

# LSCOG 2050 LRTP - Base Year SE Data Development

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## 1 Set up the environment

This section establishes the computational environment for processing socioeconomic data inputs for the Lower Savannah Council of Governments regional travel demand model using both R and Python platforms.

### 1.1 Install and load packages

The package installation process incorporates essential libraries for comprehensive geospatial data analysis.

The R environment includes `{tidyverse}` for data manipulation, `{sf}` for spatial data handling, `{tidycensus}` for Census Bureau data access, and `{lehdr}` for Longitudinal Employer-Household Dynamics data retrieval.

The Python environment focuses on core data science libraries including `{pandas}` for data manipulation, `{geopandas}` for spatial analysis, and `{pygrs}` for Census data queries. These packages form the analytical backbone for processing demographic, employment, and geographic data required for travel demand modeling.

#### 1.1.-a R

```
# # Install required packages
# install.packages(c(
#   "tidyverse",
#   "vroom",
#   "sf",
#   "tidycensus",
#   "lehdr",
#   "arcgislayers",
#   "mapview",
#   "RColorBrewer",
#   "janitor"
# ), dependencies = TRUE)

# Load packages
library(tidyverse) # Data manipulation and visualization
library(vroom)     # Read rectangular data
library(sf)        # Spatial analysis
library(tidycensus) # Accessing US Census Data
library(lehdr)     # Access LODES data
```

```
library(arcgislayers) # ArcGIS REST API access
library(mapview)      # Interactive mapping
library(RColorBrewer) # Color palettes for maps
library(janitor)      # Data cleaning and preparation
```

### 1.1.-b Python

```
# Install required packages if not available
# pip install numpy pandas geopandas shapely folium requests pygris

# Load processing libraries & modules
import os
from pathlib import Path
import zipfile
import requests
import urllib.parse
import warnings
warnings.filterwarnings('ignore')

# Load data and visualization libraries & modules
import numpy as np
import pandas as pd
import geopandas as gpd
import folium
from shapely.geometry import Point

# Census data query libraries & modules
from pygis import blocks, block_groups
from pygis.helpers import validate_state, validate_county
from pygis.data import get_census, get_lodes
```

## 1.2 Set global options and parameters

Configuration settings optimize performance and establish spatial consistency. The {tigris} cache prevents redundant TIGER/Line shapefile downloads. The South Carolina State Plane coordinate system (EPSG:3361) serves as the standard projection for accurate GIS operations

### 1.2.-a R

```
# Set options
options(tigris_use_cache = TRUE) # cache tiger/line shapefile for future use

# set project CRS
project_crs <- "EPSG:3361"
```

### 1.2.-b Python

```
# Set project CRS
project_crs = "EPSG:3361"
```

### 1.3 Set census API key

API authentication enables access to detailed demographic and economic datasets from the Census Bureau. The key configuration supports both R and Python environments for automated data retrieval workflows.

💡 **Need a Census API key?** Get one for free at [census.gov/developers](https://census.gov/developers)

#### 1.3.-.a R

```
# Set your API key into environment
tidycensus::census_api_key("your_api_key_here", install = TRUE)
```

#### 1.3.-.b Python

```
# Set your API key into environment
os.environ['CENSUS_API_KEY'] = 'your_api_key_here'
```

### 1.4 Project folder

The centralized directory structure organizes input data, processing files, and model outputs. The standardized root folder path ensures consistent file management across computing environments and team members.

#### 1.4.-.a R

```
# Set your main data folder
root <- "M:/MA_Project/SC_LSCOG LRTP"
```

#### 1.4.-.b Python

```
# Set your main data folder
root = "M:/MA_Project/SC_LSCOG LRTP"
```

## 2 Define study area

This section defines the geographic extent of the Lower Savannah Council of Governments region and loads the Traffic Analysis Zone (TAZ) geometry for spatial analysis.

### 2.1 Define state and counties

The study area encompasses six counties within South Carolina: Aiken, Allendale, Bamberg, Barnwell, Calhoun, and Orangeburg. These counties constitute the LSCOG planning region for travel demand modeling purposes.

### 2.1.-a R

```
# Define state abbreviation and county names
state_abb <- "SC"
county_names <- c(
  "Aiken",
  "Allendale",
  "Bamberg",
  "Barnwell",
  "Calhoun",
  "Orangeburg"
)
```

### 2.1.-b Python

```
# Define state abbreviation and county names
state_abb = "SC"
county_names = [
  "Aiken",
  "Allendale",
  "Bamberg",
  "Barnwell",
  "Calhoun",
  "Orangeburg"
]
```

FIPS code conversion translates state abbreviations and county names into standardized Federal Information Processing Standard codes. These codes enable consistent data retrieval across census datasets and ensure proper geographic matching with demographic and economic data sources.

### 2.1.-c R

```
# Converting state abbreviation code to FIPS code
state_fips <- tidycensus::validate_state(state = state_abb)
county_fips <- vapply(
  county_names,
  function(x) tidycensus::validate_county(state = state_abb, county = x),
  character(1)
)

# Converting County Names to FIPS code
fips_codes <- paste(state_fips, county_fips, sep = "")
fips_codes
```

```
[1] "45003" "45005" "45009" "45011" "45017" "45075"
```

### 2.1.-d Python

```
# Converting state abbreviation code to FIPS code
state_fips = validate_state(state_abb)
```

Using FIPS code '45' for input 'SC'

```
# Converting County Names to FIPS code
county_fips = [
    validate_county(state_fips, county)
    for county in county_names
]
```

```
Using FIPS code '003' for input 'Aiken'
Using FIPS code '005' for input 'Allendale'
Using FIPS code '009' for input 'Bamberg'
Using FIPS code '011' for input 'Barnwell'
Using FIPS code '017' for input 'Calhoun'
Using FIPS code '075' for input 'Orangeburg'
```

```
# Converting County Names to FIPS code
fips_codes = [f"{state_fips}{county}" for county in county_fips]
fips_codes
```

```
['45003', '45005', '45009', '45011', '45017', '45075']
```

## 2.2 Load TAZ geometry

The TAZ shapefile provides the fundamental spatial framework for travel demand modeling. The geometry is loaded from the TDM exports geodatabase and filtered to include only zones within the six-county study area using FIPS code matching.

Coordinate transformation converts the TAZ geometry to the project's standard coordinate reference system (EPSG:3361) for accurate spatial calculations. The attribute selection retains essential fields including TAZ identifiers, area measurements, area type classifications, and county assignments.

### 2.2.-a R

```
# Load TAZ Shapefile
lscog_taz <- sf::read_sf(
    file.path(root, "GIS/data_temp/TDM Exports/TDM_Exports.gdb"),
    query = paste0(
        "SELECT * FROM \"SE_2019_AD_10_30_2023\" WHERE countyID IN (",
        paste0("", fips_codes, "", collapse = ", "),
        ")"
    )
```

```

)
) |>
sf::st_transform(project_crs) |>
dplyr::select(
  ID,
  Area,
  Acres,
  TAZ_ID = TAZ_IDs,
  AREA_TYPE,
  COUNTY,
  COUNTYID = countyID
)

lscog_taz

```

Simple feature collection with 585 features and 7 fields  
 Geometry type: MULTIPOLYGON  
 Dimension: XY  
 Bounding box: xmin: 1691490 ymin: 331894 xmax: 2237471 ymax: 744679.9  
 Projected CRS: NAD83(HARN) / South Carolina (ft)  
 # A tibble: 585 × 8

|    | ID       | Area  | Acres  | TAZ_ID   | AREA_TYPE | COUNTY       | COUNTYID |
|----|----------|-------|--------|----------|-----------|--------------|----------|
|    | <int>    | <dbl> | <dbl>  | <int>    | <chr>     | <chr>        | <int>    |
| 1  | 9050130  | 13.3  | 8518.  | 9050130  | RURAL     | Bamberg SC   | 45009    |
| 2  | 9050132  | 39.2  | 25084. | 9050132  | RURAL     | Bamberg SC   | 45009    |
| 3  | 75050131 | 9.03  | 5778.  | 75050131 | RURAL     | Orangeburg S | 45075    |
| 4  | 75050045 | 15.5  | 9934.  | 75050045 | RURAL     | Orangeburg S | 45075    |
| 5  | 75050182 | 17.5  | 11216. | 75050182 | SUBURBAN  | Orangeburg S | 45075    |
| 6  | 75050183 | 12.8  | 8191.  | 75050183 | RURAL     | Orangeburg S | 45075    |
| 7  | 75050172 | 8.10  | 5181.  | 75050172 | SUBURBAN  | Orangeburg S | 45075    |
| 8  | 75050204 | 13.4  | 8568.  | 75050204 | SUBURBAN  | Orangeburg S | 45075    |
| 9  | 75050200 | 6.00  | 3843.  | 75050200 | SUBURBAN  | Orangeburg S | 45075    |
| 10 | 75050201 | 5.06  | 3239.  | 75050201 | SUBURBAN  | Orangeburg S | 45075    |

# i 575 more rows  
 # i 1 more variable: SHAPE <MULTIPOLYGON [foot]>

## 2.2.-b Python

```

# Load TAZ Shapefile
lscog_taz = gpd.read_file(
    Path(root) / "GIS/data_temp/TDM Exports/TDM_Exports.gdb",
    layer="SE_2019_AD_10_30_2023",
    where=f"countyID IN ({', '.join([f'"{fips}"' for fips in fips_codes])})"
)

lscog_taz = lscog_taz.to_crs(project_crs)

```

```
lscog_taz = lscog_taz.rename(
    columns={
        'TAZ_IDs': 'TAZ_ID',
        'countyID': 'COUNTYID'
    })[['ID', 'Area', 'Acres', 'TAZ_ID', 'AREA_TYPE', 'COUNTY', 'COUNTYID',
        'geometry']]

lscog_taz
```

```

      ID  ... geometry
0    9050130  ... MULTIPOLYGON (((2046194.08 478862.054, 2046134...
1    9050132  ... MULTIPOLYGON (((2012593.472 500179.47, 2013190...
2    75050131  ... MULTIPOLYGON (((2056266.071 515975.986, 205617...
3    75050045  ... MULTIPOLYGON (((2061826.693 488917.873, 206173...
4    75050182  ... MULTIPOLYGON (((2154221.857 534929.221, 215441...
..      ...  ...
580  5050049  ... MULTIPOLYGON (((1924248.136 433664.04, 1924004...
581  5050055  ... MULTIPOLYGON (((1905461.23 427627.626, 1905456...
582  5050066  ... MULTIPOLYGON (((1880812.362 414251.546, 188090...
583  5050054  ... MULTIPOLYGON (((1871871.454 413403.458, 187167...
584  5050065  ... MULTIPOLYGON (((1849074.015 398566.33, 1849218...

[585 rows x 8 columns]
```

The interactive map visualization displays the TAZ structure colored by county, providing spatial context for the analysis area and enabling quality assurance of the geometric data loading process.

## 2.2.-c R

```
# Create interactive map
mapview::mapview(lscog_taz, zcol = "COUNTY", lwd = 1.6, map.types =
"CartoDB.Voyager", col.regions = RColorBrewer::brewer.pal(6, "Dark2"))
```

## 2.2.-d Python

```
# Create interactive map
lscog_taz.explore(column="COUNTY", categorical=True, legend=True,
tiles="CartoDB.Voyager", zoom_start=8)
```

# 3 Fetch raw data

This section retrieves demographic, economic, and employment data from multiple Census Bureau sources at the appropriate geographic scales for travel demand modeling.



### 3.1 2020 Decennial census

The 2020 Decennial Census provides population and housing data at the census block level, offering the finest spatial resolution for demographic analysis. Population variables include total population, group quarters population, and household population derived by subtraction. Housing variables encompass total dwelling units and household counts by size categories.

Household size distributions are consolidated into four categories: 1-person, 2-person, 3-person, and 4-or-more-person households. The 4-or-more category aggregates larger household sizes to simplify model implementation while maintaining essential demographic stratification for trip generation analysis.

For more information on the Decennial Census data, refer to the Decennial Census Technical Documentation.

#### 3.1.-a R

```
# Define variables to download
dec_variables <- c(
  TOTPOP = "P1_001N", # Total Population
  GQPOP = "P18_001N", # Population living in Group Quarters
  DU = "H1_001N", # Dwelling Units
  HH_1 = "H9_002N", # 1-person household
  HH_2 = "H9_003N", # 2-person household
  HH_3 = "H9_004N", # 3-person household
  # HH_4 = "H9_005N", # 4-person household
  # HH_5 = "H9_006N", # 5-person household
  # HH_6 = "H9_007N", # 6-person household
  # HH_7 = "H9_008N", # 7-or-more-person household
  HH = "H9_001N" # Total Number of Households
)

# Load Population and Household Data
lscog_dec <- tidycensus::get_decennial(
  year = 2020,
  sumfile = "dhc",
  geography = "block",
  state = state_fips,
  county = county_fips,
  output = "wide",
  cb = FALSE,
  geometry = TRUE,
  keep_geo_vars = TRUE,
  # key = Sys.getenv('CENSUS_API_KEY'),
  variables = dec_variables
) |>
sf::st_transform(project_crs) |>
dplyr::mutate(
```

```

HHPOP = TOTPOP - GQPOP,
HH_4 = HH - (HH_1 + HH_2 + HH_3)
) |>
dplyr::select(GEOID, TOTPOP, GQPOP, HHPOP, HH, HH_1, HH_2, HH_3, HH_4, DU)

```

lscog\_dec

Simple feature collection with 13961 features and 10 fields

Geometry type: MULTIPOLYGON

Dimension: XY

Bounding box: xmin: 1691517 ymin: 331891.7 xmax: 2237472 ymax: 744669.5

Projected CRS: NAD83(HARN) / South Carolina (ft)

# A tibble: 13,961 × 11

|    | GEOID           | TOTPOP | GQPOP | HHPOP | HH    | HH_1  | HH_2  | HH_3  | HH_4  | DU    |
|----|-----------------|--------|-------|-------|-------|-------|-------|-------|-------|-------|
|    | <chr>           | <dbl>  | <dbl> | <dbl> | <dbl> | <dbl> | <dbl> | <dbl> | <dbl> | <dbl> |
| 1  | 450179504004051 | 0      | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| 2  | 450179504003011 | 0      | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| 3  | 450179502011045 | 54     | 4     | 50    | 16    | 3     | 1     | 3     | 9     | 18    |
| 4  | 450179504001020 | 0      | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| 5  | 450750105003029 | 13     | 0     | 13    | 4     | 0     | 3     | 0     | 1     | 4     |
| 6  | 450750117021009 | 10     | 0     | 10    | 3     | 3     | 0     | 0     | 0     | 8     |
| 7  | 450750117011051 | 0      | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| 8  | 450750118021087 | 6      | 0     | 6     | 4     | 0     | 1     | 2     | 1     | 4     |
| 9  | 450750120003020 | 0      | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| 10 | 450179501003046 | 18     | 0     | 18    | 0     | 0     | 0     | 0     | 0     | 1     |

