29 years	At home	51237	80568	29331	255225	11.5
Work	Over 64 years	At home	53283	75495	22212	255225	8.7
Work	30-64 years	Other Transport	29532	27822	-1710	-1935	88.4
Work	15-29 years	Other Transport	16263	15972	-291	-1935	15.0
Work	Over 64 years	Other Transport	2274	2340	66	-1935	-3.4
Work	Over 64 years	Private Transport	137610	156627	19017	22551	84.3
Work	30-64 years	Private Transport	1656420	1660773	4353	22551	19.3
Work	15-29 years	Private Transport	611115	610296	-819	22551	-3.6
Work	30-64 years	Public Transport	142038	113472	-28566	-46593	61.3
Work	15-29 years	Public Transport	99681	82485	-17196	-46593	36.9
Work	Over 64 years	Public Transport	7857	7026	-831	-46593	1.8

Interpretation of output

- Education:
  - Active decline is mostly driven by 15–29 and Under 15.
  - "At home" increase is driven mainly by 30–64 (57.5%) and 15–29 (36.3%).
  - Private increase is overwhelmingly driven by Under 15 (97.4%).
- Work:
  - "At home" increase is dominated by 30–64 (79.8%).
  - Public decline is mainly 30–64 (61.3%) and 15–29 (36.9%).

Conclusion

30–64 is the dominant driver of Work changes (especially "At home"), while Education changes are split across school-aged and younger cohorts (Under 15, 15–29) depending on the travel category.

9.11 Contribution by Region: Δ Counts (Education vs Work)

This identifies which regions account for the largest absolute increases/decreases in each travel category.

```
contrib_region_by_journey <- delta_contrib_by_group_journey(edu_work_data, "region") %>%
  arrange(journey_type, travel_category, desc(abs(delta)))

contrib_region_by_journey
```

journey_type	region	travel_category	y2018	y2023	delta	total_delta	contrib_pct
Education	Auckland Region	Active Transport	181941	171099	-10842	-26541	40.9
Education	Wellington Region	Active Transport	36912	30666	-6246	-26541	23.5
Education	Waikato Region	Active Transport	24129	21372	-2757	-26541	10.4
Education	Canterbury Region	Active Transport	38784	41406	2622	-26541	-9.9
Education	Manawatu-Whanganui Region	Active Transport	13095	10620	-2475	-26541	9.3
Education	Bay of Plenty Region	Active Transport	15687	14025	-1662	-26541	6.3

(continued)

