In-class Exercise 11: Calibrating Spatial Interaction Models (SIM) with R

## Getting Started

pacman::p\_load(tmap, sf, sp, stplanr,   
 reshape2, broom, performance,  
 gtsummary, ggpubr, tidyverse)

## Preparing the Flow Data

### Importing the OD data

Firstly, we will import the *Passenger Volume by Origin Destination Bus Stops* data set downloaded from LTA DataMall by using read\_csv() of **readr** package.

odbus <- read\_csv("data/aspatial/origin\_destination\_bus\_202210.csv")

A quick check of odbus tibble data frame shows that the values in OROGIN\_PT\_CODE and DESTINATON\_PT\_CODE are in numeric data type. Hence, the code chunk below is used to convert these data values into character data type.

odbus$ORIGIN\_PT\_CODE <- as.factor(odbus$ORIGIN\_PT\_CODE)  
odbus$DESTINATION\_PT\_CODE <- as.factor(odbus$DESTINATION\_PT\_CODE)

### Extracting the study data

For the purpose of this exercise, we will extract commuting flows on weekday and between 7 and 9 o’clock.

odbus7\_9 <- odbus %>%  
 filter(DAY\_TYPE == "WEEKDAY") %>%  
 filter(TIME\_PER\_HOUR >= 7 &  
 TIME\_PER\_HOUR <= 9) %>%  
 group\_by(ORIGIN\_PT\_CODE,  
 DESTINATION\_PT\_CODE) %>%  
 summarise(TRIPS = sum(TOTAL\_TRIPS))

We will save the output in rds format for future used.

write\_rds(odbus7\_9, "data/rds/odbus7\_9.rds")

The code chunk below will be used to import the save odbus7\_9.rds into R environment.

odbus7\_9 <- read\_rds("data/rds/odbus7\_9.rds")

## Working with Geospatial Data

For the purpose of this exercise, two geospatial data will be used. They are:

* BusStop: This data provides the location of bus stop as at last quarter of 2022.
* MPSZ-2019: This data provides the sub-zone boundary of URA Master Plan 2019.

Both data sets are in ESRI shapefile format.

### Importing geospatial data

Two geospatial data will be used in this exercise, they are:

busstop <- st\_read(dsn = "data/geospatial",  
 layer = "BusStop") %>%  
 st\_transform(crs = 3414)

mpsz <- st\_read(dsn = "data/geospatial",  
 layer = "MPSZ-2019") %>%  
 st\_transform(crs = 3414)

Reading layer `MPSZ-2019' from data source   
 `D:\tskam\IS415-GAA\In-class\_Ex\In-class\_Ex11\data\geospatial'   
 using driver `ESRI Shapefile'  
Simple feature collection with 332 features and 6 fields  
Geometry type: MULTIPOLYGON  
Dimension: XY  
Bounding box: xmin: 103.6057 ymin: 1.158699 xmax: 104.0885 ymax: 1.470775  
Geodetic CRS: WGS 84

mpsz

Simple feature collection with 332 features and 6 fields  
Geometry type: MULTIPOLYGON  
Dimension: XY  
Bounding box: xmin: 2667.538 ymin: 15748.72 xmax: 56396.44 ymax: 50256.33  
Projected CRS: SVY21 / Singapore TM  
First 10 features:  
 SUBZONE\_N SUBZONE\_C PLN\_AREA\_N PLN\_AREA\_C REGION\_N  
1 MARINA EAST MESZ01 MARINA EAST ME CENTRAL REGION  
2 INSTITUTION HILL RVSZ05 RIVER VALLEY RV CENTRAL REGION  
3 ROBERTSON QUAY SRSZ01 SINGAPORE RIVER SR CENTRAL REGION  
4 JURONG ISLAND AND BUKOM WISZ01 WESTERN ISLANDS WI WEST REGION  
5 FORT CANNING MUSZ02 MUSEUM MU CENTRAL REGION  
6 MARINA EAST (MP) MPSZ05 MARINE PARADE MP CENTRAL REGION  
7 SUDONG WISZ03 WESTERN ISLANDS WI WEST REGION  
8 SEMAKAU WISZ02 WESTERN ISLANDS WI WEST REGION  
9 SOUTHERN GROUP SISZ02 SOUTHERN ISLANDS SI CENTRAL REGION  
10 SENTOSA SISZ01 SOUTHERN ISLANDS SI CENTRAL REGION  
 REGION\_C geometry  
1 CR MULTIPOLYGON (((33222.98 29...  
2 CR MULTIPOLYGON (((28481.45 30...  
3 CR MULTIPOLYGON (((28087.34 30...  
4 WR MULTIPOLYGON (((14557.7 304...  
5 CR MULTIPOLYGON (((29542.53 31...  
6 CR MULTIPOLYGON (((35279.55 30...  
7 WR MULTIPOLYGON (((15772.59 21...  
8 WR MULTIPOLYGON (((19843.41 21...  
9 CR MULTIPOLYGON (((30870.53 22...  
10 CR MULTIPOLYGON (((26879.04 26...