# i 13,951 more rows

# i 1 more variable: geometry <MULTIPOLYGON [foot]>

### 3.1.-b Python

```

# Define variables to download
dec_variables = {
    'P1_001N': 'TOTPOP',      # Total Population
    'P18_001N': 'GQPOP',     # Population living in Group Quarters
    'H1_001N': 'DU',         # Dwelling Units
    'H9_002N': 'HH_1',       # 1-person household
    'H9_003N': 'HH_2',       # 2-person household
    'H9_004N': 'HH_3',       # 3-person household
    # 'H9_005N': 'HH_4',     # 4-person household
    # 'H9_006N': 'HH_5',     # 5-person household
    # 'H9_007N': 'HH_6',     # 6-person household
    # 'H9_008N': 'HH_7',     # 7-or-more-person household
    'H9_001N': 'HH'          # Total Number of Households
}

# get census block geometries
lscog_cb = blocks(

```

```

    state=state_fips,
    county=county_fips,
    year=2020,
    cache=True
)

# Download decennial census data at block level
lscog_dec = get_census(
    dataset="dec/dhc",
    year=2020,
    variables=list(dec_variables.keys()),
    params={
        "for": f"block:*",
        # "key": f"{os.getenv('CENSUS_API_KEY')}",
        "in": f"state:{state_fips} county:{','.join(county_fips)}"
    },
    return_geoid=True,
    guess_dtypes=True,
)

# join data to geometry
lscog_dec = lscog_cb[['GE0ID20', 'geometry']].merge(lscog_dec, left_on =
"GE0ID20", right_on = "GE0ID")

# Rename columns
lscog_dec = lscog_dec.rename(columns=dec_variables)

# Transform CRS
lscog_dec = lscog_dec.to_crs(project_crs)

# Calculate derived variables
lscog_dec['HHP0P'] = lscog_dec['TOTPOP'] - lscog_dec['GQPOP']
lscog_dec['HH_4'] = lscog_dec['HH'] - (
    lscog_dec['HH_1'] + lscog_dec['HH_2'] + lscog_dec['HH_3']
)

# Select final columns
lscog_dec = lscog_dec[['GE0ID', 'TOTPOP', 'GQPOP', 'HHP0P',
                        'HH', 'HH_1', 'HH_2', 'HH_3', 'HH_4', 'DU', 'geometry']]

lscog_dec

```

|   | GE0ID           | ... | geometry  |
|---|-----------------|-----|---|
| 0 | 450179504004051 | ... | POLYGON ((2084300.974 622308.526, 2084460.74 6... |
| 1 | 450179504003011 | ... | POLYGON ((2112518.54 626782.208, 2112608.778 6... |
| 2 | 450179502011045 | ... | POLYGON ((2067775.167 662339.483, 2068091.491 ... |
| 3 | 450179504001020 | ... | POLYGON ((2087947.053 684345.612, 2087992.284 ... |

```

4      450750105003029 ... POLYGON ((2089072.743 552687.443, 2089248.831 ...
...      ...      ...
13956 450059705003050 ... POLYGON ((1926607.333 409005.466, 1926609.861 ...
13957 450030203042000 ... POLYGON ((1778751.197 641782.585, 1778797.329 ...
13958 450030218002115 ... POLYGON ((1919787.314 648288.439, 1919913.531 ...
13959 450030206012008 ... POLYGON ((1723756.559 630234.507, 1723784.384 ...
13960 450059705002005 ... POLYGON ((1926817.622 432583.896, 1930423.825 ...

[13961 rows x 11 columns]

```

### 3.2 2020 ACS estimates

The American Community Survey 5-year estimates provide household income data at the block group level. Income categories are aggregated into three broad ranges: under \$15,000, \$15,000-\$49,999, and \$50,000 and above. This stratification aligns with travel behavior research indicating distinct mobility patterns across income levels.

The block group geography represents the finest spatial resolution available for ACS income data, providing sufficient detail for socioeconomic modeling while maintaining statistical reliability through the 5-year aggregation period.

For more information on the ACS data, refer to the ACS Technical Documentation.

#### 3.2.-a R

```

# Define variables to download
acs_variables <- c(
  INC_CAT_02 = "B19001_002", # Less than $10,000
  INC_CAT_03 = "B19001_003", # $10,000 to $14,999
  INC_CAT_04 = "B19001_004", # $15,000 to $19,999
  INC_CAT_05 = "B19001_005", # $20,000 to $24,999
  INC_CAT_06 = "B19001_006", # $25,000 to $29,999
  INC_CAT_07 = "B19001_007", # $30,000 to $34,999
  INC_CAT_08 = "B19001_008", # $35,000 to $39,999
  INC_CAT_09 = "B19001_009", # $40,000 to $44,999
  INC_CAT_10 = "B19001_010", # $45,000 to $49,999
  # INC_CAT_11 = "B19001_011", # $50,000 to $59,999
  # INC_CAT_12 = "B19001_012", # $60,000 to $74,999
  # INC_CAT_13 = "B19001_013", # $75,000 to $99,999
  # INC_CAT_14 = "B19001_014", # $100,000 to $124,999
  # INC_CAT_15 = "B19001_015", # $125,000 to $149,999
  # INC_CAT_16 = "B19001_016", # $150,000 to $199,999
  # INC_CAT_17 = "B19001_017", # $200,000 or more
  INC_CAT_01 = "B19001_001" # Total
)

# Load Household Income Data

```

```

lscog_acs <- tidycensus::get_acs(
  year = 2020,
  survey = "acs5",
  geography = "block group",
  state = state_fips,
  county = county_fips,
  output = "wide",
  cb = FALSE,
  geometry = TRUE,
  # key = Sys.getenv('CENSUS_API_KEY'),
  variables = acs_variables
) |>
sf::st_transform(project_crs) |>
dplyr::mutate(
  INC_14999 = INC_CAT_02E + INC_CAT_03E,
  INC_49999 = INC_CAT_04E +
    INC_CAT_05E +
    INC_CAT_06E +
    INC_CAT_07E +
    INC_CAT_08E +
    INC_CAT_09E +
    INC_CAT_10E,
  INC_50000 = INC_CAT_01E - (INC_14999 + INC_49999)
) |>
dplyr::select(GEOID, INC_TOTAL = INC_CAT_01E, INC_14999, INC_49999,
INC_50000)

lscog_acs

```

Simple feature collection with 262 features and 5 fields  
Geometry type: MULTIPOLYGON  
Dimension: XY  
Bounding box: xmin: 1691517 ymin: 331891.7 xmax: 2237472 ymax: 744669.5  
Projected CRS: NAD83(HARN) / South Carolina (ft)  
First 10 features:

|    | GEOID        | INC_TOTAL | INC_14999 | INC_49999 | INC_50000 |
|----|--------------|-----------|-----------|-----------|-----------|
| 1  | 450030207011 | 467       | 82        | 171       | 214       |
| 2  | 450030212052 | 949       | 0         | 256       | 693       |
| 3  | 450030212051 | 857       | 21        | 250       | 586       |
| 4  | 450030213001 | 612       | 103       | 129       | 380       |
| 5  | 450030216031 | 1191      | 176       | 303       | 712       |
| 6  | 450030215003 | 773       | 95        | 240       | 438       |
| 7  | 450030205004 | 1081      | 56        | 302       | 723       |
| 8  | 450030205003 | 937       | 37        | 158       | 742       |
| 9  | 450030212041 | 758       | 37        | 344       | 377       |
| 10 | 450030215004 | 973       | 77        | 247       | 649       |

geometry

```

1 MULTIPOLYGON (((1701402 614...
2 MULTIPOLYGON (((1776367 591...
3 MULTIPOLYGON (((1768340 598...
4 MULTIPOLYGON (((1768476 630...
5 MULTIPOLYGON (((1785900 618...
6 MULTIPOLYGON (((1782074 620...
7 MULTIPOLYGON (((1707972 630...
8 MULTIPOLYGON (((1708123 634...
9 MULTIPOLYGON (((1775528 610...
10 MULTIPOLYGON (((1779272 619...

```

### 3.2.-b Python

```

# Define variables to download
acs_variables = {
    'B19001_002E': 'INC_CAT_02', # Less than $10,000
    'B19001_003E': 'INC_CAT_03', # $10,000 to $14,999
    'B19001_004E': 'INC_CAT_04', # $15,000 to $19,999
    'B19001_005E': 'INC_CAT_05', # $20,000 to $24,999
    'B19001_006E': 'INC_CAT_06', # $25,000 to $29,999
    'B19001_007E': 'INC_CAT_07', # $30,000 to $34,999
    'B19001_008E': 'INC_CAT_08', # $35,000 to $39,999
    'B19001_009E': 'INC_CAT_09', # $40,000 to $44,999
    'B19001_010E': 'INC_CAT_10', # $45,000 to $49,999
    # 'B19001_011E': 'INC_CAT_11', # $50,000 to $59,999
    # 'B19001_012E': 'INC_CAT_12', # $60,000 to $74,999
    # 'B19001_013E': 'INC_CAT_13', # $75,000 to $99,999
    # 'B19001_014E': 'INC_CAT_14', # $100,000 to $124,999
    # 'B19001_015E': 'INC_CAT_15', # $125,000 to $149,999
    # 'B19001_016E': 'INC_CAT_16', # $150,000 to $199,999
    # 'B19001_017E': 'INC_CAT_17', # $200,000 or more
    'B19001_001E': 'INC_CAT_01' # Total
}

# get blockgroup geometries
lscog_bg = block_groups(
    state=state_fips,
    county=county_fips,
    year=2020,
    cache=True
)

# Download household income data at block group level
lscog_acs = get_census(
    dataset="acs/acs5",
    year=2020,
    variables=list(acs_variables.keys()),
    params={

```

```

        "for": f"block group:*",
        # "key": f"{os.getenv('CENSUS_API_KEY')}",
        "in": f"state:{state_fips} county:{','.join(county_fips)}"
    },
    return_geoid=True,
    guess_dtypes=True
)

# join data to geometry
lscog_acs = lscog_bg[['GEOID', 'geometry']].merge(lscog_acs, on = "GEOID")

# Rename columns
lscog_acs = lscog_acs.rename(columns=acs_variables)

# Transform CRS
lscog_acs = lscog_acs.to_crs(project_crs)

# Calculate derived variables
lscog_acs['INC_14999'] = lscog_acs['INC_CAT_02'] + lscog_acs['INC_CAT_03']
lscog_acs['INC_49999'] = (
    lscog_acs['INC_CAT_04'] +
    lscog_acs['INC_CAT_05'] +
    lscog_acs['INC_CAT_06'] +
    lscog_acs['INC_CAT_07'] +
    lscog_acs['INC_CAT_08'] +
    lscog_acs['INC_CAT_09'] +
    lscog_acs['INC_CAT_10']
)
lscog_acs['INC_50000'] = lscog_acs['INC_CAT_01'] - (
    lscog_acs['INC_14999'] + lscog_acs['INC_49999']
)

# Select final columns
lscog_acs = lscog_acs.rename(columns={'INC_CAT_01': 'INC_TOTAL'})
lscog_acs = lscog_acs[['GEOID', 'INC_TOTAL', 'INC_14999', 'INC_49999',
'INC_50000', 'geometry'
]]

lscog_acs

```

```

      GEOID  ... geometry
0  450030207011  ... POLYGON ((1701402.37 614608.958, 1701441.07 61...
1  450030212052  ... POLYGON ((1776366.684 591083.944, 1776445.37 5...
2  450030212051  ... POLYGON ((1768340.248 598546.468, 1768482.141 ...
3  450030213001  ... POLYGON ((1768475.931 630588.733, 1768610.076 ...
4  450030216031  ... POLYGON ((1785900.107 618251.028, 1786047.488 ...
..          ...  ...

```

```

257 450750119004 ... POLYGON ((1974249.527 620700.361, 1975105.197 ...
258 450750103011 ... POLYGON ((2142864.631 581695.327, 2142874.033 ...
259 450750109011 ... POLYGON ((2033500.16 608479.774, 2033509.304 6...
260 450750109022 ... POLYGON ((2013478.807 622487.426, 2013488.515 ...
261 450750109023 ... POLYGON ((2022268.105 617836.647, 2022656.655 ...

```

[262 rows x 6 columns]

### 3.3 2019 LEHD data

The Longitudinal Employer-Household Dynamics Workplace Area Characteristics data provides employment counts by industry sector at the census block level. Employment categories follow the North American Industry Classification System and are aggregated into transportation-relevant sectors including retail, services, manufacturing, and public administration.

The 2019 reference year represents pre-pandemic employment patterns, providing a stable baseline for long-term transportation planning. Employment data at the block level enables precise spatial allocation of work destinations within the travel demand model framework.

For more information on the LEHD data, refer to the LODES Technical Documentation.