journey_type	region	travel_category	y2018	y2023	delta	total_delta	contrib_pct
Education	Hawke's Bay Region	Active Transport	9126	7626	-1500	-26541	5.7
Education	Northland Region	Active Transport	5376	4371	-1005	-26541	3.8
Education	Gisborne Region	Active Transport	2541	1836	-705	-26541	2.7
Education	Southland Region	Active Transport	4812	4173	-639	-26541	2.4
Education	Taranaki Region	Active Transport	5814	5235	-579	-26541	2.2
Education	West Coast Region	Active Transport	1572	1215	-357	-26541	1.3
Education	Nelson Region	Active Transport	4287	4005	-282	-26541	1.1
Education	Tasman Region	Active Transport	2883	2757	-126	-26541	0.5
Education	Marlborough Region	Active Transport	2370	2406	36	-26541	-0.1
Education	Area Outside Region	Active Transport	30	18	-12	-26541	0.0
Education	Otago Region	Active Transport	21930	21918	-12	-26541	0.0
Education	Auckland Region	At home	32178	58863	26685	50817	52.5
Education	Canterbury Region	At home	7977	12906	4929	50817	9.7
Education	Wellington Region	At home	7740	11901	4161	50817	8.2
Education	Waikato Region	At home	6690	10269	3579	50817	7.0
Education	Bay of Plenty Region	At home	4536	6978	2442	50817	4.8
Education	Otago Region	At home	3279	4938	1659	50817	3.3
Education	Manawatu-Whanganui Region	At home	4572	6225	1653	50817	3.3
Education	Northland Region	At home	2976	4374	1398	50817	2.8
Education	Hawke's Bay Region	At home	2544	3702	1158	50817	2.3
Education	Taranaki Region	At home	2232	3120	888	50817	1.7
Education	Southland Region	At home	1380	1965	585	50817	1.2
Education	Nelson Region	At home	783	1215	432	50817	0.9
Education	Gisborne Region	At home	741	1128	387	50817	0.8
Education	Marlborough Region	At home	819	1146	327	50817	0.6
Education	Tasman Region	At home	978	1266	288	50817	0.6
Education	West Coast Region	At home	591	840	249	50817	0.5
Education	Area Outside Region	At home	12	9	-3	50817	0.0
Education	Auckland Region	Other Transport	10722	11961	1239	771	160.7
Education	Bay of Plenty Region	Other Transport	882	807	-75	771	-9.7
Education	Otago Region	Other Transport	624	552	-72	771	-9.3
Education	Wellington Region	Other Transport	2118	2058	-60	771	-7.8
Education	Gisborne Region	Other Transport	228	171	-57	771	-7.4
Education	Northland Region	Other Transport	375	318	-57	771	-7.4
Education	Marlborough Region	Other Transport	180	129	-51	771	-6.6
Education	Southland Region	Other Transport	276	225	-51	771	-6.6
Education	Canterbury Region	Other Transport	2616	2658	42	771	5.4
Education	Manawatu-Whanganui Region	Other Transport	798	765	-33	771	-4.3
Education	Tasman Region	Other Transport	183	150	-33	771	-4.3
Education	West Coast Region	Other Transport	66	42	-24	771	-3.1
Education	Taranaki Region	Other Transport	363	342	-21	771	-2.7
Education	Waikato Region	Other Transport	1233	1254	21	771	2.7
Education	Hawke's Bay Region	Other Transport	600	612	12	771	1.6
Education	Area Outside Region	Other Transport	6	0	-6	771	-0.8
Education	Nelson Region	Other Transport	258	255	-3	771	-0.4
Education	Auckland Region	Private Transport	402993	426135	23142	47247	49.0
Education	Canterbury Region	Private Transport	73218	79206	5988	47247	12.7
Education	Waikato Region	Private Transport	63450	69117	5667	47247	12.0
Education	Manawatu-Whanganui Region	Private Transport	31668	34425	2757	47247	5.8
Education	Bay of Plenty Region	Private Transport	39429	41436	2007	47247	4.2
Education	Hawke's Bay Region	Private Transport	21078	23079	2001	47247	4.2
Education	Northland Region	Private Transport	21093	22953	1860	47247	3.9

(continued)

journey_type	region	travel_category	y2018	y2023	delta	total_delta	contrib_pct
Education	Taranaki Region	Private Transport	14829	16284	1455	47247	3.1
Education	Gisborne Region	Private Transport	6795	7761	966	47247	2.0
Education	Otago Region	Private Transport	25305	25944	639	47247	1.4
Education	Southland Region	Private Transport	11901	12177	276	47247	0.6
Education	West Coast Region	Private Transport	2685	2919	234	47247	0.5
Education	Wellington Region	Private Transport	54297	54525	228	47247	0.5
Education	Tasman Region	Private Transport	5001	5103	102	47247	0.2
Education	Nelson Region	Private Transport	5202	5121	-81	47247	-0.2
Education	Area Outside Region	Private Transport	24	33	9	47247	0.0
Education	Marlborough Region	Private Transport	4707	4704	-3	47247	0.0
Education	Auckland Region	Public Transport	181758	173595	-8163	-8835	92.4
Education	Bay of Plenty Region	Public Transport	13557	15201	1644	-8835	-18.6
Education	Canterbury Region	Public Transport	22227	20760	-1467	-8835	16.6
Education	Manawatu-Whanganui Region	Public Transport	8835	7563	-1272	-8835	14.4
Education	Wellington Region	Public Transport	28278	29409	1131	-8835	-12.8
Education	Otago Region	Public Transport	7131	7746	615	-8835	-7.0
Education	Hawke's Bay Region	Public Transport	5643	5136	-507	-8835	5.7
Education	Waikato Region	Public Transport	18588	18216	-372	-8835	4.2
Education	Northland Region	Public Transport	10977	10701	-276	-8835	3.1
Education	West Coast Region	Public Transport	1326	1077	-249	-8835	2.8
Education	Taranaki Region	Public Transport	4356	4500	144	-8835	-1.6
Education	Southland Region	Public Transport	4431	4338	-93	-8835	1.1
Education	Nelson Region	Public Transport	1029	1098	69	-8835	-0.8
Education	Gisborne Region	Public Transport	2007	1947	-60	-8835	0.7
Education	Marlborough Region	Public Transport	1179	1221	42	-8835	-0.5
Education	Tasman Region	Public Transport	2496	2478	-18	-8835	0.2
Education	Area Outside Region	Public Transport	45	42	-3	-8835	0.0
Work	Auckland Region	Active Transport	88986	74073	-14913	-27066	55.1
Work	Wellington Region	Active Transport	35952	31569	-4383	-27066	16.2
Work	Manawatu-Whanganui Region	Active Transport	9246	7371	-1875	-27066	6.9
Work	Waikato Region	Active Transport	13227	11415	-1812	-27066	6.7
Work	Hawke's Bay Region	Active Transport	4956	4125	-831	-27066	3.1
Work	Bay of Plenty Region	Active Transport	7944	7167	-777	-27066	2.9
Work	Otago Region	Active Transport	14091	13314	-777	-27066	2.9
Work	Taranaki Region	Active Transport	3891	3327	-564	-27066	2.1
Work	Northland Region	Active Transport	3882	3366	-516	-27066	1.9
Work	Nelson Region	Active Transport	3636	3972	336	-27066	-1.2
Work	Marlborough Region	Active Transport	2379	2079	-300	-27066	1.1
Work	West Coast Region	Active Transport	1719	1443	-276	-27066	1.0
Work	Southland Region	Active Transport	3360	3141	-219	-27066	0.8
Work	Gisborne Region	Active Transport	1380	1191	-189	-27066	0.7
Work	Tasman Region	Active Transport	2328	2469	141	-27066	-0.5
Work	Canterbury Region	Active Transport	26718	26610	-108	-27066	0.4
Work	Area Outside Region	Active Transport	33	30	-3	-27066	0.0
Work	Auckland Region	At home	145302	317148	171846	255225	67.3
Work	Wellington Region	At home	25341	56004	30663	255225	12.0
Work	Canterbury Region	At home	41172	55731	14559	255225	5.7
Work	Waikato Region	At home	34608	46317	11709	255225	4.6
Work	Bay of Plenty Region	At home	22455	29481	7026	255225	2.8
Work	Northland Region	At home	14190	18528	4338	255225	1.7
Work	Otago Region	At home	17163	21468	4305	255225	1.7
Work	Manawatu-Whanganui Region	At home	16368	20364	3996	255225	1.6