|  |
| --- |
| Note |
| * st\_read() function of sf package is used to import the shapefile into R as sf data frame. * st\_transform() function of sf package is used to transform the projection to crs 3414. |

## Geospatial data wrangling

### Combining Busstop and mpsz

Code chunk below populates the planning subzone code (i.e. SUBZONE\_C) of mpsz sf data frame into busstop sf data frame.

busstop\_mpsz <- st\_intersection(busstop, mpsz) %>%  
 select(BUS\_STOP\_N, SUBZONE\_C) %>%  
 st\_drop\_geometry()

|  |
| --- |
| Note |
| * st\_intersection() is used to perform point and polygon overly and the output will be in point sf object. * select() of dplyr package is then use to retain only BUS\_STOP\_N and SUBZONE\_C in the busstop\_mpsz sf data frame. * five bus stops are excluded in the resultant data frame because they are outside of Singapore bpundary. |

Before moving to the next step, it is wise to save the output into rds format.

write\_rds(busstop\_mpsz, "data/rds/busstop\_mpsz.csv")

Next, we are going to append the planning subzone code from busstop\_mpsz data frame onto odbus7\_9 data frame.

od\_data <- left\_join(odbus7\_9 , busstop\_mpsz,  
 by = c("ORIGIN\_PT\_CODE" = "BUS\_STOP\_N")) %>%  
 rename(ORIGIN\_BS = ORIGIN\_PT\_CODE,  
 ORIGIN\_SZ = SUBZONE\_C,  
 DESTIN\_BS = DESTINATION\_PT\_CODE)

Before continue, it is a good practice for us to check for duplicating records.

duplicate <- od\_data %>%  
 group\_by\_all() %>%  
 filter(n()>1) %>%  
 ungroup()

If duplicated records are found, the code chunk below will be used to retain the unique records.

od\_data <- unique(od\_data)

It will be a good practice to confirm if the duplicating records issue has been addressed fully.

Next, we will update od\_data data frame cwith the planning subzone codes.

od\_data <- left\_join(od\_data , busstop\_mpsz,  
 by = c("DESTIN\_BS" = "BUS\_STOP\_N"))

duplicate <- od\_data %>%  
 group\_by\_all() %>%  
 filter(n()>1) %>%  
 ungroup()

od\_data <- unique(od\_data)

od\_data <- od\_data %>%  
 rename(DESTIN\_SZ = SUBZONE\_C) %>%  
 drop\_na()

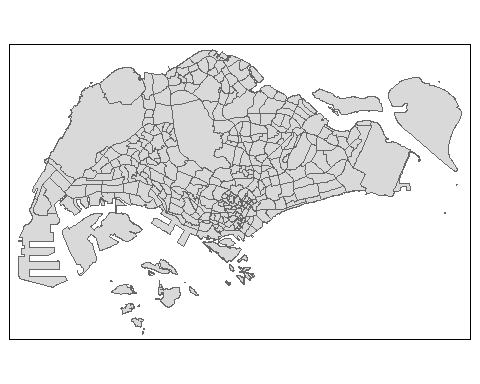
It is time to save the output into an rds file format.