#### 3.3.-a R

```

# Download LEHD WAC data at block level
lscog_emp <- lehdr::grab_lodes(
  version = "LODES8",
  state = tolower(state_abb),
  lodes_type = "wac",
  segment = "S000",
  job_type = "JT00",
  year = 2019,
  state_part = "",
  agg_geo = "block",
  use_cache = TRUE
) |>
dplyr::filter(grepl(
  paste("^( ", paste(fips_codes, collapse = "|"), ")", sep = ""),
  w_geocode
)) |>
# check the documentation at: https://lehd.ces.census.gov/data/lodes/LODES8/
LODESTechDoc8.0.pdf
dplyr::mutate(
  GEOID = as.character(w_geocode),
  TOTAL_EMP = C000, # Total Employment
  AGR_FOR_FI = CNS01, # Agricultural, forestry, and fishing employment
  MINING = CNS02, # Mining employment
  CONSTRUCTI = CNS04, # Construction employment

```



```

MANUFACTUR = CNS05, # Manufacturing employment
TRANSP_COM = CNS08 + CNS09, # Transportation, communication employment
WHOLESALE = CNS06, # Wholesale employment
RETAIL = CNS07, # Retail employment
FIRE = CNS10 + CNS11, # Finance / Insurance / Real Estate employment
SERVICES = CNS03 +
  CNS12 +
  CNS13 +
  CNS14 + # Service employment
  CNS15 +
  CNS16 +
  CNS17 +
  CNS18 +
  CNS19,
PUBLIC_ADM = CNS20 # Public Administration employment
) |>
dplyr::select(
  GEOID,
  TOTAL_EMP,
  AGR_FOR_FI,
  MINING,
  CONSTRUCTI,
  MANUFACTUR,
  TRANSP_COM,
  WHOLESALE,
  RETAIL,
  FIRE,
  SERVICES,
  PUBLIC_ADM
)

lscog_emp

```

```

# A tibble: 2,450 × 12
  GEOID TOTAL_EMP AGR_FOR_FI MINING CONSTRUCTI MANUFACTUR TRANSP_COM
WHOLESALE
  <chr>      <dbl>      <dbl> <dbl>      <dbl>      <dbl>      <dbl>
<dbl>
1 45003...      6          6      0          0          0          0
0
2 45003...      4          0      0          0          0          4
0
3 45003...     12          0      0         12          0          0
0
4 45003...      1          0      0          0          0          0
0
5 45003...     11         11      0          0          0          0

```

```

0
6 45003...      1      0      0      0      0      0
0
7 45003...      9      0      0      0      0      0
0
8 45003...     18      0      0     18      0      0
0
9 45003...      1      0      0      1      0      0
0
10 45003...      4      4      0      0      0      0
0
# i 2,440 more rows
# i 4 more variables: RETAIL <dbl>, FIRE <dbl>, SERVICES <dbl>,
#   PUBLIC_ADM <dbl>

```

### 3.3.-b Python

```

# Download LEHD WAC data at block level
lscog_emp = get_lodes(
    state=state_abb,
    year=2019,
    version="LODES8",
    lodes_type="wac",
    part="main",
    segment="S000",
    job_type="JT00",
    agg_level="block",
    cache=True,
    return_geometry=False
)

# Filter for specific FIPS codes
lscog_emp =
lscog_emp[lscog_emp['w_geocode'].str.match(f"^{({'|'.join(fips_codes))}")]]

# Create new columns with employment categories
# Check documentation at: https://lehd.ces.census.gov/data/lodes/LODES8/LODESTechDoc8.0.pdf
lscog_emp = lscog_emp.assign(
    GEOID=lscog_emp['w_geocode'].astype(str),
    TOTAL_EMP=lscog_emp['C000'], # Total Employment
    AGR_FOR_FI=lscog_emp['CNS01'], # Agricultural, forestry, and fishing
    employment
    MINING=lscog_emp['CNS02'], # Mining employment
    CONSTRUCTI=lscog_emp['CNS04'], # Construction employment
    MANUFACTUR=lscog_emp['CNS05'], # Manufacturing employment
    TRANSP_COM=lscog_emp['CNS08'] + lscog_emp['CNS09'], # Transportation,
    communication employment

```

```

    WHOLESALE=lscog_emp['CNS06'], # Wholesale employment
    RETAIL=lscog_emp['CNS07'], # Retail employment
    FIRE=lscog_emp['CNS10'] + lscog_emp['CNS11'], # Finance / Insurance /
Real Estate employment
    SERVICES=(lscog_emp['CNS03'] +
               lscog_emp['CNS12'] +
               lscog_emp['CNS13'] +
               lscog_emp['CNS14'] +
               lscog_emp['CNS15'] +
               lscog_emp['CNS16'] +
               lscog_emp['CNS17'] +
               lscog_emp['CNS18'] +
               lscog_emp['CNS19']), # Service employment
    PUBLIC_ADM=lscog_emp['CNS20'] # Public Administration employment
)

# Select only the desired columns
lscog_emp = lscog_emp[['GEOID', 'TOTAL_EMP', 'AGR_FOR_FI', 'MINING',
'CONSTRUCTI',
                        'MANUFACTUR', 'TRANSP_COM', 'WHOLESALE', 'RETAIL',
'FIRE',
                        'SERVICES', 'PUBLIC_ADM']]

# Display structure/info about the dataframe
lscog_emp

```

|       | GEOID           | TOTAL_EMP | AGR_FOR_FI | ... | FIRE | SERVICES | PUBLIC_ADM |
|-------|-----------------|-----------|------------|-----|------|----------|------------|
| 191   | 450030201001001 | 6         | 6          | ... | 0    | 0        | 0          |
| 192   | 450030201001017 | 4         | 0          | ... | 0    | 0        | 0          |
| 193   | 450030201001037 | 12        | 0          | ... | 0    | 0        | 0          |
| 194   | 450030201001049 | 1         | 0          | ... | 0    | 0        | 0          |
| 195   | 450030201002006 | 11        | 11         | ... | 0    | 0        | 0          |
| ...   | ...             | ...       | ...        | ... | ...  | ...      | ...        |
| 28115 | 450750120002099 | 25        | 0          | ... | 0    | 0        | 0          |
| 28116 | 450750120002108 | 8         | 0          | ... | 0    | 0        | 0          |
| 28117 | 450750120002118 | 3         | 0          | ... | 0    | 0        | 0          |
| 28118 | 450750120004038 | 3         | 0          | ... | 0    | 0        | 0          |
| 28119 | 450750120004071 | 6         | 0          | ... | 0    | 5        | 0          |

[2450 rows x 12 columns]

### 3.4 2020 NCES school and college enrollment data

The National Center for Education Statistics provides comprehensive educational institution data including enrollment and staffing information for transportation planning analysis.

#### Public schools

Public school data is made available by National Center for Education Statistics through their Common Core of Data (CCD) program. For ease of processing, we retrieve the CCD from the ArcGIS REST service for the 2019-2020 academic year. The dataset includes total student enrollment and full-time equivalent teacher counts for each institution within the six-county region. Public schools represent major trip generation sources for both student and employee travel, requiring precise spatial location data for accurate modeling.

For more information on the NCES Public School data, refer to CCD Online Documentation.

To retrieve the data from ArcGIS REST service, we use the `{arcgislayers}` package in R and create a custom function in Python to read the ArcGIS FeatureLayer or Table. This has been implemented to function similarly to the `{arcgislayers}` package in R, allowing us to query the service with a SQL WHERE clause and return the data as a GeoDataFrame.

### 3.4.-a R

```
# Public School Location data 2019-2020
lscog_pub_sch_enroll <- arcgislayers::arc_read(
  url = "https://nces.ed.gov/opengis/rest/services/K12_School_Locations/EDGE_
ADMINDATA_PUBLICSCH_1920/MapServer/0",
  where = paste0(
    "LSTATE = '",
    state_abb,
    "' AND NMCNTY IN (",
    paste0("'", paste0(county_names, " County"), "'", collapse = ", "),
    ")"
  ),
  alias = "label",
  crs = project_crs
) |>
dplyr::select(
  INSTITUTION_ID = NCESSCH,
  NAME = SCH_NAME,
  STATE = LSTATE,
  STUDENT_COUNT_PUB = TOTAL,
  TEACHER_COUNT_PUB = FTE
)

lscog_pub_sch_enroll
```

```
Simple feature collection with 98 features and 5 fields
Geometry type: POINT
Dimension: XY
Bounding box: xmin: 1700952 ymin: 406810.6 xmax: 2203406 ymax: 724699.4
Projected CRS: NAD83(HARN) / South Carolina (ft)
First 10 features:
```

|    | INSTITUTION_ID    | NAME                          | STATE | STUDENT_COUNT_PUB |
|----|-------------------|-------------------------------|-------|-------------------|
| 1  | 450108001163      | Barnwell Elementary           | SC    | 462               |
| 2  | 450075000064      | Allendale Fairfax High        | SC    | 283               |
| 3  | 450075001184      | Allendale Elementary          | SC    | 245               |
| 4  | 450075001415      | Allendale-Fairfax Middle      | SC    | 268               |
| 5  | 450093000119      | Bamberg-Ehrhardt High         | SC    | 381               |
| 6  | 450093000120      | Bamberg-Ehrhardt Middle       | SC    | 188               |
| 7  | 450096000122      | Denmark Olar High             | SC    | 162               |
| 8  | 450096000123      | Denmark-Olar Middle           | SC    | 149               |
| 9  | 450096001426      | Denmark-Olar Elementary       | SC    | 353               |
| 10 | 450098000127      | Barnwell County Career Center | SC    | 0                 |
|    | TEACHER_COUNT_PUB | geometry                      |       |                   |
| 1  | 32.0              | POINT (1891531 517378.5)      |       |                   |
| 2  | 28.9              | POINT (1913416 420526.6)      |       |                   |
| 3  | 18.0              | POINT (1916344 418212.2)      |       |                   |
| 4  | 18.0              | POINT (1913416 420526.6)      |       |                   |
| 5  | 28.5              | POINT (1991502 535259.1)      |       |                   |
| 6  | 15.0              | POINT (1990622 534442.6)      |       |                   |
| 7  | 20.0              | POINT (1962410 543779)        |       |                   |
| 8  | 10.0              | POINT (1956236 534420.3)      |       |                   |
| 9  | 25.0              | POINT (1960237 537023.1)      |       |                   |
| 10 | 12.0              | POINT (1894891 540093)        |       |                   |

### 3.4.-b Python

```
# Create function to read ArcGIS FeatureLayer or Table
def arc_read(url, where="1=1", outFields="*", outSR=4326, **kwargs):
    """
    Read an ArcGIS FeatureLayer or Table to a GeoDataFrame.

    Parameters:
    url (str): The ArcGIS REST service URL ending with /MapServer/0 or /
    FeatureServer/0
    where (str): SQL WHERE clause for filtering. Default: "1=1" (all records)
    outFields (str): Comma-separated field names or "*" for all fields.
    Default: "*"
    outSR (int): Output spatial reference EPSG code. Default: 4326
    **kwargs: Additional query parameters passed to the ArcGIS REST API

    Returns:
    geopandas.GeoDataFrame: Spatial data from the service
    """

    # Ensure URL ends with /query
    if not url.endswith('/query'):
        url = url.rstrip('/') + '/query'

    # Build query parameters
```

```

params = {
    'where': where,
    'outFields': outFields,
    'returnGeometry': 'true',
    # 'geometryType': 'esriGeometryPoint',
    'outSR': outSR,
    'f': 'geojson'
}

# Add any additional parameters
params.update(kwargs)

# Make request
response = requests.get(url, params=params)

# Read as GeoDataFrame
return gpd.read_file(response.text)

```

```

# Public School Enrollment data 2019-2020
lscog_pub_sch_enroll = arc_read(
    url="https://nces.ed.gov/ipeds/data/colleges/2019/MapServer/0",
    where=f"LSTATE = '{state_abb}' AND NMCNTY IN ('{', ' ".join([f'{name}'
County" for name in county_names]))'",
    outFields='NCESSCH,SCH_NAME,LSTATE,TOTAL,FTE'
)

# Transform CRS
lscog_pub_sch_enroll = lscog_pub_sch_enroll.to_crs(project_crs)

# Select and rename columns
lscog_pub_sch_enroll = lscog_pub_sch_enroll.rename(columns={
    'NCESSCH': 'INSTITUTION_ID',
    'SCH_NAME': 'NAME',
    'LSTATE': 'STATE',
    'TOTAL': 'STUDENT_COUNT_PUB',
    'FTE': 'TEACHER_COUNT_PUB'
})

lscog_pub_sch_enroll

```

|   | INSTITUTION_ID | ... | geometry                       |
|---|----------------|-----|--------------------------------|
| 0 | 450108001163   | ... | POINT (1891532.112 517376.183) |
| 1 | 450075000064   | ... | POINT (1913417.281 420524.266) |
| 2 | 450075001184   | ... | POINT (1916345.361 418209.84)  |
| 3 | 450075001415   | ... | POINT (1913417.281 420524.266) |

```

4    450093000119 ... POINT (1991503.106 535256.782)
..    ... ..
93   450391001291 ... POINT (2048660.583 606357.033)
94   450391001370 ... POINT (2040865.5 608975.982)
95   450391001604 ... POINT (2050404.085 617575.512)
96   450391001693 ... POINT (2030130.8 597632.129)
97   450391001694 ... POINT (2043557.083 596562.932)

[98 rows x 6 columns]

```

### Private schools

Private school enrollment data is accessed from the NCES Private School Universe Survey (PSS) archived dataset. The data is spatially enabled using latitude and longitude coordinates and filtered to include only institutions within the study area TAZ boundaries. Private schools contribute to the regional education trip matrix and must be incorporated alongside public institutions for comprehensive coverage.

For more information on the NCES Private Schools data, refer to PSS Online Documentation.

### 3.4.-c R

```

# Private School Enrollment data 2019-2020
lscog_pvt_sch_enroll <- vroom::vroom(
  unz(
    file.path(
      root,
      "GIS/data_external/20250315 NCES/PSS - Private/2019-20/
pss1920_pu_csv.zip"
    ),
    "pss1920_pu.csv"
  ),
  col_types = vroom::cols_only(
    PPIN      = vroom::col_character(),
    PINST     = vroom::col_character(),
    PL_STABB  = vroom::col_character(),
    PCNTNM    = vroom::col_character(),
    SIZE      = vroom::col_double(),
    NUMTEACH  = vroom::col_double(),
    LATITUDE20 = vroom::col_double(),
    LONGITUDE20 = vroom::col_double()
  )
) |>
sf::st_as_sf(coords = c("LONGITUDE20", "LATITUDE20"), crs = "EPSG:4326") |>
sf::st_transform(project_crs) |>
sf::st_filter(lscog_taz, .predicate = st_intersects) |>
dplyr::select(

```

```

    INSTITUTION_ID = PPIN,
    NAME = PINST,
    STATE = PL_STABB,
    STUDENT_COUNT_PVT = SIZE,
    TEACHER_COUNT_PVT = NUMTEACH
)

lscog_pvt_sch_enroll

```

```

Simple feature collection with 24 features and 5 fields
Geometry type: POINT
Dimension:      XY
Bounding box:   xmin: 1704062 ymin: 492304.2 xmax: 2179510 ymax: 720184.2
Projected CRS:  NAD83(HARN) / South Carolina (ft)
# A tibble: 24 × 6
  INSTITUTION_ID NAME                STATE STUDENT_COUNT_PVT
TEACHER_COUNT_PVT
    <chr>          <chr>                <chr>          <dbl>
<dbl>
1 K9305823      AIKENS FBC PRESCHOOL SC                1
1.3
2 01264947      ANDREW JACKSON ACAD... SC                3
13.3
3 A9106158      BARNWELL CHRISTIAN ... <NA>                2
5.8
4 01263568      CALHOUN ACADEMY      SC                3
26.6
5 A1771477      FIRST BAPTIST CHURC... <NA>                1
3.1
6 A9703151      FIRST PRESBYTERIAN ... <NA>                1
2.8
7 BB170334      FIRST SOUTHERN METH... SC                1
6
8 A1102039      FOUNDATION CHRISTIA... <NA>                1
5
9 A0307976      GRACE CHILD DEVELOP... <NA>                1
2.9
10 A0307978     GREATER FAITH BAPTI... <NA>                1
1
# i 14 more rows
# i 1 more variable: geometry <POINT [foot]>

```

### 3.4.-.d Python

```

# Private School Enrollment data 2019-2020
zip_path = Path(root) / "GIS/data_external/20250315 NCES/PSS -
Private/2019-20/pss1920_pu_csv.zip"