(continued)

journey_type	region	travel_category	y2018	y2023	delta	total_delta	contrib_pct
Work	Hawke's Bay Region	At home	11637	13911	2274	255225	0.9
Work	Taranaki Region	At home	10410	11979	1569	255225	0.6
Work	Tasman Region	At home	5118	6369	1251	255225	0.5
Work	Nelson Region	At home	3249	4071	822	255225	0.3
Work	Gisborne Region	At home	3429	4002	573	255225	0.2
Work	Marlborough Region	At home	4062	4428	366	255225	0.1
Work	West Coast Region	At home	3423	3252	-171	255225	-0.1
Work	Southland Region	At home	9273	9348	75	255225	0.0
Work	Area Outside Region	At home	90	114	24	255225	0.0
Work	Canterbury Region	Other Transport	5013	5934	921	-1935	-47.6
Work	Auckland Region	Other Transport	21924	21114	-810	-1935	41.9
Work	Wellington Region	Other Transport	5145	4686	-459	-1935	23.7
Work	Waikato Region	Other Transport	3903	3492	-411	-1935	21.2
Work	Hawke's Bay Region	Other Transport	1167	855	-312	-1935	16.1
Work	Manawatu-Whanganui Region	Other Transport	2004	1698	-306	-1935	15.8
Work	Taranaki Region	Other Transport	1299	1116	-183	-1935	9.5
Work	Northland Region	Other Transport	1077	954	-123	-1935	6.4
Work	Marlborough Region	Other Transport	369	255	-114	-1935	5.9
Work	Bay of Plenty Region	Other Transport	2007	1953	-54	-1935	2.8
Work	Gisborne Region	Other Transport	345	291	-54	-1935	2.8
Work	Southland Region	Other Transport	1158	1125	-33	-1935	1.7
Work	Tasman Region	Other Transport	435	468	33	-1935	-1.7
Work	West Coast Region	Other Transport	249	225	-24	-1935	1.2
Work	Area Outside Region	Other Transport	18	12	-6	-1935	0.3
Work	Nelson Region	Other Transport	528	525	-3	-1935	0.2
Work	Otago Region	Other Transport	1428	1431	3	-1935	-0.2
Work	Auckland Region	Private Transport	1221918	1199895	-22023	22551	-97.7
Work	Waikato Region	Private Transport	176433	188100	11667	22551	51.7
Work	Canterbury Region	Private Transport	249279	257052	7773	22551	34.5
Work	Bay of Plenty Region	Private Transport	120948	128079	7131	22551	31.6
Work	Wellington Region	Private Transport	162012	156303	-5709	22551	-25.3
Work	Manawatu-Whanganui Region	Private Transport	88719	94209	5490	22551	24.3
Work	Otago Region	Private Transport	86250	90204	3954	22551	17.5
Work	Northland Region	Private Transport	62754	66213	3459	22551	15.3
Work	Taranaki Region	Private Transport	43587	46965	3378	22551	15.0
Work	Hawke's Bay Region	Private Transport	66219	69117	2898	22551	12.9
Work	Southland Region	Private Transport	39642	41106	1464	22551	6.5
Work	Gisborne Region	Private Transport	17529	18846	1317	22551	5.8
Work	Tasman Region	Private Transport	20022	21153	1131	22551	5.0
Work	Marlborough Region	Private Transport	19104	19692	588	22551	2.6
Work	West Coast Region	Private Transport	11448	11976	528	22551	2.3
Work	Nelson Region	Private Transport	18990	18522	-468	22551	-2.1
Work	Area Outside Region	Private Transport	291	264	-27	22551	-0.1
Work	Auckland Region	Public Transport	178575	135615	-42960	-46593	92.2
Work	Wellington Region	Public Transport	50175	45462	-4713	-46593	10.1
Work	Otago Region	Public Transport	3228	4212	984	-46593	-2.1
Work	Canterbury Region	Public Transport	9456	9810	354	-46593	-0.8
Work	Manawatu-Whanganui Region	Public Transport	1218	987	-231	-46593	0.5
Work	Waikato Region	Public Transport	3030	3195	165	-46593	-0.4
Work	Northland Region	Public Transport	492	357	-135	-46593	0.3
Work	Hawke's Bay Region	Public Transport	525	414	-111	-46593	0.2