write\_rds(od\_data, "data/rds/od\_data.rds")

od\_data <- read\_rds("data/rds/od\_data.rds")

## Visualising the Geospatial Data

tmap\_mode("plot")  
tmap\_options(check.and.fix = TRUE)  
qtm(mpsz)



# Viewing the Subzone spatial file

head(mpsz, 10)

Simple feature collection with 10 features and 6 fields  
Geometry type: MULTIPOLYGON  
Dimension: XY  
Bounding box: xmin: 8012.578 ymin: 15748.72 xmax: 35287.9 ymax: 31092.38  
Projected CRS: SVY21 / Singapore TM  
 SUBZONE\_N SUBZONE\_C PLN\_AREA\_N PLN\_AREA\_C REGION\_N  
1 MARINA EAST MESZ01 MARINA EAST ME CENTRAL REGION  
2 INSTITUTION HILL RVSZ05 RIVER VALLEY RV CENTRAL REGION  
3 ROBERTSON QUAY SRSZ01 SINGAPORE RIVER SR CENTRAL REGION  
4 JURONG ISLAND AND BUKOM WISZ01 WESTERN ISLANDS WI WEST REGION  
5 FORT CANNING MUSZ02 MUSEUM MU CENTRAL REGION  
6 MARINA EAST (MP) MPSZ05 MARINE PARADE MP CENTRAL REGION  
7 SUDONG WISZ03 WESTERN ISLANDS WI WEST REGION  
8 SEMAKAU WISZ02 WESTERN ISLANDS WI WEST REGION  
9 SOUTHERN GROUP SISZ02 SOUTHERN ISLANDS SI CENTRAL REGION  
10 SENTOSA SISZ01 SOUTHERN ISLANDS SI CENTRAL REGION  
 REGION\_C geometry  
1 CR MULTIPOLYGON (((33222.98 29...  
2 CR MULTIPOLYGON (((28481.45 30...  
3 CR MULTIPOLYGON (((28087.34 30...  
4 WR MULTIPOLYGON (((14557.7 304...  
5 CR MULTIPOLYGON (((29542.53 31...  
6 CR MULTIPOLYGON (((35279.55 30...  
7 WR MULTIPOLYGON (((15772.59 21...  
8 WR MULTIPOLYGON (((19843.41 21...  
9 CR MULTIPOLYGON (((30870.53 22...  
10 CR MULTIPOLYGON (((26879.04 26...

# Isolating SUBZONE\_C (subzone\_code) into a new df

mpsz <- mpsz[order(mpsz$SUBZONE\_C),]  
head(mpsz, 10)

Simple feature collection with 10 features and 6 fields  
Geometry type: MULTIPOLYGON  
Dimension: XY  
Bounding box: xmin: 26154.57 ymin: 37511.2 xmax: 31072.47 ymax: 41804.65  
Projected CRS: SVY21 / Singapore TM  
 SUBZONE\_N SUBZONE\_C PLN\_AREA\_N PLN\_AREA\_C REGION\_N  
171 ANG MO KIO TOWN CENTRE AMSZ01 ANG MO KIO AM NORTH-EAST REGION  
170 CHENG SAN AMSZ02 ANG MO KIO AM NORTH-EAST REGION  
163 CHONG BOON AMSZ03 ANG MO KIO AM NORTH-EAST REGION  
330 TOWNSVILLE AMSZ04 ANG MO KIO AM NORTH-EAST REGION  
329 SHANGRI-LA AMSZ05 ANG MO KIO AM NORTH-EAST REGION  
172 KEBUN BAHRU AMSZ06 ANG MO KIO AM NORTH-EAST REGION  
233 SEMBAWANG HILLS AMSZ07 ANG MO KIO AM NORTH-EAST REGION  
254 TAGORE AMSZ08 ANG MO KIO AM NORTH-EAST REGION  
242 YIO CHU KANG WEST AMSZ09 ANG MO KIO AM NORTH-EAST REGION  
252 YIO CHU KANG AMSZ10 ANG MO KIO AM NORTH-EAST REGION  
 REGION\_C geometry  
171 NER MULTIPOLYGON (((29692.8 389...  
170 NER MULTIPOLYGON (((30384.33 39...  
163 NER MULTIPOLYGON (((30676.17 39...  
330 NER MULTIPOLYGON (((29649.88 38...  
329 NER MULTIPOLYGON (((28228.2 392...  
172 NER MULTIPOLYGON (((28491.21 39...  
233 NER MULTIPOLYGON (((27744.03 38...  
254 NER MULTIPOLYGON (((27193.46 41...  
242 NER MULTIPOLYGON (((29269.91 39...  
252 NER MULTIPOLYGON (((29598.36 39...