```



```

with zipfile.ZipFile(zip_path, 'r') as zip_ref:
    with zip_ref.open('pss1920_pu.csv') as csv_file:
        lscog_pvt_sch_enroll = pd.read_csv(
            csv_file,
            usecols=['PPIN', 'PINST', 'PL_STABB', 'PCNTNM', 'SIZE',
                    'NUMTEACH', 'LATITUDE20', 'LONGITUDE20'],
            dtype={'PPIN': 'str', 'PINST': 'str', 'PL_STABB': 'str', 'PCNTNM':
                  'str', 'SIZE': 'float64', 'NUMTEACH': 'float64'})

lscog_pvt_sch_enroll = gpd.GeoDataFrame(
    lscog_pvt_sch_enroll,
    geometry=gpd.points_from_xy(lscog_pvt_sch_enroll['LONGITUDE20'],
    lscog_pvt_sch_enroll['LATITUDE20']),
    crs='EPSG:4326'
).to_crs(project_crs)

lscog_pvt_sch_enroll = gpd.sjoin(lscog_pvt_sch_enroll, lscog_taz, how='inner',
    predicate='intersects')[
    ['PPIN', 'PINST', 'PL_STABB', 'SIZE', 'NUMTEACH', 'geometry']]
lscog_pvt_sch_enroll.rename(columns={
    'PPIN': 'INSTITUTION_ID',
    'PINST': 'NAME',
    'PL_STABB': 'STATE',
    'SIZE': 'STUDENT_COUNT_PVT',
    'NUMTEACH': 'TEACHER_COUNT_PVT'
})

lscog_pvt_sch_enroll

```

|       | INSTITUTION_ID | ... | geometry                       |
|-------|----------------|-----|--------------------------------|
| 17469 | K9305823       | ... | POINT (1781275.702 629440.997) |
| 17474 | 01264947       | ... | POINT (1993756.78 492304.247)  |
| 17476 | A9106158       | ... | POINT (1914982.59 524548.558)  |
| 17484 | 01263568       | ... | POINT (2072197.427 660303.544) |
| 17533 | A1771477       | ... | POINT (1704061.773 606321.234) |
| 17537 | A9703151       | ... | POINT (1780623.642 630282.337) |
| 17538 | BB170334       | ... | POINT (2037420.57 608741.769)  |
| 17543 | A1102039       | ... | POINT (2006658.982 720184.199) |
| 17547 | A0307976       | ... | POINT (1704601.274 606316.17)  |
| 17550 | A0307978       | ... | POINT (2047302.618 604573.723) |
| 17566 | A1904026       | ... | POINT (2179509.785 547981.083) |
| 17571 | 01263692       | ... | POINT (1918041.289 549840.623) |
| 17599 | 01264754       | ... | POINT (1779301.654 629488.248) |
| 17601 | A0308015       | ... | POINT (1733987.726 611499.727) |
| 17623 | A1303185       | ... | POINT (1853302.82 681159.161)  |

```

17637      A9903938 ... POINT (2047246.79 597082.682)
17651      A0109147 ... POINT (1780574.399 631607.375)
17657      01264288 ... POINT (1778262.542 613244.891)
17658      K9305825 ... POINT (1779510.666 617490.702)
17663      K9305640 ... POINT (2041004.71 611841.216)
17672      A9703170 ... POINT (1780823.53 629681.358)
17676      01262826 ... POINT (1781344.96 628712.135)
17722      01932407 ... POINT (2037497.91 608547.947)
17733      A9903957 ... POINT (1875514.037 565892.953)

```

[24 rows x 6 columns]

### Post-secondary institutions

Post-secondary institution locations are obtained from the NCES Integrated Postsecondary Education Data System (IPEDS), filtered by state and county FIPS codes. These institutions generate significant travel demand through student commuting, employee travel, and visitor trips, making them essential components of the regional transportation network analysis.

For more information on the NCES Post-Secondary Education data, refer to IPEDS Documentation.

### 3.4.-e R

```

# Post-Secondary Location data 2019-2020
lscog_college_loc <- arcgislayers::arc_read(
  url = "https://nces.ed.gov/opengis/rest/services/Postsecondary_School_
Locations/EDGE_GEOCODE_POSTSECONDARYSCH_1920/MapServer/0",
  where = paste0(
    "STATE = '",
    state_abb,
    "' AND CNTY IN (",
    paste0("'", fips_codes, "'", collapse = ", "),
    ")"
  ),
  alias = "label",
  crs = project_crs
)

lscog_college_loc

```

```

Simple feature collection with 11 features and 24 fields
Geometry type: POINT
Dimension:      XY
Bounding box:   xmin: 1708029 ymin: 429827.9 xmax: 2052011 ymax: 633710.3
Projected CRS:  NAD83(HARN) / South Carolina (ft)

```

First 10 features:

|    | OBJECTID | UNITID | NAME   |
|----|----------|--------|--|
| 1  | 3411     | 217615 | Aiken Technical College                            |
| 2  | 3424     | 217873 | Claflin University                                 |
| 3  | 3431     | 217989 | Denmark Technical College                          |
| 4  | 3439     | 218159 | Kenneth Shuler School of Cosmetology-North Augusta |
| 5  | 3448     | 218487 | Orangeburg Calhoun Technical College               |
| 6  | 3451     | 218645 | University of South Carolina Aiken                 |
| 7  | 3455     | 218681 | University of South Carolina-Salkehatchie          |
| 8  | 3459     | 218733 | South Carolina State University                    |
| 9  | 3468     | 218919 | Voorhees College                                   |
| 10 | 5829     | 457998 | Aiken School of Cosmetology and Barbering          |

|    |      | STREET                  | CITY          | STATE | ZIP        | STFIP | CNTY  |
|----|------|-------------------------|---------------|-------|------------|-------|-------|
| 1  | 2276 | Jefferson Davis Highway | Graniteville  | SC    | 29829      | 45    | 45003 |
| 2  |      | 400 Magnolia Street     | Orangeburg    | SC    | 29115-4498 | 45    | 45075 |
| 3  | 1126 | Solomon Blatt Blvd      | Denmark       | SC    | 29042      | 45    | 45009 |
| 4  |      | 1113 Knox Avenue        | North Augusta | SC    | 29841      | 45    | 45003 |
| 5  | 3250 | Saint Matthews Rd       | Orangeburg    | SC    | 29118-8299 | 45    | 45075 |
| 6  |      | 471 University Pkwy     | Aiken         | SC    | 29801      | 45    | 45003 |
| 7  | 465  | James Brandt Blvd       | Allendale     | SC    | 29810-0617 | 45    | 45005 |
| 8  |      | 300 College St NE       | Orangeburg    | SC    | 29117-0001 | 45    | 45075 |
| 9  |      | 481 Porter Drive        | Denmark       | SC    | 29042      | 45    | 45009 |
| 10 | 225  | Richland Ave East       | Aiken         | SC    | 29801      | 45    | 45003 |

|    | NMCNTY            | LOCALE | LAT      | LON       | CBSA  |
|----|-------------------|--------|----------|-----------|-------|
| 1  | Aiken County      | 41     | 33.53383 | -81.84167 | 12260 |
| 2  | Orangeburg County | 32     | 33.49844 | -80.85432 | 36700 |
| 3  | Bamberg County    | 41     | 33.31336 | -81.12363 | N     |
| 4  | Aiken County      | 21     | 33.49759 | -81.95789 | 12260 |
| 5  | Orangeburg County | 41     | 33.54485 | -80.82927 | 36700 |
| 6  | Aiken County      | 21     | 33.57270 | -81.76761 | 12260 |
| 7  | Allendale County  | 41     | 33.01431 | -81.30184 | N     |
| 8  | Orangeburg County | 32     | 33.49797 | -80.84872 | 36700 |
| 9  | Bamberg County    | 32     | 33.30720 | -81.12786 | N     |
| 10 | Aiken County      | 21     | 33.55954 | -81.71728 | 12260 |

NMCBSA CBSATYPE CSA

NMCSA

|   |                                |   |                                      |
|---|--------------------------------|---|--------------------------------------|
| 1 | Augusta-Richmond County, GA-SC | 1 | N                                    |
| N |                                |   |                                      |
| 2 | Orangeburg, SC                 | 2 | 192 Columbia-Orangeburg-Newberry, SC |
| 3 | N                              | 0 | N                                    |
| N |                                |   |                                      |
| 4 | Augusta-Richmond County, GA-SC | 1 | N                                    |
| N |                                |   |                                      |
| 5 | Orangeburg, SC                 | 2 | 192 Columbia-Orangeburg-Newberry, SC |
| 6 | Augusta-Richmond County, GA-SC | 1 | N                                    |
| N |                                |   |                                      |

```

7          N          0  N
N
8          Orangeburg, SC          2 192 Columbia-Orangeburg-Newberry,
SC
9          N          0  N
N
10 Augusta-Richmond County, GA-SC          1  N
N
      NECTA NMNECTA   CD  SLDL  SLDU SCHOOLYEAR          geometry
1      N      N 4502 45084 45025 2019-2020 POINT (1743560 619744.3)
2      N      N 4506 45095 45039 2019-2020 POINT (2044404 605856.3)
3      N      N 4506 45090 45040 2019-2020 POINT (1962235 538509.9)
4      N      N 4502 45083 45024 2019-2020 POINT (1708029 606866.3)
5      N      N 4506 45095 45040 2019-2020 POINT (2052011 622751.3)
6      N      N 4502 45081 45025 2019-2020 POINT (1766228 633710.3)
7      N      N 4506 45091 45045 2019-2020 POINT (1907482 429827.9)
8      N      N 4506 45095 45039 2019-2020 POINT (2046110 605685.6)
9      N      N 4506 45090 45040 2019-2020 POINT (1960939 536271.9)
10     N      N 4502 45081 45026 2019-2020 POINT (1781522 628812.8)

```

### 3.4.-f Python

```

# Post-Secondary Location data 2019-2020
lscog_college_loc = arc_read(
    url="https://nces.ed.gov/opengis/rest/services/Postsecondary_School_
Locations/EDGE_GEOCODE_POSTSECONDARYSCH_1920/MapServer/0",
    where=f"STATE = '{state_abb}' AND CNTY IN ('{''}', '".join([f'"{fip}"' for fip
in fips_codes]))'",
    outFields='*',
    outSR=project_crs
)

lscog_college_loc = lscog_college_loc.to_crs(project_crs)

lscog_college_loc

```

```

      OBJECTID  UNITID  ... SCHOOLYEAR          geometry
0      3411  217615  ...  2019-2020  POINT (1743561.221 619741.983)
1      3424  217873  ...  2019-2020  POINT (2044404.666 605853.958)
2      3431  217989  ...  2019-2020  POINT (1962236.326 538507.569)
3      3439  218159  ...  2019-2020  POINT (1708030.354 606863.953)
4      3448  218487  ...  2019-2020  POINT (2052011.899 622748.89)
5      3451  218645  ...  2019-2020  POINT (1766228.593 633707.888)
6      3455  218681  ...  2019-2020  POINT (1907483.079 429825.628)
7      3459  218733  ...  2019-2020  POINT (2046110.928 605683.233)
8      3468  218919  ...  2019-2020  POINT (1960940.241 536269.53)
9      5829  457998  ...  2019-2020  POINT (1781523.402 628810.398)

```

```
10      6683 488022 ... 2019-2020 POINT (2043606.983 603651.758)

[11 rows x 25 columns]
```

## 4 Clean data

The data cleaning process involves harmonizing multiple Census data sources to create a comprehensive socioeconomic dataset at the census block level. This requires careful interpolation and integration of American Community Survey (ACS) estimates with Decennial Census counts to maintain spatial consistency and statistical accuracy.

### 4.1 Household-weighted interpolation

The interpolation process transfers ACS block group data to individual census blocks using household counts as weights. This method ensures that socioeconomic characteristics are distributed proportionally based on residential density rather than simple geometric overlay. The `{tidycensus}` package provides robust interpolation functionality that preserves the extensive nature of count variables while maintaining spatial relationships. For Python, the `interpolate_pw()` function is implemented to achieve similar functionality using population-weighted interpolation.

#### 4.1.-a R

```
# Interpolate ACS data to Decennial Census blocks
lscog_acs_cb <- tidycensus::interpolate_pw(
  from = lscog_acs,
  to = lscog_dec,
  to_id = "GEOID",
  extensive = TRUE,
  weights = lscog_dec,
  crs = project_crs,
  weight_column = "HH"
)

lscog_acs_cb
```

```
Simple feature collection with 13961 features and 5 fields
Geometry type: MULTIPOLYGON
Dimension: XY
Bounding box: xmin: 1691517 ymin: 331891.7 xmax: 2237472 ymax: 744669.5
Projected CRS: NAD83(HARN) / South Carolina (ft)
# A tibble: 13,961 × 6
  GEOID geometry INC_TOTAL INC_14999 INC_49999
INC_50000
  <chr> <MULTIPOLYGON [foot]> <dbl> <dbl> <dbl>
<dbl>
```

```

1 4501795040... (((2084301 622308.5, 208...      0      0      0
0
2 4501795040... (((2112519 626782.2, 211...      0      0      0
0
3 4501795020... (((2067775 662339.5, 206...    20.6    4.27    7.56
8.72
4 4501795040... (((2087947 684345.6, 208...      0      0      0
0
5 4507501050... (((2089073 552687.4, 208...     5.78    1.94    0.924
2.92
6 4507501170... (((2046694 542273.9, 204...     2.48    0.393    1.30
0.780
7 4507501170... (((2056704 510850.5, 205...      0      0      0
0
8 4507501180... (((1960896 587381.7, 196...     3.19    0.694    1.42
1.08
9 4507501200... (((2000969 657869.3, 200...      0      0      0
0
10 4501795010... (((2016178 708106.6, 201...      0      0      0
0
# i 13,951 more rows

```

#### 4.1.-b Python

```

def interpolate_pw(from_gdf, to_gdf, weights_gdf, to_id=None, extensive=True,
                  weight_column=None, weight_placement='surface', crs=None):
    """
    Population-weighted areal interpolation between geometries.

    Transfers numeric data from source geometries to target geometries using
    population-weighted interpolation based on point weights (e.g., census
    blocks).

    Parameters:
    -----
    from_gdf : GeoDataFrame
        Source geometries with numeric data to interpolate
    to_gdf : GeoDataFrame
        Target geometries to interpolate data to
    weights_gdf : GeoDataFrame
        Weight geometries (e.g., census blocks) used for interpolation.
        If polygons, will be converted to points. Can be the same as to_gdf.
    to_id : str, optional
        Column name for unique identifier in target geometries.
        If None, creates an 'id' column.
    extensive : bool, default True
        If True, return weighted sums (for counts).
        If False, return weighted means (for rates/percentages).