(continued)

journey_type	region	travel_category	y2018	y2023	delta	total_delta	contrib_pct
Work	Nelson Region	Public Transport	264	330	66	-46593	-0.1
Work	Gisborne Region	Public Transport	102	66	-36	-46593	0.1
Work	Taranaki Region	Public Transport	258	294	36	-46593	-0.1
Work	Bay of Plenty Region	Public Transport	1830	1809	-21	-46593	0.0
Work	Southland Region	Public Transport	237	249	12	-46593	0.0
Work	Marlborough Region	Public Transport	42	51	9	-46593	0.0
Work	Area Outside Region	Public Transport	6	0	-6	-46593	0.0
Work	Tasman Region	Public Transport	117	111	-6	-46593	0.0
Work	West Coast Region	Public Transport	21	21	0	-46593	0.0

Interpretation of output

For both Education and Work, changes across all travel categories are dominated by Auckland, which contributes the largest absolute increases or decreases in almost every case. Wellington, Canterbury, and Waikato consistently appear as secondary contributors, while most other regions have relatively small effects. In several categories, increases in some regions partially offset declines in others, but these offsets are insufficient to alter the overall national direction.

Conclusion

National-level changes are driven by a small number of large regions, indicating that aggregate trends primarily reflect major urban centres rather than uniform nationwide shifts. This concentration suggests that national results should be interpreted through the lens of regional dynamics.

9.12 Top Drivers Summary: Regions (Compact Reporting Table)

This produces a concise, report-friendly table of the top regional contributors (by absolute Δ count) for each journey type and travel category.

```
top_driver_summary <- contrib_region_by_journey %>%
  group_by(journey_type, travel_category) %>%
  slice_max(order_by = abs(delta), n = 5, with_ties = FALSE) %>%
  ungroup() %>%
  select(journey_type, travel_category, region, delta, contrib_pct) %>%
  arrange(journey_type, travel_category, desc(abs(delta)))

top_driver_summary
```

journey_type	travel_category	region	delta	contrib_pct
Education	Active Transport	Auckland Region	-10842	40.9
Education	Active Transport	Wellington Region	-6246	23.5
Education	Active Transport	Waikato Region	-2757	10.4
Education	Active Transport	Canterbury Region	2622	-9.9
Education	Active Transport	Manawatu-Whanganui Region	-2475	9.3
Education	At home	Auckland Region	26685	52.5
Education	At home	Canterbury Region	4929	9.7
Education	At home	Wellington Region	4161	8.2
Education	At home	Waikato Region	3579	7.0
Education	At home	Bay of Plenty Region	2442	4.8
Education	Other Transport	Auckland Region	1239	160.7