## Computing Distance Matrix

The are at least two ways to compute the required distance matrix. One is based on sf and the other is based on sp. Past experience shows that computing distance matrix by using sf function took relatively longer time that sp method. In view of this, sp method is used in the code chunks below.

### Converting from sf data.table to SpatialPolygonDataFrame

mpsz\_sp <- as(mpsz, "Spatial")

### Computing the distance matrix

dist <- spDists(mpsz\_sp)  
dist

### Sorting the distance matrix by plannint sub-zone code

sz\_names <- mpsz$SUBZONE\_C

### Attaching SUBZONE\_C to row and column for distance matrix matching ahead

colnames(dist) <- paste0(sz\_names)  
rownames(dist) <- paste0(sz\_names)

### Pivoting distance value by SUBZONE\_C

distPair <- melt(dist) %>%  
 rename(dist = value)  
head(distPair, 10)

### Updating intra-zonal distances

distPair %>%  
 filter(dist > 0) %>%  
 summary()

A constant distance value of 50m is added into intra-zones

distPair$dist <- ifelse(distPair$dist == 0,  
 50, distPair$dist)

The code chunk below will be used to check the result data.frame.

distPair %>%  
 summary()

The code chunk below is used to rename the origin and destination fields.

distPair <- distPair %>%  
 rename(orig = Var1,  
 dest = Var2)

Lastly, code chunk is used to save the data frame for future use.

write\_rds(distPair, "data/distPair.rds")

## Preparing flow data

The code chunk below is used to prepared the flow\_data.

od\_data <- read\_rds("data/rds/od\_data.rds")

flow\_data <- od\_data %>%  
 group\_by(ORIGIN\_SZ, DESTIN\_SZ) %>%   
 summarize(TRIPS = sum(TRIPS))

The code chunk below is used to view the passenger volume df

head(flow\_data, 10)

### Separating intra-flow from passenger volume df

flow\_data$FlowNoIntra <- ifelse(  
 flow\_data$ORIGIN\_SZ == flow\_data$DESTIN\_SZ,   
 0, flow\_data$TRIPS)  
flow\_data$offset <- ifelse(  
 flow\_data$ORIGIN\_SZ == flow\_data$DESTIN\_SZ,   
 0.000001, 1)

### Combining passenger volume data with distance value

flow\_data$ORIGIN\_SZ <- as.factor(flow\_data$ORIGIN\_SZ)  
flow\_data$DESTIN\_SZ <- as.factor(flow\_data$DESTIN\_SZ)

flow\_data1 <- flow\_data %>%  
 left\_join (distPair,  
 by = c("ORIGIN\_SZ" = "orig",  
 "DESTIN\_SZ" = "dest"))

## Visualising Spatial Interaction

In this section, you will learn how to prepare a desire line by using **stplanr** package.

### Removing intra-zonal flows

We will not plot the intra-zonal flows. The code chunk below will be used to remove intra-zonal flows.

flow\_data1 <- flow\_data1[flow\_data1$ORIGIN\_SZ!=flow\_data1$DESTIN\_SZ,]

The code chunk below removes all but the origin, destination and flow columns.