```

```

weight_column : str, optional
    Column name in weights_gdf for weighting (e.g., 'POP', 'HH').
    If None, all weights are equal.
weight_placement : str, default 'surface'
    How to convert polygons to points: 'surface' or 'centroid'
crs : str or CRS object, optional
    Coordinate reference system to project all datasets to

Returns:
-----
GeoDataFrame
    Target geometries with interpolated numeric values
"""

# Input validation
if not all(isinstance(gdf, gpd.GeoDataFrame) for gdf in [from_gdf, to_gdf,
weights_gdf]):
    raise ValueError("All inputs must be GeoDataFrames")

# Make copies to avoid modifying originals
from_gdf = from_gdf.copy()
to_gdf = to_gdf.copy()
weights_gdf = weights_gdf.copy()

# Set CRS if provided
if crs:
    from_gdf = from_gdf.to_crs(crs)
    to_gdf = to_gdf.to_crs(crs)
    weights_gdf = weights_gdf.to_crs(crs)

# Check CRS consistency
if not (from_gdf.crs == to_gdf.crs == weights_gdf.crs):
    raise ValueError("All inputs must have the same CRS")

# Handle to_id
if to_id is None:
    to_id = 'id'
    to_gdf[to_id] = to_gdf.index.astype(str)

# Remove conflicting columns
if to_id in from_gdf.columns:
    from_gdf = from_gdf.drop(columns=[to_id])

# Create unique from_id
from_id = 'from_id'
from_gdf[from_id] = from_gdf.index.astype(str)

# Handle weight column

```

```

if weight_column is None:
    weight_column = 'interpolation_weight'
    weights_gdf[weight_column] = 1.0
else:
    # Rename to avoid conflicts
    weights_gdf['interpolation_weight'] = weights_gdf[weight_column]
    weight_column = 'interpolation_weight'

# Convert weights to points if needed
if weights_gdf.geometry.geom_type.iloc[0] in ['Polygon', 'MultiPolygon']:
    if weight_placement == 'surface':
        weights_gdf = weights_gdf.copy()
        weights_gdf.geometry = weights_gdf.geometry.representative_point()
    elif weight_placement == 'centroid':
        weights_gdf = weights_gdf.copy()
        weights_gdf.geometry = weights_gdf.geometry.centroid
    else:
        raise ValueError("weight_placement must be 'surface' or
'centroid'")

# Keep only weight column and geometry
weight_points = weights_gdf[[weight_column, 'geometry']].copy()

# Calculate denominators (total weights per source geometry)
with warnings.catch_warnings():
    warnings.filterwarnings('ignore', category=UserWarning)
    source_weights = gpd.sjoin(from_gdf, weight_points, how='left',
predicate='contains')

    denominators = (source_weights.groupby(from_id)[weight_column]
        .sum()
        .reset_index()
        .rename(columns={weight_column: 'weight_total'}))

# Calculate intersections between from and to
with warnings.catch_warnings():
    warnings.filterwarnings('ignore', category=UserWarning)
    intersections = gpd.overlay(from_gdf, to_gdf, how='intersection')

# Filter to keep only polygon intersections
intersections =
intersections[intersections.geometry.geom_type.isin(['Polygon',
'MultiPolygon', 'GeometryCollection'])]

if len(intersections) == 0:
    raise ValueError("No valid polygon intersections found between source
and target geometries")

```



```

# Add intersection ID
intersections['intersection_id'] = range(len(intersections))

# Spatial join intersections with weight points to get weights within each
intersection
with warnings.catch_warnings():
    warnings.filterwarnings('ignore', category=UserWarning)
    intersection_weights = gpd.sjoin(intersections, weight_points,
how='left', predicate='contains')

# Calculate intersection values (sum of weights per intersection)
intersection_values = (intersection_weights.groupby('intersection_id')
[weight_column]
                        .sum()
                        .reset_index()
                        .rename(columns={weight_column:
'intersection_value'}))

# Merge back to intersections and keep only unique intersections
intersections = intersections.merge(intersection_values,
on='intersection_id', how='left')
intersections['intersection_value'] =
intersections['intersection_value'].fillna(0)

# Remove duplicates created by the spatial join
intersections = intersections.drop_duplicates(subset='intersection_id')

# Merge with denominators to calculate weight coefficients
intersections = intersections.merge(denominators, on=from_id, how='left')
intersections['weight_total'] = intersections['weight_total'].fillna(1)

# Calculate weight coefficients (intersection weight / total weight in
source)
intersections.loc[intersections['weight_total'] > 0, 'weight_coef'] = (
    intersections['intersection_value'] / intersections['weight_total']
)
intersections['weight_coef'] = intersections['weight_coef'].fillna(0)

# Get numeric columns from source data
numeric_cols = from_gdf.select_dtypes(include=[np.number]).columns
# Remove ID columns
numeric_cols = [col for col in numeric_cols if col not in [from_id]]

# Prepare intersection data for interpolation
intersection_data = intersections[['from_id', 'to_id', 'weight_coef'] +
numeric_cols].copy()

if extensive:

```

```

        # For extensive variables: multiply by weight coefficient, then sum by
        target
        for col in numeric_cols:
            intersection_data[col] = intersection_data[col] *
intersection_data['weight_coef']

        interpolated = (intersection_data.groupby(to_id)[numeric_cols]
                        .sum()
                        .reset_index())
    else:
        # For intensive variables: weighted average
        interpolated_data = []
        for target_id in intersection_data[to_id].unique():
            target_data = intersection_data[intersection_data[to_id] ==
target_id]
            if len(target_data) > 0 and target_data['weight_coef'].sum() > 0:
                weighted_vals = {}
                for col in numeric_cols:
                    weighted_vals[col] = (target_data[col] *
target_data['weight_coef']).sum() / target_data['weight_coef'].sum()
                weighted_vals[to_id] = target_id
                interpolated_data.append(weighted_vals)

        interpolated = pd.DataFrame(interpolated_data)

    # Merge with target geometries
    result = to_gdf[[to_id, 'geometry']].merge(interpolated, on=to_id,
how='left')

    # Fill NaN values with 0 for missing interpolations
    for col in numeric_cols:
        if col in result.columns:
            result[col] = result[col].fillna(0)

    return result

```

```

# Interpolate ACS data to Decennial Census blocks
lscog_acs_cb = interpolate_pw(
    from_gdf=lscog_acs,
    to_gdf=lscog_dec,
    weights_gdf=lscog_dec,
    to_id='GEOID',
    extensive=True,
    weight_column='HH',
    crs=project_crs
)

```

```
lscog_acs_cb.head()
```

```

      GEOID ... INC_50000
0  450179504004051 ...  0.000000
1  450179504003011 ...  0.000000
2  450179502011045 ...  8.723288
3  450179504001020 ...  0.000000
4  450750105003029 ...  2.916335

```

```
[5 rows x 6 columns]
```

The comparative visualization reveals the increased spatial resolution achieved through interpolation. Block-level data provides more granular detail for transportation modeling applications, enabling better representation of local variations in income distribution across the study area.

#### 4.1.-c R

```

# Compare before and after interpolation
mapview::mapview(lscog_acs_cb, zcol = "INC_49999", color = NA) |
  mapview::mapview(lscog_acs, zcol = "INC_49999", color = NA)

```

#### 4.1.-d Python

```

# Compare before and after interpolation
lscog_acs_cb.explore(column="INC_49999", color="blue", legend=True,
tiles="CartoDB positron") | \
  lscog_acs.explore(column="INC_49999", color="red", legend=True,
tiles="CartoDB positron")

```

## 4.2 Combine population and households

The integration step merges the interpolated ACS socioeconomic data with the Decennial Census population and household counts. This join operation creates a unified dataset containing both demographic totals and detailed characteristics at the census block level. The left join ensures that all census blocks retain their geographic boundaries while incorporating available socioeconomic attributes.

#### 4.2.-a R

```

## Combine ACS Data to Decennial data
lscog_pop_hh <- lscog_dec |>
  dplyr::left_join(
    sf::st_drop_geometry(lscog_acs_cb),
    by = dplyr::join_by(GEOID)
  )

```

```
lscog_pop_hh
```

Simple feature collection with 13961 features and 14 fields

Geometry type: MULTIPOLYGON

Dimension: XY

Bounding box: xmin: 1691517 ymin: 331891.7 xmax: 2237472 ymax: 744669.5

Projected CRS: NAD83(HARN) / South Carolina (ft)

# A tibble: 13,961 × 15

|    | GEOID<br><chr>  | TOTPOP<br><dbl> | GQPOP<br><dbl> | HHPop<br><dbl> | HH<br><dbl> | HH_1<br><dbl> | HH_2<br><dbl> | HH_3<br><dbl> | HH_4<br><dbl> | DU<br><dbl> |
|----|-----------------|-----------------|----------------|----------------|-------------|---------------|---------------|---------------|---------------|-------------|
| 1  | 450179504004051 | 0               | 0              | 0              | 0           | 0             | 0             | 0             | 0             | 0           |
| 2  | 450179504003011 | 0               | 0              | 0              | 0           | 0             | 0             | 0             | 0             | 0           |
| 3  | 450179502011045 | 54              | 4              | 50             | 16          | 3             | 1             | 3             | 9             | 18          |
| 4  | 450179504001020 | 0               | 0              | 0              | 0           | 0             | 0             | 0             | 0             | 0           |
| 5  | 450750105003029 | 13              | 0              | 13             | 4           | 0             | 3             | 0             | 1             | 4           |
| 6  | 450750117021009 | 10              | 0              | 10             | 3           | 3             | 0             | 0             | 0             | 8           |
| 7  | 450750117011051 | 0               | 0              | 0              | 0           | 0             | 0             | 0             | 0             | 0           |
| 8  | 450750118021087 | 6               | 0              | 6              | 4           | 0             | 1             | 2             | 1             | 4           |
| 9  | 450750120003020 | 0               | 0              | 0              | 0           | 0             | 0             | 0             | 0             | 0           |
| 10 | 450179501003046 | 18              | 0              | 18             | 0           | 0             | 0             | 0             | 0             | 1           |

# i 13,951 more rows

# i 5 more variables: geometry <MULTIPOLYGON [foot]>, INC\_TOTAL <dbl>,

# INC\_14999 <dbl>, INC\_49999 <dbl>, INC\_50000 <dbl>

#### 4.2.-b Python

```
## Combine ACS Data to Decennial data
lscog_pop_hh = lscog_dec.merge(
    lscog_acs_cb.drop(columns=['geometry']),
    on='GEOID',
    how='left'
)

lscog_pop_hh
```

|       | GEOID           | TOTPOP | GQPOP | ... | INC_14999 | INC_49999 | INC_50000 |
|-------|-----------------|--------|-------|-----|-----------|-----------|-----------|
| 0     | 450179504004051 | 0      | 0     | ... | 0.000000  | 0.000000  | 0.000000  |
| 1     | 450179504003011 | 0      | 0     | ... | 0.000000  | 0.000000  | 0.000000  |
| 2     | 450179502011045 | 54     | 4     | ... | 4.273973  | 7.561644  | 8.723288  |
| 3     | 450179504001020 | 0      | 0     | ... | 0.000000  | 0.000000  | 0.000000  |
| 4     | 450750105003029 | 13     | 0     | ... | 1.944223  | 0.924303  | 2.916335  |
| ...   | ...             | ...    | ...   | ... | ...       | ...       | ...       |
| 13956 | 450059705003050 | 5      | 0     | ... | 0.000000  | 0.000000  | 0.000000  |
| 13957 | 450030203042000 | 0      | 0     | ... | 0.000000  | 0.000000  | 0.000000  |
| 13958 | 450030218002115 | 8      | 0     | ... | 0.101167  | 0.470817  | 0.295720  |
| 13959 | 450030206012008 | 0      | 0     | ... | 0.000000  | 0.000000  | 0.000000  |

```
13960  450059705002005      0      0 ...  0.000000  0.000000  0.000000

[13961 rows x 15 columns]
```

Income category adjustments reconcile the interpolated ACS estimates with actual household counts from the Decennial Census. The proportional allocation method redistributes income categories based on the ratio of interpolated totals to observed household counts, maintaining consistency between data sources. The three-tier income classification (under \$15,000, \$15,000-\$49,999, and \$50,000 and above) provides sufficient granularity for travel demand modeling while ensuring statistical reliability.

#### 4.2.-c R

```
## Combine adjusted HH income level to Decennial census instead of ACS
lscog_pop_hh <- lscog_pop_hh |>
  dplyr::mutate(
    INC_49999 = tidyr::replace_na(round(INC_49999 / INC_TOTAL * HH, 0), 0),
    INC_50000 = tidyr::replace_na(round(INC_50000 / INC_TOTAL * HH, 0), 0),
    INC_14999 = HH - (INC_49999 + INC_50000)
  ) |>
  dplyr::select(-INC_TOTAL)

lscog_pop_hh
```

```
Simple feature collection with 13961 features and 13 fields
Geometry type: MULTIPOLYGON
Dimension: XY
Bounding box: xmin: 1691517 ymin: 331891.7 xmax: 2237472 ymax: 744669.5
Projected CRS: NAD83(HARN) / South Carolina (ft)
# A tibble: 13,961 × 14
  GEOID      TOTPOP GQPOP HHPOP   HH HH_1 HH_2 HH_3 HH_4  DU
  <chr>      <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
1 450179504004051      0      0      0      0      0      0      0      0      0
2 450179504003011      0      0      0      0      0      0      0      0      0
3 450179502011045     54      4     50     16      3      1      3      9     18
4 450179504001020      0      0      0      0      0      0      0      0      0
5 450750105003029     13      0     13      4      0      3      0      1      4
6 450750117021009     10      0     10      3      3      0      0      0      8
7 450750117011051      0      0      0      0      0      0      0      0      0
8 450750118021087      6      0      6      4      0      1      2      1      4
9 450750120003020      0      0      0      0      0      0      0      0      0
10 450179501003046     18      0     18      0      0      0      0      0      1
# i 13,951 more rows
# i 4 more variables: geometry <MULTIPOLYGON [foot]>, INC_14999 <dbl>,
#   INC_49999 <dbl>, INC_50000 <dbl>
```

## 4.2.-d Python

```
## Combine adjusted HH income level to Decennial census instead of ACS
lscog_pop_hh["INC_49999"] = ((lscog_pop_hh["INC_49999"] /
lscog_pop_hh["INC_TOTAL"]) * lscog_pop_hh["HH"]).round().fillna(0)
lscog_pop_hh["INC_50000"] = ((lscog_pop_hh["INC_50000"] /
lscog_pop_hh["INC_TOTAL"]) * lscog_pop_hh["HH"]).round().fillna(0)
lscog_pop_hh["INC_14999"] = lscog_pop_hh["HH"] - (lscog_pop_hh["INC_49999"] +
lscog_pop_hh["INC_50000"])

lscog_pop_hh = lscog_pop_hh.drop(columns="INC_TOTAL")
lscog_pop_hh
```

|       | GEOID           | TOTPOP | GQPOP | ... | INC_14999 | INC_49999 | INC_50000 |
|-------|-----------------|--------|-------|-----|-----------|-----------|-----------|
| 0     | 450179504004051 | 0      | 0     | ... | 0.0       | 0.0       | 0.0       |
| 1     | 450179504003011 | 0      | 0     | ... | 0.0       | 0.0       | 0.0       |
| 2     | 450179502011045 | 54     | 4     | ... | 3.0       | 6.0       | 7.0       |
| 3     | 450179504001020 | 0      | 0     | ... | 0.0       | 0.0       | 0.0       |
| 4     | 450750105003029 | 13     | 0     | ... | 1.0       | 1.0       | 2.0       |
| ...   | ...             | ...    | ...   | ... | ...       | ...       | ...       |
| 13956 | 450059705003050 | 5      | 0     | ... | 0.0       | 0.0       | 0.0       |
| 13957 | 450030203042000 | 0      | 0     | ... | 0.0       | 0.0       | 0.0       |
| 13958 | 450030218002115 | 8      | 0     | ... | 0.0       | 1.0       | 0.0       |
| 13959 | 450030206012008 | 0      | 0     | ... | 0.0       | 0.0       | 0.0       |
| 13960 | 450059705002005 | 0      | 0     | ... | 0.0       | 0.0       | 0.0       |

[13961 rows x 14 columns]

## 4.3 Employment data

The employment integration incorporates LEHD (Longitudinal Employer-Household Dynamics) workplace area characteristics into the combined dataset. This addition provides employment counts by census block, enabling the development of trip attraction models and work-based travel pattern analysis. The merge operation maintains the geographic integrity of census blocks while adding employment variables essential for comprehensive transportation planning.