(continued)

journey_type	travel_category	region	delta	contrib_pct
Education	Other Transport	Bay of Plenty Region	-75	-9.7
Education	Other Transport	Otago Region	-72	-9.3
Education	Other Transport	Wellington Region	-60	-7.8
Education	Other Transport	Gisborne Region	-57	-7.4
Education	Private Transport	Auckland Region	23142	49.0
Education	Private Transport	Canterbury Region	5988	12.7
Education	Private Transport	Waikato Region	5667	12.0
Education	Private Transport	Manawatu-Whanganui Region	2757	5.8
Education	Private Transport	Bay of Plenty Region	2007	4.2
Education	Public Transport	Auckland Region	-8163	92.4
Education	Public Transport	Bay of Plenty Region	1644	-18.6
Education	Public Transport	Canterbury Region	-1467	16.6
Education	Public Transport	Manawatu-Whanganui Region	-1272	14.4
Education	Public Transport	Wellington Region	1131	-12.8
Work	Active Transport	Auckland Region	-14913	55.1
Work	Active Transport	Wellington Region	-4383	16.2
Work	Active Transport	Manawatu-Whanganui Region	-1875	6.9
Work	Active Transport	Waikato Region	-1812	6.7
Work	Active Transport	Hawke's Bay Region	-831	3.1
Work	At home	Auckland Region	171846	67.3
Work	At home	Wellington Region	30663	12.0
Work	At home	Canterbury Region	14559	5.7
Work	At home	Waikato Region	11709	4.6
Work	At home	Bay of Plenty Region	7026	2.8
Work	Other Transport	Canterbury Region	921	-47.6
Work	Other Transport	Auckland Region	-810	41.9
Work	Other Transport	Wellington Region	-459	23.7
Work	Other Transport	Waikato Region	-411	21.2
Work	Other Transport	Hawke's Bay Region	-312	16.1
Work	Private Transport	Auckland Region	-22023	-97.7
Work	Private Transport	Waikato Region	11667	51.7
Work	Private Transport	Canterbury Region	7773	34.5
Work	Private Transport	Bay of Plenty Region	7131	31.6
Work	Private Transport	Wellington Region	-5709	-25.3
Work	Public Transport	Auckland Region	-42960	92.2
Work	Public Transport	Wellington Region	-4713	10.1
Work	Public Transport	Otago Region	984	-2.1
Work	Public Transport	Canterbury Region	354	-0.8
Work	Public Transport	Manawatu-Whanganui Region	-231	0.5

Interpretation of output

- Education: Auckland is the top driver for several categories (e.g., "At home" +26,685; Private +23,142; Public −8,163).
- Work: Auckland dominates "At home" growth (+171,846) and Public decline (−42,960).

Conclusion

The largest absolute changes are concentrated in major population regions, especially Auckland, consistent with the scale of those regions' counts.

9.13 Top Drivers by Gender (Compact Table)

Ranks genders by absolute Δ count within each (journey type × travel category), giving a concise contributor view.

```
contrib_gender_by_journey <- delta_contrib_by_group_journey(edu_work_data, "gender")

top_driver_gender <- contrib_gender_by_journey %>%
  group_by(journey_type, travel_category) %>%
  slice_max(order_by = abs(delta), n = 5, with_ties = FALSE) %>%
  ungroup() %>%
  select(journey_type, travel_category, gender, delta, contrib_pct) %>%
  arrange(journey_type, travel_category, desc(abs(delta)))

top_driver_gender
```