OD\_data <- flow\_data1[,c(1,2,3)]

### Creating desire lines

In this code chunk below, od2line() of **stplanr** package is used to create the desire lines.

flowLine <- od2line(flow = OD\_data,   
 zones = mpsz,  
 zone\_code = "SUBZONE\_C")

### Visualising the desire lines

To visualise the resulting desire lines, the code chunk below is used.

tm\_shape(mpsz) +  
 tm\_polygons() +  
tm\_shape(flowLine) +  
 tm\_lines(lwd = "TRIPS",  
 style = "quantile",  
 scale = c(0.1, 1, 3, 5, 10),  
 n = 5,  
 alpha = 0.1)

|  |
| --- |
| Warning |
| Be patient, the rendering process takes more time because of the transparency argument (i.e. alpha) |

## Preparing Origin and Destination Attributes

### Importing population data

pop <- read\_csv("data/aspatial/pop.csv")

### Geospatial data wrangling

pop <- pop %>%  
 left\_join(mpsz,  
 by = c("PA" = "PLN\_AREA\_N",  
 "SZ" = "SUBZONE\_N")) %>%  
 select(1:6) %>%  
 rename(SZ\_NAME = SZ,  
 SZ = SUBZONE\_C)

### Preparing origin attribute

flow\_data1 <- flow\_data1 %>%  
 left\_join(pop,  
 by = c(ORIGIN\_SZ = "SZ")) %>%  
 rename(ORIGIN\_AGE7\_12 = AGE7\_12,  
 ORIGIN\_AGE13\_24 = AGE13\_24,  
 ORIGIN\_AGE25\_64 = AGE25\_64) %>%  
 select(-c(PA, SZ\_NAME))

### Preparing destination attribute

flow\_data1 <- flow\_data1 %>%  
 left\_join(pop,  
 by = c(DESTIN\_SZ = "SZ")) %>%  
 rename(DESTIN\_AGE7\_12 = AGE7\_12,  
 DESTIN\_AGE13\_24 = AGE13\_24,  
 DESTIN\_AGE25\_64 = AGE25\_64) %>%  
 select(-c(PA, SZ\_NAME))

write\_rds(flow\_data1, "data/rds/SIM\_data")

## Calibrating Spatial Interaction Models

In this section, you will learn how to calibrate Spatial Interaction Models by using Poisson Regression method.

### Importing the modelling data

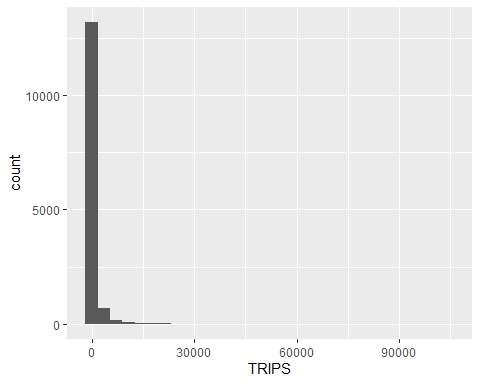
Firstly, let us import the modelling data by using the code chunk below.

SIM\_data <- read\_rds("data/rds/SIM\_data.rds")

### Visualising the dependent variable

Firstly, let us plot the distribution of the dependent variable (i.e. TRIPS) by using histogram method by using the code chunk below.

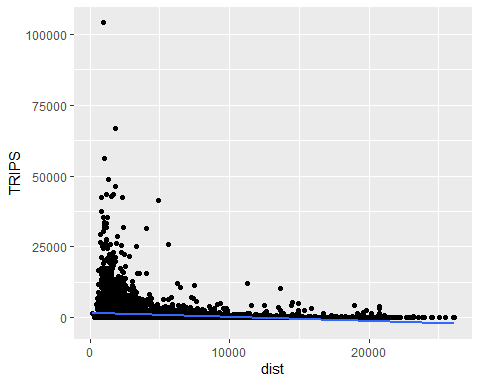
ggplot(data = SIM\_data,  
 aes(x = TRIPS)) +  
 geom\_histogram()



Notice that the distribution is highly skewed and not resemble bell shape or also known as normal distribution.

Next, let us visualise the relation between the dependent variable and one of the key independent variable in Spatial Interaction Model, namely distance.