### 4.3.-a R

```
# Join LEHD Data to the Decennial data
lscog_pop_hh_emp <- lscog_pop_hh |>
  dplyr::left_join(lscog_emp, by = dplyr::join_by(GEOID))

lscog_pop_hh_emp
```

Simple feature collection with 13961 features and 24 fields  
Geometry type: MULTIPOLYGON  
Dimension: XY

```

Bounding box: xmin: 1691517 ymin: 331891.7 xmax: 2237472 ymax: 744669.5
Projected CRS: NAD83(HARN) / South Carolina (ft)
# A tibble: 13,961 × 25
  GEOID      TOTPOP GQPOP HHPOP   HH HH_1 HH_2 HH_3 HH_4  DU
  <chr>      <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
1 450179504004051      0      0      0      0      0      0      0      0      0
2 450179504003011      0      0      0      0      0      0      0      0      0
3 450179502011045     54      4     50     16      3      1      3      9     18
4 450179504001020      0      0      0      0      0      0      0      0      0
5 450750105003029     13      0     13      4      0      3      0      1      4
6 450750117021009     10      0     10      3      3      0      0      0      8
7 450750117011051      0      0      0      0      0      0      0      0      0
8 450750118021087      6      0      6      4      0      1      2      1      4
9 450750120003020      0      0      0      0      0      0      0      0      0
10 450179501003046     18      0     18      0      0      0      0      0      1
# i 13,951 more rows
# i 15 more variables: geometry <MULTIPOLYGON [foot]>, INC_14999 <dbl>,
#   INC_49999 <dbl>, INC_50000 <dbl>, TOTAL_EMP <dbl>, AGR_FOR_FI <dbl>,
#   MINING <dbl>, CONSTRUCTI <dbl>, MANUFACTUR <dbl>, TRANSP_COM <dbl>,
#   WHOLESALE <dbl>, RETAIL <dbl>, FIRE <dbl>, SERVICES <dbl>, PUBLIC_ADM
<dbl>

```

#### 4.3.-b Python

```

# Join LEHD Data to the Decennial data
lscog_pop_hh_emp = lscog_pop_hh.merge(
    lscog_emp,
    on='GEOID',
    how='left'
)

lscog_pop_hh_emp

```

|       | GEOID           | TOTPOP | GQPOP | ... | FIRE | SERVICES | PUBLIC_ADM |
|-------|-----------------|--------|-------|-----|------|----------|------------|
| 0     | 450179504004051 | 0      | 0     | ... | NaN  | NaN      | NaN        |
| 1     | 450179504003011 | 0      | 0     | ... | NaN  | NaN      | NaN        |
| 2     | 450179502011045 | 54     | 4     | ... | NaN  | NaN      | NaN        |
| 3     | 450179504001020 | 0      | 0     | ... | NaN  | NaN      | NaN        |
| 4     | 450750105003029 | 13     | 0     | ... | NaN  | NaN      | NaN        |
| ...   | ...             | ...    | ...   | ... | ...  | ...      | ...        |
| 13956 | 450059705003050 | 5      | 0     | ... | NaN  | NaN      | NaN        |
| 13957 | 450030203042000 | 0      | 0     | ... | NaN  | NaN      | NaN        |
| 13958 | 450030218002115 | 8      | 0     | ... | NaN  | NaN      | NaN        |
| 13959 | 450030206012008 | 0      | 0     | ... | NaN  | NaN      | NaN        |
| 13960 | 450059705002005 | 0      | 0     | ... | NaN  | NaN      | NaN        |

[13961 rows x 25 columns]

## 5 Export raw data

The data export process creates standardized datasets for travel demand model development, maintaining both tabular and spatial formats to support various modeling applications. All exports follow consistent file naming conventions and directory structures to facilitate model integration and data management workflows.

### 5.1 TAZ data

The Traffic Analysis Zone (TAZ) boundary export provides the fundamental geographic framework for the regional travel demand model. The blank TAZ file serves as a template for subsequent socioeconomic data allocation, containing only zone identification fields and geometric boundaries without attribute data.

#### Export as CSV flat file

##### 5.1.-a R

```
# Export as CSV
lscog_taz |>
  sf::st_drop_geometry() |>
  readr::write_csv(
    file.path(
      root,
      "Task 1 TDM Development/Base Year/_raw/lscog_taz_blank.csv"
    ),
    append = FALSE
  )
```

##### 5.1.-b Python

```
# Export as CSV
lscog_taz.to_csv(
    Path(root) / "Task 1 TDM Development" / "Base Year" / "_raw" /
    "lscog_taz_blank.csv",
    index=False
)
```

#### Export as Geodatabase layer

##### 5.1.-c R

```
# Export as GDB
lscog_taz |>
  sf::write_sf(
    file.path(
      root,
      "Task 1 TDM Development/Base Year/_gis/LSCOG_2020Base_SE.gdb"
    ),
  )
```



```

    layer = "lscog_taz_blank",
    append = FALSE
)

```

### 5.1.-d Python

```

# Export as GDB
lscog_taz.to_file(
    Path(root) / "Task 1 TDM Development" / "Base Year" / "_gis" /
    "LSCOG_2020Base_SE.gdb",
    layer='lscog_taz_blank',
    driver='FileGDB'
)

```

## 5.2 Census blocks to TAZ conversion

The block-to-TAZ conversion table establishes the critical linkage between fine-scale Census geography and the modeling zone system. This crosswalk file enables the aggregation of block-level socioeconomic data to TAZ boundaries while maintaining traceability to source geographies.

### Export as CSV flat file

#### 5.2.-a R

```

# Export as CSV
lscog_cb |>
  sf::st_join(lscog_taz) |>
  dplyr::select(GEOID20, ID, TAZ_ID) |>
  sf::st_drop_geometry() |>
  readr::write_csv(
    file.path(
      root,
      "Task 1 TDM Development/Base Year/_raw/lscog_block_taz.csv"
    ),
    append = FALSE
  )

```

#### 5.2.-b Python

```

# Export as CSV
lscog_cb.merge(lscog_taz[['ID', 'TAZ_ID']], left_on='GEOID20', right_on='ID')
[['GEOID20', 'ID', 'TAZ_ID']].to_csv(
    Path(root) / "Task 1 TDM Development" / "Base Year" / "_raw" /
    "lscog_block_taz.csv",
    index=False
)

```

### 5.3 Decennial census data at census block level

The decennial census block export captures the foundational demographic counts used throughout the modeling process. This dataset provides the most reliable population and household totals at the finest geographic resolution, serving as the base for all subsequent data integration and validation steps.

#### Export as CSV flat file

##### 5.3.-a R

```
# Export as CSV
lscog_dec |>
  sf::st_drop_geometry() |>
  readr::write_csv(
    file.path(
      root,
      "Task 1 TDM Development/Base Year/_raw/lscog_dec_block.csv"
    ),
    append = FALSE
  )
```

##### 5.3.-b Python

```
# Export as CSV
lscog_dec.to_csv(
  Path(root) / "Task 1 TDM Development" / "Base Year" / "_raw" /
  "lscog_dec_block.csv",
  index=False
)
```

#### Export as Geodatabase layer

##### 5.3.-c R

```
# Export as GDB
lscog_dec |>
  sf::write_sf(
    file.path(
      root,
      "Task 1 TDM Development/Base Year/_gis/LSCOG_2020Base_SE.gdb"
    ),
    layer = "lscog_dec_block",
    append = FALSE
  )
```

##### 5.3.-d Python

```
# Export as GDB
lscog_dec.to_file(
    Path(root) / "Task 1 TDM Development" / "Base Year" / "_gis" /
    "LSCOG_2020Base_SE.gdb",
    layer='lscog_dec_block',
    driver='FileGDB'
)
```

## 5.4 ACS estimates at census block level

The interpolated ACS data export delivers income distribution estimates at the census block level, providing the socioeconomic stratification necessary for trip generation modeling. This processed dataset represents the final product of the household-weighted interpolation methodology, ready for direct integration into the travel demand model framework.

### Export as CSV flat file

#### 5.4.-a R

```
# Export as CSV
lscog_acs_cb |>
  dplyr::select(GEOID, INC_14999, INC_49999, INC_50000) |>
  sf::st_drop_geometry() |>
  readr::write_csv(
    file.path(
      root,
      "Task 1 TDM Development/Base Year/_raw/lscog_acs_block.csv"
    ),
    append = FALSE
  )
```

#### 5.4.-b Python

```
# Export as CSV
lscog_acs_cb[['GEOID', 'INC_14999', 'INC_49999', 'INC_50000']].to_csv(
    Path(root) / "Task 1 TDM Development" / "Base Year" / "_raw" /
    "lscog_acs_block.csv",
    index=False
)
```

### Export as Geodatabase layer

#### 5.4.-c R

```
# Export as GDB
lscog_acs_cb |>
  dplyr::select(GEOID, INC_14999, INC_49999, INC_50000) |>
  sf::write_sf(
```

```

file.path(
  root,
  "Task 1 TDM Development/Base Year/_gis/LSCOG_2020Base_SE.gdb"
),
layer = "lscog_acs_block",
append = FALSE
)

```

#### 5.4.-d Python

```

# Export as GDB
lscog_acs_cb[['GEOID', 'INC_14999', 'INC_49999', 'INC_50000']].to_file(
  Path(root) / "Task 1 TDM Development" / "Base Year" / "_gis" /
  "LSCOG_2020Base_SE.gdb",
  layer='lscog_acs_block',
  driver='FileGDB'
)

```

### 5.5 LEHD data at census block level

The employment data export provides comprehensive workplace characteristics by industry sector at the census block level. This dataset captures the spatial distribution of employment opportunities across the study region, supporting both trip attraction modeling and economic impact analysis.

#### Export as CSV flat file

##### 5.5.-a R

```

# Export as CSV
lscog_pop_hh_emp |>
  dplyr::select(GEOID, TOTAL_EMP:PUBLIC_ADM) |>
  sf::st_drop_geometry() |>
  readr::write_csv(
    file.path(
      root,
      "Task 1 TDM Development/Base Year/_raw/lscog_emp_block.csv"
    ),
    append = FALSE
  )

```

##### 5.5.-b Python

```

# Export as CSV
lscog_pop_hh_emp[['GEOID', 'TOTAL_EMP', 'AGR_FOR_FI', 'MINING', 'CONSTRUCTI',
  'MANUFACTUR', 'TRANSP_COM', 'WHOLESALE', 'RETAIL', 'FIRE',
  'SERVICES', 'PUBLIC_ADM']].to_csv(
  Path(root) / "Task 1 TDM Development" / "Base Year" / "_raw" /

```

```
"lscog_emp_block.csv",
  index=False
)
```

## Export as Geodatabase layer

### 5.5.-c R

```
# Export as GDB
lscog_pop_hh_emp |>
  dplyr::select(GEOID, TOTAL_EMP:PUBLIC_ADM) |>
  sf::write_sf(
    file.path(
      root,
      "Task 1 TDM Development/Base Year/_gis/LSCOG_2020Base_SE.gdb"
    ),
    layer = "lscog_emp_block",
    append = FALSE
  )
```

### 5.5.-d Python

```
# Export as GDB
lscog_pop_hh_emp[['GEOID', 'TOTAL_EMP', 'AGR_FOR_FI', 'MINING', 'CONSTRUCTI',
                  'MANUFACTUR', 'TRANSP_COM', 'WHOLESALE', 'RETAIL', 'FIRE',
                  'SERVICES', 'PUBLIC_ADM']].to_file(
    Path(root) / "Task 1 TDM Development" / "Base Year" / "_gis" /
    "LSCOG_2020Base_SE.gdb",
    layer='lscog_emp_block',
    driver='FileGDB'
)
```

## 5.6 Public schools to TAZ

The public school location export integrates educational facility data with the TAZ system, providing essential inputs for school-related trip modeling. Student and teacher counts by facility support the development of specialized trip generation rates for educational purposes.

### Export as CSV flat file

#### 5.6.-a R

```
# Export as CSV
lscog_pub_sch_enroll |>
  sf::st_join(lscog_taz |> dplyr::select(ID, TAZ_ID)) |>
  sf::st_drop_geometry() |>
  readr::write_csv(
    file.path(
```

```

    root,
    "Task 1 TDM Development/Base Year/_raw/lscog_pubsch_loc.csv"
),
append = FALSE
)

```

### 5.6.-.b Python

```

# Export as CSV
lscog_pub_sch_enroll.sjoin(
    lscog_taz[['ID', 'TAZ_ID']],
    how='left'
)[['INSTITUTION_ID', 'NAME', 'STATE', 'STUDENT_COUNT_PUB',
'TEACHER_COUNT_PUB', 'geometry']] \
    .to_csv(
        Path(root) / "Task 1 TDM Development" / "Base Year" / "_raw" /
        "lscog_pubsch_loc.csv",
        index=False
    )

```

### Export as Geodatabase layer

### 5.6.-.c R

```

# Export as GDB
lscog_pub_sch_enroll |>
  sf::st_join(lscog_taz |> dplyr::select(ID, TAZ_ID)) |>
  sf::write_sf(
    file.path(
      root,
      "Task 1 TDM Development/Base Year/_gis/LSCOG_2020Base_SE.gdb"
    ),
    layer = "lscog_pubsch_loc",
    append = FALSE
  )

```

### 5.6.-.d Python

```

# Export as GDB
lscog_pub_sch_enroll.sjoin(
    lscog_taz[['ID', 'TAZ_ID']],
    how='left'
).to_file(
    Path(root) / "Task 1 TDM Development" / "Base Year" / "_gis" /
    "LSCOG_2020Base_SE.gdb",
    layer='lscog_pubsch_loc',

```

```

    driver='FileGDB'
)

```

## 5.7 Private schools to TAZ

The private school dataset complements the public education data by capturing enrollment patterns in private educational institutions. This comprehensive coverage of educational facilities ensures that all school-related travel demand is properly represented in the regional model.