journey_type	travel_category	gender	delta	contrib_pct
Education	Active Transport	Male	-14478	54.5
Education	Active Transport	Female	-13371	50.4
Education	Active Transport	Other	1308	-4.9
Education	At home	Female	35103	69.1
Education	At home	Male	14958	29.4
Education	At home	Other	756	1.5
Education	Other Transport	Female	540	70.0
Education	Other Transport	Male	300	38.9
Education	Other Transport	Other	-69	-8.9
Education	Private Transport	Male	23853	50.5
Education	Private Transport	Female	21672	45.9
Education	Private Transport	Other	1722	3.6
Education	Public Transport	Female	-6153	69.6
Education	Public Transport	Male	-4848	54.9
Education	Public Transport	Other	2166	-24.5
Work	Active Transport	Male	-13920	51.4
Work	Active Transport	Female	-10335	38.2
Work	Active Transport	Other	-2811	10.4
Work	At home	Female	142608	55.9
Work	At home	Male	114297	44.8
Work	At home	Other	-1680	-0.7
Work	Other Transport	Male	-3003	155.2
Work	Other Transport	Female	2703	-139.7
Work	Other Transport	Other	-1635	84.5
Work	Private Transport	Female	14058	62.3
Work	Private Transport	Male	11517	51.1
Work	Private Transport	Other	-3024	-13.4
Work	Public Transport	Female	-23610	50.7
Work	Public Transport	Male	-22014	47.2
Work	Public Transport	Other	-969	2.1

Interpretation of output

- "At home" growth is led by Female then Male for both Education and Work.
- Public declines are again dominated by Female and Male contributions.

Conclusion

Gender-based drivers are stable across journey types: Female and Male account for nearly all volume change.

9.14 Top Drivers by Age Group (Compact Table)

Ranks age groups by absolute Δ count within each (journey type × travel category).

```
contrib_age_by_journey <- delta_contrib_by_group_journey(edu_work_data, "age_group")

top_driver_age <- contrib_age_by_journey %>%
  group_by(journey_type, travel_category) %>%
  slice_max(order_by = abs(delta), n = 5, with_ties = FALSE) %>%
  ungroup() %>%
  select(journey_type, travel_category, age_group, delta, contrib_pct) %>%
  arrange(journey_type, travel_category, desc(abs(delta)))

top_driver_age
```

journey_type	travel_category	age_group	delta	contrib_pct
Education	Active Transport	15-29 years	-12486	47.0
Education	Active Transport	Under 15 years	-11313	42.6
Education	Active Transport	30-64 years	-2733	10.3
Education	Active Transport	Over 64 years	-9	0.0
Education	At home	30-64 years	29235	57.5
Education	At home	15-29 years	18444	36.3
Education	At home	Under 15 years	1731	3.4
Education	At home	Over 64 years	1407	2.8
Education	Other Transport	Under 15 years	627	81.3
Education	Other Transport	15-29 years	447	58.0
Education	Other Transport	30-64 years	-312	-40.5
Education	Other Transport	Over 64 years	9	1.2
Education	Private Transport	Under 15 years	45996	97.4
Education	Private Transport	15-29 years	6516	13.8
Education	Private Transport	30-64 years	-4806	-10.2
Education	Private Transport	Over 64 years	-459	-1.0
Education	Public Transport	15-29 years	-10779	122.0
Education	Public Transport	Under 15 years	4764	-53.9
Education	Public Transport	30-64 years	-2643	29.9
Education	Public Transport	Over 64 years	-177	2.0
Work	Active Transport	15-29 years	-19809	73.2
Work	Active Transport	30-64 years	-7953	29.4
Work	Active Transport	Over 64 years	696	-2.6
Work	At home	30-64 years	203682	79.8
Work	At home	15-29 years	29331	11.5
Work	At home	Over 64 years	22212	8.7
Work	Other Transport	30-64 years	-1710	88.4
Work	Other Transport	15-29 years	-291	15.0
Work	Other Transport	Over 64 years	66	-3.4
Work	Private Transport	Over 64 years	19017	84.3
Work	Private Transport	30-64 years	4353	19.3
Work	Private Transport	15-29 years	-819	-3.6

(continued)

journey_type	travel_category	age_group	delta	contrib_pct
Work	Public Transport	30-64 years	-28566	61.3
Work	Public Transport	15-29 years	-17196	36.9
Work	Public Transport	Over 64 years	-831	1.8

Interpretation of output

- For Work "At home," 30–64 is the dominant driver (largest delta and highest contribution).
- For Education Private, Under 15 is the dominant driver.

Conclusion

Age drivers differ by journey type: Work changes are dominated by working-age adults, while Education changes are strongly influenced by school-age cohorts for some categories.