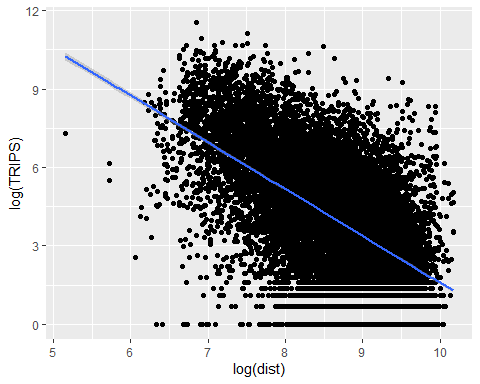
ggplot(data = SIM\_data,  
 aes(x = dist,  
 y = TRIPS)) +  
 geom\_point() +  
 geom\_smooth(method = lm)



Notice that their relationship hardly resemble linear relationship.

On the other hand, if we plot the scatter plot by using the log transformed version of both variables, we can see that their relationship is more resemble linear relationship.

ggplot(data = SIM\_data,  
 aes(x = log(dist),  
 y = log(TRIPS))) +  
 geom\_point() +  
 geom\_smooth(method = lm)



### Checking for variables with zero values

Since Poisson Regression is based of log and log 0 is undefined, it is important for us to ensure that no 0 values in the explanatory variables.

In the code chunk below, summary() of Base R is used to compute the summary statistics of all variables in *SIM\_data* data frame.

summary(SIM\_data)

ORIGIN\_SZ DESTIN\_SZ TRIPS FlowNoIntra   
 Length:14274 Length:14274 Min. : 1.0 Min. : 1.0   
 Class :character Class :character 1st Qu.: 11.0 1st Qu.: 11.0   
 Mode :character Mode :character Median : 56.0 Median : 56.0   
 Mean : 664.3 Mean : 664.3   
 3rd Qu.: 296.0 3rd Qu.: 296.0   
 Max. :104167.0 Max. :104167.0   
 offset dist ORIGIN\_AGE7\_12 ORIGIN\_AGE13\_24 ORIGIN\_AGE25\_64  
 Min. :1 Min. : 173.8 Min. : 0 Min. : 0 Min. : 0   
 1st Qu.:1 1st Qu.: 3465.4 1st Qu.: 240 1st Qu.: 460 1st Qu.: 2210   
 Median :1 Median : 6121.0 Median : 710 Median : 1400 Median : 7030   
 Mean :1 Mean : 6951.8 Mean :1037 Mean : 2278 Mean :10536   
 3rd Qu.:1 3rd Qu.: 9725.1 3rd Qu.:1500 3rd Qu.: 3282 3rd Qu.:15830   
 Max. :1 Max. :26135.8 Max. :6340 Max. :16380 Max. :74610   
 DESTIN\_AGE7\_12 DESTIN\_AGE13\_24 DESTIN\_AGE25\_64  
 Min. : 0 Min. : 0 Min. : 0   
 1st Qu.: 250 1st Qu.: 460 1st Qu.: 2210   
 Median : 720 Median : 1430 Median : 7120   
 Mean :1040 Mean : 2305 Mean :10648   
 3rd Qu.:1500 3rd Qu.: 3290 3rd Qu.:15830   
 Max. :6340 Max. :16380 Max. :74610

The print report above reveals that variables ORIGIN\_AGE7\_12, ORIGIN\_AGE13\_24, ORIGIN\_AGE25\_64,DESTIN\_AGE7\_12, DESTIN\_AGE13\_24, DESTIN\_AGE25\_64 consist of 0 values.

In view of this, code chunk below will be used to replace zero values to 0.99.