### Export as CSV flat file

#### 5.7.-a R

```

# Export as CSV
lscog_pvt_sch_enroll |>
  sf::st_join(lscog_taz |> dplyr::select(ID, TAZ_ID)) |>
  sf::st_drop_geometry() |>
  readr::write_csv(
    file.path(
      root,
      "Task 1 TDM Development/Base Year/_raw/lscog_pvtsch_loc.csv"
    ),
    append = FALSE
  )

```

#### 5.7.-b Python

```

# Export as CSV
lscog_pvt_sch_enroll.sjoin(
  lscog_taz[['ID', 'TAZ_ID']],
  how='left'
)[['INSTITUTION_ID', 'NAME', 'STATE', 'STUDENT_COUNT_PVT',
  'TEACHER_COUNT_PVT', 'geometry']] \
  .to_csv(
    Path(root) / "Task 1 TDM Development" / "Base Year" / "_raw" /
    "lscog_pvtsch_loc.csv",
    index=False
  )

```

### Export as Geodatabase layer

#### 5.7.-c R

```

# Export as GDB
lscog_pvt_sch_enroll |>
  sf::st_join(lscog_taz |> dplyr::select(ID, TAZ_ID)) |>
  sf::write_sf(
    file.path(

```

```

    root,
    "Task 1 TDM Development/Base Year/_gis/LSCOG_2020Base_SE.gdb"
  ),
  layer = "lscog_pvtsch_loc",
  append = FALSE
)

```

## 5.7.-.d Python

```

# Export as GDB
lscog_pvt_sch_enroll.sjoin(
  lscog_taz[['ID', 'TAZ_ID']],
  how='left'
).to_file(
  Path(root) / "Task 1 TDM Development" / "Base Year" / "_gis" /
  "LSCOG_2020Base_SE.gdb",
  layer='lscog_pvtsch_loc',
  driver='FileGDB'
)

```

# 6 Aggregate data to TAZ

The aggregation process transforms fine-scale census block data into TAZ-level inputs suitable for travel demand modeling. This spatial aggregation preserves the total counts while organizing data according to the modeling zone structure required for trip generation and distribution analysis.

## 6.1 Population, households, and employment

The spatial join operation aggregates all demographic, housing, and employment variables from census blocks to their corresponding TAZs using centroid-based assignment. This process ensures that each block's socioeconomic characteristics are properly allocated to the appropriate modeling zone while maintaining data integrity through comprehensive summation of all relevant variables.

### 6.1.-.a R

```

# Aggregate population, households, and employment to TAZ
lscog_taz_pop <- lscog_taz |>
  sf::st_join(
    lscog_pop_hh_emp |> sf::st_centroid(of_largest_polygon = TRUE)
  ) |>
  dplyr::group_by(
    ID,
    Area,
    TAZ_ID,
    COUNTY,
    AREA_TYPE,
    COUNTYID,

```



```

    .drop = FALSE
  ) |>
  dplyr::summarize(
    .groups = "drop",
    # Population and Household Size
    TOTPOP = sum(TOTPOP, na.rm = TRUE),
    GQPOP = sum(GQPOP, na.rm = TRUE),
    HHPOP = sum(HHPOP, na.rm = TRUE),
    HH = sum(HH, na.rm = TRUE),
    HH_1 = sum(HH_1, na.rm = TRUE),
    HH_2 = sum(HH_2, na.rm = TRUE),
    HH_3 = sum(HH_3, na.rm = TRUE),
    HH_4 = sum(HH_4, na.rm = TRUE),
    DU = sum(DU, na.rm = TRUE),
    # Household Income
    INC_14999 = sum(INC_14999, na.rm = TRUE),
    INC_49999 = sum(INC_49999, na.rm = TRUE),
    INC_50000 = sum(INC_50000, na.rm = TRUE),
    # Employment
    TOTAL_EMP = sum(TOTAL_EMP, na.rm = TRUE),
    AGR_FOR_FI = sum(AGR_FOR_FI, na.rm = TRUE),
    MINING = sum(MINING, na.rm = TRUE),
    CONSTRUCTI = sum(CONSTRUCTI, na.rm = TRUE),
    MANUFACTUR = sum(MANUFACTUR, na.rm = TRUE),
    TRANSP_COM = sum(TRANSP_COM, na.rm = TRUE),
    WHOLESALE = sum(WHOLESALE, na.rm = TRUE),
    RETAIL = sum(RETAIL, na.rm = TRUE),
    FIRE = sum(FIRE, na.rm = TRUE),
    SERVICES = sum(SERVICES, na.rm = TRUE),
    PUBLIC_ADM = sum(PUBLIC_ADM, na.rm = TRUE)
  )

lscog_taz_pop

```

Simple feature collection with 585 features and 29 fields

Geometry type: MULTIPOLYGON

Dimension: XY

Bounding box: xmin: 1691490 ymin: 331894 xmax: 2237471 ymax: 744679.9

Projected CRS: NAD83(HARN) / South Carolina (ft)

# A tibble: 585 × 30

|       | ID     | Area  | TAZ_ID | COUNTY   | AREA_TYPE | COUNTYID | TOTPOP | GQPOP | HHPOP | HH    |
|-------|--------|-------|--------|----------|-----------|----------|--------|-------|-------|-------|
| HH_1  |        |       |        |          |           |          |        |       |       |       |
|       | <int>  | <dbl> | <int>  | <chr>    | <chr>     | <int>    | <dbl>  | <dbl> | <dbl> | <dbl> |
| <dbl> |        |       |        |          |           |          |        |       |       |       |
| 1     | 3.01e6 | 0.846 | 3.01e6 | Aiken... | SUBURBAN  | 45003    | 66     | 0     | 66    | 20    |
| 2     |        |       |        |          |           |          |        |       |       |       |
| 2     | 3.01e6 | 1.10  | 3.01e6 | Aiken... | URBAN     | 45003    | 1299   | 0     | 1299  | 482   |

```

84      3 3.01e6 0.395 3.01e6 Aiken... URBAN      45003      657      0      657      268
46      4 3.01e6 0.338 3.01e6 Aiken... URBAN      45003      593      1      592      237
67      5 3.01e6 0.381 3.01e6 Aiken... URBAN      45003      462      0      462      261
152     6 3.01e6 0.125 3.01e6 Aiken... URBAN      45003      383      0      383      189
64      7 3.01e6 0.0879 3.01e6 Aiken... URBAN      45003      160      0      160      62
5       8 3.01e6 0.103 3.01e6 Aiken... URBAN      45003      420      0      420      194
50      9 3.01e6 0.0659 3.01e6 Aiken... URBAN      45003      142      0      142      67
19     10 3.01e6 0.0279 3.01e6 Aiken... URBAN      45003      100      0      100      71
30
# i 575 more rows
# i 19 more variables: HH_2 <dbl>, HH_3 <dbl>, HH_4 <dbl>, DU <dbl>,
#   INC_14999 <dbl>, INC_49999 <dbl>, INC_50000 <dbl>, TOTAL_EMP <dbl>,
#   AGR_FOR_FI <dbl>, MINING <dbl>, CONSTRUCTI <dbl>, MANUFACTUR <dbl>,
#   TRANSP_COM <dbl>, WHOLESALE <dbl>, RETAIL <dbl>, FIRE <dbl>,
#   SERVICES <dbl>, PUBLIC_ADM <dbl>, SHAPE <MULTIPOLYGON [foot]>

```

## 6.1.-b Python

```

# Aggregate population, households, and employment to TAZ
lscog_taz_pop = (lscog_taz
    .sjoin(

lscog_pop_hh_emp.assign(geometry=lscog_pop_hh_emp.geometry.centroid).to_crs(lscog_taz.crs),
    how='left'
)
.groupby(['ID', 'Area', 'TAZ_ID', 'COUNTY', 'AREA_TYPE', 'COUNTYID'],
    as_index=False, dropna=False)
.agg({
    # Population and Household Size
    'TOTPOP': lambda x: x.sum(skipna=True),
    'GQPOP': lambda x: x.sum(skipna=True),
    'HHPOP': lambda x: x.sum(skipna=True),
    'HH': lambda x: x.sum(skipna=True),
    'HH_1': lambda x: x.sum(skipna=True),
    'HH_2': lambda x: x.sum(skipna=True),
    'HH_3': lambda x: x.sum(skipna=True),
    'HH_4': lambda x: x.sum(skipna=True),
    'DU': lambda x: x.sum(skipna=True),
    # Household Income
    'INC_14999': lambda x: x.sum(skipna=True),

```

```

    'INC_49999': lambda x: x.sum(skipna=True),
    'INC_50000': lambda x: x.sum(skipna=True),
    # Employment
    'TOTAL_EMP': lambda x: x.sum(skipna=True),
    'AGR_FOR_FI': lambda x: x.sum(skipna=True),
    'MINING': lambda x: x.sum(skipna=True),
    'CONSTRUCTI': lambda x: x.sum(skipna=True),
    'MANUFACTUR': lambda x: x.sum(skipna=True),
    'TRANSP_COM': lambda x: x.sum(skipna=True),
    'WHOLESALE': lambda x: x.sum(skipna=True),
    'RETAIL': lambda x: x.sum(skipna=True),
    'FIRE': lambda x: x.sum(skipna=True),
    'SERVICES': lambda x: x.sum(skipna=True),
    'PUBLIC_ADM': lambda x: x.sum(skipna=True),
    'geometry': 'first'
  })
)

lscog_taz_pop = gpd.GeoDataFrame(lscog_taz_pop, crs=lscog_taz.crs)
lscog_taz_pop

```

```

      ID  ...      geometry
0   3010700  ...  MULTIPOLYGON (((1699181.31 620454.142, 1699123...
1   3010701  ...  MULTIPOLYGON (((1694583.352 615949.391, 169461...
2   3010702  ...  MULTIPOLYGON (((1700348.674 611719.751, 170010...
3   3010703  ...  MULTIPOLYGON (((1701031.299 609784.953, 170063...
4   3010704  ...  MULTIPOLYGON (((1698257.603 608476.138, 169825...
..   ...  ...
580  75050360  ...  MULTIPOLYGON (((1967942.928 639523.392, 196793...
581  75050361  ...  MULTIPOLYGON (((1942618.133 631129.68, 1942312...
582  75050362  ...  MULTIPOLYGON (((1985475.577 652643.249, 198567...
583  75050366  ...  MULTIPOLYGON (((2047618.073 635211.818, 204760...
584  75050373  ...  MULTIPOLYGON (((2053533.596 627788.863, 205352...

[585 rows x 30 columns]

```

## 6.2 School and college enrollment

The school enrollment combination merges public and private educational institution data into a unified dataset for comprehensive coverage of student populations.

### 6.2.-a R

```

# Combine school enrollment data
lscog_sch_enroll <- dplyr::bind_rows(
  lscog_pub_sch_enroll,
  lscog_pvt_sch_enroll
)

```

```

) |>
  dplyr::mutate(
    STUDENT_COUNT = dplyr::coalesce(STUDENT_COUNT_PUB, 0) +
      dplyr::coalesce(STUDENT_COUNT_PVT, 0),
    TEACHER_COUNT = dplyr::coalesce(TEACHER_COUNT_PUB, 0) +
      dplyr::coalesce(TEACHER_COUNT_PVT, 0)
  )

lscog_sch_enroll

```

Simple feature collection with 122 features and 9 fields

Geometry type: POINT

Dimension: XY

Bounding box: xmin: 1700952 ymin: 406810.6 xmax: 2203406 ymax: 724699.4

Projected CRS: NAD83(HARN) / South Carolina (ft)

First 10 features:

|    | INSTITUTION_ID | NAME                          | STATE | STUDENT_COUNT_PUB |
|----|----------------|-------------------------------|-------|-------------------|
| 1  | 450108001163   | Barnwell Elementary           | SC    | 462               |
| 2  | 450075000064   | Allendale Fairfax High        | SC    | 283               |
| 3  | 450075001184   | Allendale Elementary          | SC    | 245               |
| 4  | 450075001415   | Allendale-Fairfax Middle      | SC    | 268               |
| 5  | 450093000119   | Bamberg-Ehrhardt High         | SC    | 381               |
| 6  | 450093000120   | Bamberg-Ehrhardt Middle       | SC    | 188               |
| 7  | 450096000122   | Denmark Olar High             | SC    | 162               |
| 8  | 450096000123   | Denmark-Olar Middle           | SC    | 149               |
| 9  | 450096001426   | Denmark-Olar Elementary       | SC    | 353               |
| 10 | 450098000127   | Barnwell County Career Center | SC    | 0                 |

|    | TEACHER_COUNT_PUB | STUDENT_COUNT_PVT | TEACHER_COUNT_PVT |
|----|-------------------|-------------------|-------------------|
| 1  | 32.0              | NA                | NA                |
| 2  | 28.9              | NA                | NA                |
| 3  | 18.0              | NA                | NA                |
| 4  | 18.0              | NA                | NA                |
| 5  | 28.5              | NA                | NA                |
| 6  | 15.0              | NA                | NA                |
| 7  | 20.0              | NA                | NA                |
| 8  | 10.0              | NA                | NA                |
| 9  | 25.0              | NA                | NA                |
| 10 | 12.0              | NA                | NA                |

|   | geometry                 | STUDENT_COUNT | TEACHER_COUNT |
|---|--------------------------|---------------|---------------|
| 1 | POINT (1891531 517378.5) | 462           | 32.0          |
| 2 | POINT (1913416 420526.6) | 283           | 28.9          |
| 3 | POINT (1916344 418212.2) | 245           | 18.0          |
| 4 | POINT (1913416 420526.6) | 268           | 18.0          |
| 5 | POINT (1991502 535259.1) | 381           | 28.5          |
| 6 | POINT (1990622 534442.6) | 188           | 15.0          |
| 7 | POINT (1962410 543779)   | 162           | 20.0          |
| 8 | POINT (1956236 534420.3) | 149           | 10.0          |

|    |                          |     |      |
|----|--------------------------|-----|------|
| 9  | POINT (1960237 537023.1) | 353 | 25.0 |
| 10 | POINT (1894891 540093)   | 0   | 12.0 |

## 6.2.-b Python

```
# Combine school enrollment data
lscog_sch_enroll = pd.concat([
    lscog_pub_sch_enroll.assign(
        STUDENT_COUNT=lscog_pub_sch_enroll['STUDENT_COUNT_PUB'],
        TEACHER_COUNT=lscog_pub_sch_enroll['TEACHER_COUNT_PUB']
    ),
    lscog_pvt_sch_enroll.assign(
        STUDENT_COUNT=lscog_pvt_sch_enroll['STUDENT_COUNT_PVT'],
        TEACHER_COUNT=lscog_pvt_sch_enroll['TEACHER_COUNT_PVT']
    )
])

lscog_sch_enroll
```

|       | INSTITUTION_ID | ... | TEACHER_COUNT_PVT |
|-------|----------------|-----|-------------------|
| 0     | 450108001163   | ... | NaN               |
| 1     | 450075000064   | ... | NaN               |
| 2     | 450075001184   | ... | NaN               |
| 3     | 450075001415   | ... | NaN               |
| 4     | 450093000119   | ... | NaN               |
| ...   | ...            | ... | ...               |
| 17663 | K9305640       | ... | 3.0               |
| 17672 | A9703170       | ... | 4.8               |
| 17676 | 01262826       | ... | 23.0              |
| 17722 | 01932407       | ... | 6.0               |
| 17733 | A9903957       | ... | 1.0               |

[122 rows x 10 columns]

The subsequent TAZ aggregation counts total student enrollment within each zone, providing essential data for modeling education-related trip patterns and supporting specialized trip generation rates for school-based travel.