9.15 Combined "Top Drivers" Table (Region + Gender + Age Group)

This combines top drivers across the three subgroup types into one long table for compact reporting and cross-driver comparison.

```
top_driver_region <- contrib_region_by_journey %>%
  group_by(journey_type, travel_category) %>%
  slice_max(order_by = abs(delta), n = 5, with_ties = FALSE) %>%
  ungroup() %>%
  transmute(
    journey_type, travel_category,
    driver_type = "Region",
    driver_value = region,
    delta, contrib_pct
  )

top_driver_gender_long <- top_driver_gender %>%
  transmute(
    journey_type, travel_category,
    driver_type = "Gender",
    driver_value = gender,
    delta, contrib_pct
  )

top_driver_age_long <- top_driver_age %>%
  transmute(
    journey_type, travel_category,
    driver_type = "Age group",
    driver_value = age_group,
    delta, contrib_pct
  )

top_drivers_all <- bind_rows(top_driver_region, top_driver_gender_long, top_driver_age_long) %>%
  arrange(journey_type, travel_category, driver_type, desc(abs(delta)))

top_drivers_all
```

journey_type	travel_category	driver_type	driver_value	delta	contrib_pct
Education	Active Transport	Age group	15-29 years	-12486	47.0
Education	Active Transport	Age group	Under 15 years	-11313	42.6
Education	Active Transport	Age group	30-64 years	-2733	10.3
Education	Active Transport	Age group	Over 64 years	-9	0.0
Education	Active Transport	Gender	Male	-14478	54.5
Education	Active Transport	Gender	Female	-13371	50.4
Education	Active Transport	Gender	Other	1308	-4.9
Education	Active Transport	Region	Auckland Region	-10842	40.9
Education	Active Transport	Region	Wellington Region	-6246	23.5
Education	Active Transport	Region	Waikato Region	-2757	10.4
Education	Active Transport	Region	Canterbury Region	2622	-9.9
Education	Active Transport	Region	Manawatu-Whanganui Region	-2475	9.3
Education	At home	Age group	30-64 years	29235	57.5
Education	At home	Age group	15-29 years	18444	36.3
Education	At home	Age group	Under 15 years	1731	3.4
Education	At home	Age group	Over 64 years	1407	2.8
Education	At home	Gender	Female	35103	69.1
Education	At home	Gender	Male	14958	29.4
Education	At home	Gender	Other	756	1.5
Education	At home	Region	Auckland Region	26685	52.5
Education	At home	Region	Canterbury Region	4929	9.7
Education	At home	Region	Wellington Region	4161	8.2
Education	At home	Region	Waikato Region	3579	7.0
Education	At home	Region	Bay of Plenty Region	2442	4.8
Education	Other Transport	Age group	Under 15 years	627	81.3
Education	Other Transport	Age group	15-29 years	447	58.0
Education	Other Transport	Age group	30-64 years	-312	-40.5
Education	Other Transport	Age group	Over 64 years	9	1.2
Education	Other Transport	Gender	Female	540	70.0
Education	Other Transport	Gender	Male	300	38.9
Education	Other Transport	Gender	Other	-69	-8.9
Education	Other Transport	Region	Auckland Region	1239	160.7
Education	Other Transport	Region	Bay of Plenty Region	-75	-9.7
Education	Other Transport	Region	Otago Region	-72	-9.3
Education	Other Transport	Region	Wellington Region	-60	-7.8
Education	Other Transport	Region	Gisborne Region	-57	-7.4
Education	Private Transport	Age group	Under 15 years	45996	97.4
Education	Private Transport	Age group	15-29 years	6516	13.8
Education	Private Transport	Age group	30-64 years	-4806	-10.2
Education	Private Transport	Age group	Over 64 years	-459	-1.0
Education	Private Transport	Gender	Male	23853	50.5
Education	Private Transport	Gender	Female	21672	45.9
Education	Private Transport	Gender	Other	1722	3.6
Education	Private Transport	Region	Auckland Region	23142	49.0
Education	Private Transport	Region	Canterbury Region	5988	12.7
Education	Private Transport	Region	Waikato Region	5667	12.0
Education	Private Transport	Region	Manawatu-Whanganui Region	2757	5.8
Education	Private Transport	Region	Bay of Plenty Region	2007	4.2
Education	Public Transport	Age group	15-29 years	-10779	122.0
Education	Public Transport	Age group	Under 15 years	4764	-53.9
Education	Public Transport	Age group	30-64 years	-2643	29.9
Education	Public Transport	Age group	Over 64 years	-177	2.0