SIM\_data$DESTIN\_AGE7\_12 <- ifelse(  
 SIM\_data$DESTIN\_AGE7\_12 == 0,  
 0.99, SIM\_data$DESTIN\_AGE7\_12)  
SIM\_data$DESTIN\_AGE13\_24 <- ifelse(  
 SIM\_data$DESTIN\_AGE13\_24 == 0,  
 0.99, SIM\_data$DESTIN\_AGE13\_24)  
SIM\_data$DESTIN\_AGE25\_64 <- ifelse(  
 SIM\_data$DESTIN\_AGE25\_64 == 0,  
 0.99, SIM\_data$DESTIN\_AGE25\_64)  
SIM\_data$ORIGIN\_AGE7\_12 <- ifelse(  
 SIM\_data$ORIGIN\_AGE7\_12 == 0,  
 0.99, SIM\_data$ORIGIN\_AGE7\_12)  
SIM\_data$ORIGIN\_AGE13\_24 <- ifelse(  
 SIM\_data$ORIGIN\_AGE13\_24 == 0,  
 0.99, SIM\_data$ORIGIN\_AGE13\_24)  
SIM\_data$ORIGIN\_AGE25\_64 <- ifelse(  
 SIM\_data$ORIGIN\_AGE25\_64 == 0,  
 0.99, SIM\_data$ORIGIN\_AGE25\_64)

You can run the summary() again.

summary(SIM\_data)

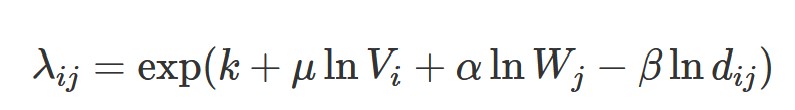
ORIGIN\_SZ DESTIN\_SZ TRIPS FlowNoIntra   
 Length:14274 Length:14274 Min. : 1.0 Min. : 1.0   
 Class :character Class :character 1st Qu.: 11.0 1st Qu.: 11.0   
 Mode :character Mode :character Median : 56.0 Median : 56.0   
 Mean : 664.3 Mean : 664.3   
 3rd Qu.: 296.0 3rd Qu.: 296.0   
 Max. :104167.0 Max. :104167.0   
 offset dist ORIGIN\_AGE7\_12 ORIGIN\_AGE13\_24   
 Min. :1 Min. : 173.8 Min. : 0.99 Min. : 0.99   
 1st Qu.:1 1st Qu.: 3465.4 1st Qu.: 240.00 1st Qu.: 460.00   
 Median :1 Median : 6121.0 Median : 710.00 Median : 1400.00   
 Mean :1 Mean : 6951.8 Mean :1036.73 Mean : 2278.59   
 3rd Qu.:1 3rd Qu.: 9725.1 3rd Qu.:1500.00 3rd Qu.: 3282.50   
 Max. :1 Max. :26135.8 Max. :6340.00 Max. :16380.00   
 ORIGIN\_AGE25\_64 DESTIN\_AGE7\_12 DESTIN\_AGE13\_24 DESTIN\_AGE25\_64   
 Min. : 0.99 Min. : 0.99 Min. : 0.99 Min. : 0.99   
 1st Qu.: 2210.00 1st Qu.: 250.00 1st Qu.: 460.00 1st Qu.: 2210.00   
 Median : 7030.00 Median : 720.00 Median : 1430.00 Median : 7120.00   
 Mean :10535.93 Mean :1039.98 Mean : 2305.33 Mean :10647.95   
 3rd Qu.:15830.00 3rd Qu.:1500.00 3rd Qu.: 3290.00 3rd Qu.:15830.00   
 Max. :74610.00 Max. :6340.00 Max. :16380.00 Max. :74610.00

Notice that all the 0 values have been replaced by 0.99.

### Unconstrained Spatial Interaction Model

In this section, you will learn how to calibrate an unconstrained spatial interaction model by using glm() of Base Stats. The explanatory variables are origin population by different age cohort, destination population by different age cohort (i.e. wj3\_destmedinc) and distance between origin and destination in km (i.e. dist).