## 6.2.-c R

```
# count the number of school enrollment within each TAZ
lscog_taz_enroll <- lscog_taz |>
  sf::st_join(lscog_sch_enroll) |>
  dplyr::group_by(
    ID,
    Area,
```

```

    TAZ_ID,
    COUNTY,
    AREA_TYPE,
    COUNTYID,
    .drop = FALSE
  ) |>
  dplyr::summarize(
    .groups = "drop",
    STUDENT_COUNT = sum(STUDENT_COUNT, na.rm = TRUE)
  )

lscog_taz_enroll

```

Simple feature collection with 585 features and 7 fields  
 Geometry type: MULTIPOLYGON  
 Dimension: XY  
 Bounding box: xmin: 1691490 ymin: 331894 xmax: 2237471 ymax: 744679.9  
 Projected CRS: NAD83(HARN) / South Carolina (ft)  
 # A tibble: 585 × 8

|    | ID      | Area   | TAZ_ID  | COUNTY   | AREA_TYPE | COUNTYID | STUDENT_COUNT |
|----|---------|--------|---------|----------|-----------|----------|---------------|
|    | <int>   | <dbl>  | <int>   | <chr>    | <chr>     | <int>    | <dbl>         |
| 1  | 3010700 | 0.846  | 3010700 | Aiken SC | SUBURBAN  | 45003    | 0             |
| 2  | 3010701 | 1.10   | 3010701 | Aiken SC | URBAN     | 45003    | 0             |
| 3  | 3010702 | 0.395  | 3010702 | Aiken SC | URBAN     | 45003    | 0             |
| 4  | 3010703 | 0.338  | 3010703 | Aiken SC | URBAN     | 45003    | 0             |
| 5  | 3010704 | 0.381  | 3010704 | Aiken SC | URBAN     | 45003    | 0             |
| 6  | 3010705 | 0.125  | 3010705 | Aiken SC | URBAN     | 45003    | 717           |
| 7  | 3010706 | 0.0879 | 3010706 | Aiken SC | URBAN     | 45003    | 0             |
| 8  | 3010707 | 0.103  | 3010707 | Aiken SC | URBAN     | 45003    | 0             |
| 9  | 3010708 | 0.0659 | 3010708 | Aiken SC | URBAN     | 45003    | 0             |
| 10 | 3010709 | 0.0279 | 3010709 | Aiken SC | URBAN     | 45003    | 0             |

# i 575 more rows  
 # i 1 more variable: SHAPE <MULTIPOLYGON [foot]>

## 6.2.-.d Python

```

# count the number of school enrollment within each TAZ
lscog_taz_enroll = lscog_taz.sjoin(lscog_sch_enroll, how='left') \
    .groupby(['ID', 'Area', 'TAZ_ID', 'COUNTY', 'AREA_TYPE', 'COUNTYID'],
as_index=False) \
    .agg({'STUDENT_COUNT': 'sum'})

lscog_taz_enroll

```

|   | ID      | Area     | TAZ_ID  | ... | AREA_TYPE | COUNTYID | STUDENT_COUNT |
|---|---------|----------|---------|-----|-----------|----------|---------------|
| 0 | 3010700 | 0.846321 | 3010700 | ... | SUBURBAN  | 45003    | 0.0           |

|     |          |           |          |     |          |       |       |
|-----|----------|-----------|----------|-----|----------|-------|-------|
| 1   | 3010701  | 1.098166  | 3010701  | ... | URBAN    | 45003 | 0.0   |
| 2   | 3010702  | 0.395302  | 3010702  | ... | URBAN    | 45003 | 0.0   |
| 3   | 3010703  | 0.338204  | 3010703  | ... | URBAN    | 45003 | 0.0   |
| 4   | 3010704  | 0.381229  | 3010704  | ... | URBAN    | 45003 | 0.0   |
| ..  | ...      | ...       | ...      | ... | ...      | ...   | ...   |
| 580 | 75050360 | 9.593491  | 75050360 | ... | RURAL    | 45075 | 549.0 |
| 581 | 75050361 | 17.433178 | 75050361 | ... | RURAL    | 45075 | 0.0   |
| 582 | 75050362 | 13.319107 | 75050362 | ... | RURAL    | 45075 | 0.0   |
| 583 | 75050366 | 4.323094  | 75050366 | ... | SUBURBAN | 45075 | 0.0   |
| 584 | 75050373 | 6.635425  | 75050373 | ... | RURAL    | 45075 | 0.0   |

[585 rows x 7 columns]

## 7 Combine into a single data

This step integrates all TAZ-level socioeconomic datasets into a comprehensive base year file for travel demand modeling. This consolidated dataset contains all essential variables organized in a standardized format with geographic identifiers, demographic characteristics, employment data, and educational enrollment totals for each traffic analysis zone in the study region.

### 7.0.-.a R

```
# Combine population, household, employments, and school enrollment
lscog_se_base <- lscog_taz_pop |>
  dplyr::left_join(
    lscog_taz_enroll |> sf::st_drop_geometry(),
    by = dplyr::join_by(ID, Area, TAZ_ID, COUNTY, AREA_TYPE, COUNTYID)
  ) |>
  dplyr::select(
    ID,
    Area,
    TAZ_ID,
    COUNTY,
    AREA_TYPE,
    COUNTYID,
    INC_14999,
    INC_49999,
    INC_50000,
    TOTPOP,
    GQPOP,
    HHPOP,
    HH,
    HH_1,
    HH_2,
    HH_3,
    HH_4,
    DU,
    dplyr::everything()
```

```
)

lscog_se_base
```

```
Simple feature collection with 585 features and 30 fields
Geometry type: MULTIPOLYGON
Dimension:      XY
Bounding box:   xmin: 1691490 ymin: 331894 xmax: 2237471 ymax: 744679.9
Projected CRS: NAD83(HARN) / South Carolina (ft)
# A tibble: 585 × 31
      ID Area TAZ_ID COUNTY AREA_TYPE COUNTYID INC_14999 INC_49999
INC_50000
    <int> <dbl> <int> <chr> <chr>      <int>    <dbl>    <dbl>
<dbl>
1 3010700 0.846 3.01e6 Aiken... SUBURBAN    45003         0         4
16
2 3010701 1.10 3.01e6 Aiken... URBAN      45003        12        85
385
3 3010702 0.395 3.01e6 Aiken... URBAN      45003         5        88
175
4 3010703 0.338 3.01e6 Aiken... URBAN      45003         7        86
144
5 3010704 0.381 3.01e6 Aiken... URBAN      45003        49        48
164
6 3010705 0.125 3.01e6 Aiken... URBAN      45003         3        69
117
7 3010706 0.0879 3.01e6 Aiken... URBAN      45003         1        23
38
8 3010707 0.103 3.01e6 Aiken... URBAN      45003         0        99
95
9 3010708 0.0659 3.01e6 Aiken... URBAN      45003         0        35
32
10 3010709 0.0279 3.01e6 Aiken... URBAN      45003         0        36
35
# i 575 more rows
# i 22 more variables: TOTPOP <dbl>, GQPOP <dbl>, HHPOP <dbl>, HH <dbl>,
# HH_1 <dbl>, HH_2 <dbl>, HH_3 <dbl>, HH_4 <dbl>, DU <dbl>, TOTAL_EMP <dbl>,
# AGR_FOR_FI <dbl>, MINING <dbl>, CONSTRUCTI <dbl>, MANUFACTUR <dbl>,
# TRANSP_COM <dbl>, WHOLESALE <dbl>, RETAIL <dbl>, FIRE <dbl>,
# SERVICES <dbl>, PUBLIC_ADM <dbl>, SHAPE <MULTIPOLYGON [foot]>,
# STUDENT_COUNT <dbl>
```

## 7.0.-b Python

```
# Define the column order
field_order = [
    'ID', 'Area', 'TAZ_ID', 'COUNTY', 'AREA_TYPE', 'COUNTYID',
```



```

    'INC_14999', 'INC_49999', 'INC_50000',
    'TOTPOP', 'GQPOP', 'HHPOP',
    'HH', 'HH_1', 'HH_2', 'HH_3', 'HH_4', 'DU'
]

# Combine population, household, employments, and school enrollment
lscog_se_base = lscog_taz_pop.merge(
    lscog_taz_enroll,
    on=['ID', 'Area', 'TAZ_ID', 'COUNTY', 'AREA_TYPE', 'COUNTYID'],
    how='left'
)

lscog_se_base = lscog_se_base[field_order +
list(lscog_se_base.columns.difference(field_order))]

lscog_se_base

```

```

      ID  ... geometry
0  3010700  ... MULTIPOLYGON (((1699181.31 620454.142, 1699123...
1  3010701  ... MULTIPOLYGON (((1694583.352 615949.391, 169461...
2  3010702  ... MULTIPOLYGON (((1700348.674 611719.751, 170010...
3  3010703  ... MULTIPOLYGON (((1701031.299 609784.953, 170063...
4  3010704  ... MULTIPOLYGON (((1698257.603 608476.138, 169825...
..  ...  ...
580 75050360  ... MULTIPOLYGON (((1967942.928 639523.392, 196793...
581 75050361  ... MULTIPOLYGON (((1942618.133 631129.68, 1942312...
582 75050362  ... MULTIPOLYGON (((1985475.577 652643.249, 198567...
583 75050366  ... MULTIPOLYGON (((2047618.073 635211.818, 204760...
584 75050373  ... MULTIPOLYGON (((2053533.596 627788.863, 205352...

[585 rows x 31 columns]

```

## 8 Data checks and validation

The validation process ensures data integrity and consistency across all socioeconomic variables through systematic checks of categorical totals. These validation steps identify any discrepancies between aggregate totals and component categories that may have occurred during the interpolation or aggregation processes.

### 8.1 Household size total

This validation confirms that the total household count matches the sum of all household size categories for each TAZ. Any discrepancies indicate potential issues in the household size distribution that require investigation and correction before model implementation.

#### 8.1.-a R

```
# check the sum of household by household size
lscog_se_base |>
  dplyr::filter(HH != (HH_1 + HH_2 + HH_3 + HH_4)) |>
  nrow()
```

```
[1] 0
```

### 8.1.-b Python

```
# check the sum of household by household size
lscog_se_base[
    lscog_se_base['HH'] != (lscog_se_base['HH_1'] + lscog_se_base['HH_2'] +
                           lscog_se_base['HH_3'] + lscog_se_base['HH_4'])
].shape[0]
```

```
0
```

## 8.2 Household income total

The income category validation verifies that household totals equal the sum of all three income brackets across all zones. This check ensures the integrity of the income distribution data following the proportional allocation methodology applied during the ACS interpolation process.

### 8.2.-a R

```
# check the sum of household by income level
lscog_se_base |>
  dplyr::filter(HH != (INC_14999 + INC_49999 + INC_50000)) |>
  nrow()
```

```
[1] 0
```

### 8.2.-b Python

```
# check the sum of household by income level
lscog_se_base[
    lscog_se_base['HH'] != (lscog_se_base['INC_14999'] +
                           lscog_se_base['INC_49999'] +
                           lscog_se_base['INC_50000'])
].shape[0]
```

```
0
```

### 8.3 Employment categories

The employment validation confirms that total employment equals the sum of all industry sector categories for each TAZ. This comprehensive check validates the LEHD data integration and ensures that no employment is lost or double-counted during the sectoral disaggregation process. RetryClaude can make mistakes. Please double-check responses.

#### 8.3.-a R

```
# check the sum of employment by categories
lscog_se_base |>
  dplyr::filter(
    TOTAL_EMP !=
      (AGR_FOR_FI +
       MINING +
       CONSTRUCTI +
       MANUFACTUR +
       TRANSP_COM +
       WHOLESALE +
       RETAIL +
       FIRE +
       SERVICES +
       PUBLIC_ADM)
  ) |>
  nrow()
```

```
[1] 0
```

#### 8.3.-b Python

```
# check the sum of employment by categories
lscog_se_base[
  lscog_se_base['TOTAL_EMP'] != (
    lscog_se_base['AGR_FOR_FI'] +
    lscog_se_base['MINING'] +
    lscog_se_base['CONSTRUCTI'] +
    lscog_se_base['MANUFACTUR'] +
    lscog_se_base['TRANSP_COM'] +
    lscog_se_base['WHOLESALE'] +
    lscog_se_base['RETAIL'] +
    lscog_se_base['FIRE'] +
    lscog_se_base['SERVICES'] +
    lscog_se_base['PUBLIC_ADM']
  )
].shape[0]
```

```
0
```

## 9 Export the final data

The final export creates the complete TAZ-level socioeconomic dataset in both tabular and spatial formats for direct integration into the travel demand model. This comprehensive dataset serves as the primary input for trip generation, providing all necessary demographic, economic, and educational variables organized by traffic analysis zone for the LSCOG regional modeling system.

### Export as CSV flat file

#### 9.0.-a R

```
# Export as CSV
lscog_se_base |>
  sf::st_drop_geometry() |>
  readr::write_csv(
    file.path(root, "Task 1 TDM Development/Base Year/_raw/lscog_se_taz.csv"),
    append = FALSE
  )
```

#### 9.0.-b Python

```
# Export as CSV
lscog_se_base |>
  gpd.GeoDataFrame.to_csv(
    Path(root) / "Task 1 TDM Development" / "Base Year" / "_raw" /
    "lscog_se_taz.csv",
    index=False
  )
```

### Export as Geodatabase layer

#### 9.0.-c R

```
# Export as GDB
lscog_se_base |>
  sf::write_sf(
    file.path(
      root,
      "Task 1 TDM Development/Base Year/_gis/LSCOG_2020Base_SE.gdb"
    ),
    layer = "lscog_se_base",
    append = FALSE
  )
```

#### 9.0.-d Python

```
# Export as GDB
lscog_se_base |>
  gpd.GeoDataFrame.to_file(
```

```
Path(root) / "Task 1 TDM Development" / "Base Year" / "_gis" /  
"LSCOG_2020Base_SE.gdb"  
layer='lscog_se_base',  
driver='FileGDB'  
)
```