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journey_type	travel_category	driver_type	driver_value	delta	contrib_pct
Education	Public Transport	Gender	Female	-6153	69.6
Education	Public Transport	Gender	Male	-4848	54.9
Education	Public Transport	Gender	Other	2166	-24.5
Education	Public Transport	Region	Auckland Region	-8163	92.4
Education	Public Transport	Region	Bay of Plenty Region	1644	-18.6
Education	Public Transport	Region	Canterbury Region	-1467	16.6
Education	Public Transport	Region	Manawatu-Whanganui Region	-1272	14.4
Education	Public Transport	Region	Wellington Region	1131	-12.8
Work	Active Transport	Age group	15-29 years	-19809	73.2
Work	Active Transport	Age group	30-64 years	-7953	29.4
Work	Active Transport	Age group	Over 64 years	696	-2.6
Work	Active Transport	Gender	Male	-13920	51.4
Work	Active Transport	Gender	Female	-10335	38.2
Work	Active Transport	Gender	Other	-2811	10.4
Work	Active Transport	Region	Auckland Region	-14913	55.1
Work	Active Transport	Region	Wellington Region	-4383	16.2
Work	Active Transport	Region	Manawatu-Whanganui Region	-1875	6.9
Work	Active Transport	Region	Waikato Region	-1812	6.7
Work	Active Transport	Region	Hawke's Bay Region	-831	3.1
Work	At home	Age group	30-64 years	203682	79.8
Work	At home	Age group	15-29 years	29331	11.5
Work	At home	Age group	Over 64 years	22212	8.7
Work	At home	Gender	Female	142608	55.9
Work	At home	Gender	Male	114297	44.8
Work	At home	Gender	Other	-1680	-0.7
Work	At home	Region	Auckland Region	171846	67.3
Work	At home	Region	Wellington Region	30663	12.0
Work	At home	Region	Canterbury Region	14559	5.7
Work	At home	Region	Waikato Region	11709	4.6
Work	At home	Region	Bay of Plenty Region	7026	2.8
Work	Other Transport	Age group	30-64 years	-1710	88.4
Work	Other Transport	Age group	15-29 years	-291	15.0
Work	Other Transport	Age group	Over 64 years	66	-3.4
Work	Other Transport	Gender	Male	-3003	155.2
Work	Other Transport	Gender	Female	2703	-139.7
Work	Other Transport	Gender	Other	-1635	84.5
Work	Other Transport	Region	Canterbury Region	921	-47.6
Work	Other Transport	Region	Auckland Region	-810	41.9
Work	Other Transport	Region	Wellington Region	-459	23.7
Work	Other Transport	Region	Waikato Region	-411	21.2
Work	Other Transport	Region	Hawke's Bay Region	-312	16.1
Work	Private Transport	Age group	Over 64 years	19017	84.3
Work	Private Transport	Age group	30-64 years	4353	19.3
Work	Private Transport	Age group	15-29 years	-819	-3.6
Work	Private Transport	Gender	Female	14058	62.3
Work	Private Transport	Gender	Male	11517	51.1
Work	Private Transport	Gender	Other	-3024	-13.4
Work	Private Transport	Region	Auckland Region	-22023	-97.7
Work	Private Transport	Region	Waikato Region	11667	51.7
Work	Private Transport	Region	Canterbury Region	7773	34.5
Work	Private Transport	Region	Bay of Plenty Region	7131	31.6
Work	Private Transport	Region	Wellington Region	-5709	-25.3

(continued)

journey_type	travel_category	driver_type	driver_value	delta	contrib_pct
Work	Public Transport	Age group	30-64 years	-28566	61.3
Work	Public Transport	Age group	15-29 years	-17196	36.9
Work	Public Transport	Age group	Over 64 years	-831	1.8
Work	Public Transport	Gender	Female	-23610	50.7
Work	Public Transport	Gender	Male	-22014	47.2
Work	Public Transport	Gender	Other	-969	2.1
Work	Public Transport	Region	Auckland Region	-42960	92.2
Work	Public Transport	Region	Wellington Region	-4713	10.1
Work	Public Transport	Region	Otago Region	984	-2.1
Work	Public Transport	Region	Canterbury Region	354	-0.8
Work	Public Transport	Region	Manawatu-Whanganui Region	-231	0.5

Interpretation of output

- The combined table allows direct comparison of whether geography, gender, or age provides the strongest concentration of drivers for each category and journey type.
- The dominant patterns are consistent: major regions (especially Auckland) and key cohorts (30–64 for Work; Under 15 for Education Private) explain much of the total change.

Conclusion

Drivers of change are concentrated in large regions and specific cohorts, and those drivers differ meaningfully between Education and Work supporting the report's focus on comparing journey types rather than treating the shifts as uniform.