The general formula of Unconstrained Spatial Interaction Model



The code chunk used to calibrate to model is shown below:

uncSIM <- glm(formula = TRIPS ~   
 log(ORIGIN\_AGE25\_64) +   
 log(DESTIN\_AGE25\_64) +  
 log(dist),  
 family = poisson(link = "log"),  
 data = SIM\_data,  
 na.action = na.exclude)  
uncSIM

Call: glm(formula = TRIPS ~ log(ORIGIN\_AGE25\_64) + log(DESTIN\_AGE25\_64) +   
 log(dist), family = poisson(link = "log"), data = SIM\_data,   
 na.action = na.exclude)  
  
Coefficients:  
 (Intercept) log(ORIGIN\_AGE25\_64) log(DESTIN\_AGE25\_64)   
 17.00287 0.21001 0.01289   
 log(dist)   
 -1.51785   
  
Degrees of Freedom: 14273 Total (i.e. Null); 14270 Residual  
Null Deviance: 36120000   
Residual Deviance: 19960000 AIC: 20040000

### R-squared function

In order to measure how much variation of the trips can be accounted by the model we will write a function to calculate R-Squared value as shown below.

CalcRSquared <- function(observed,estimated){  
 r <- cor(observed,estimated)  
 R2 <- r^2  
 R2  
}

Next, we will compute the R-squared of the unconstrained SIM by using the code chunk below.

CalcRSquared(uncSIM$data$TRIPS, uncSIM$fitted.values)

[1] 0.1694734

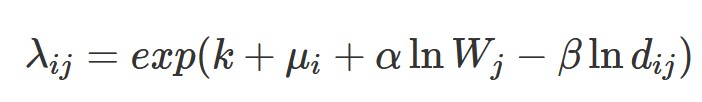
r2\_mcfadden(uncSIM)

# R2 for Generalized Linear Regression  
 R2: 0.446  
 adj. R2: 0.446

### Origin (Production) constrained SIM

In this section, we will fit an origin constrained SIM by using the code3 chunk below.

The general formula of Origin Constrained Spatial Interaction Model



orcSIM <- glm(formula = TRIPS ~   
 ORIGIN\_SZ +  
 log(DESTIN\_AGE25\_64) +  
 log(dist),  
 family = poisson(link = "log"),  
 data = SIM\_data,  
 na.action = na.exclude)  
summary(orcSIM)

Call:  
glm(formula = TRIPS ~ ORIGIN\_SZ + log(DESTIN\_AGE25\_64) + log(dist),   
 family = poisson(link = "log"), data = SIM\_data, na.action = na.exclude)  
  
Coefficients:  
 Estimate Std. Error z value Pr(>|z|)   
(Intercept) 19.9309957 0.0054015 3689.887 < 2e-16 \*\*\*  
ORIGIN\_SZAMSZ02 0.6805710 0.0052686 129.175 < 2e-16 \*\*\*  
ORIGIN\_SZAMSZ03 0.3597850 0.0054884 65.554 < 2e-16 \*\*\*  
ORIGIN\_SZAMSZ04 -0.1106566 0.0060027 -18.434 < 2e-16 \*\*\*  
ORIGIN\_SZAMSZ05 -0.3140561 0.0067998 -46.186 < 2e-16 \*\*\*  
ORIGIN\_SZAMSZ06 0.0634425 0.0060258 10.528 < 2e-16 \*\*\*  
ORIGIN\_SZAMSZ07 -1.1301580 0.0110298 -102.464 < 2e-16 \*\*\*  
ORIGIN\_SZAMSZ08 -0.6330394 0.0102949 -61.491 < 2e-16 \*\*\*  
ORIGIN\_SZAMSZ09 0.1064915 0.0063450 16.784 < 2e-16 \*\*\*  
ORIGIN\_SZAMSZ10 0.5061899 0.0053889 93.931 < 2e-16 \*\*\*  
ORIGIN\_SZAMSZ11 -1.3167911 0.0144870 -90.895 < 2e-16 \*\*\*  
ORIGIN\_SZAMSZ12 -1.5103004 0.0127453 -118.499 < 2e-16 \*\*\*  
ORIGIN\_SZBDSZ01 1.3626004 0.0051433 264.929 < 2e-16 \*\*\*  
ORIGIN\_SZBDSZ02 0.9554084 0.0059655 160.156 < 2e-16 \*\*\*  
ORIGIN\_SZBDSZ03 1.1476190 0.0054278 211.433 < 2e-16 \*\*\*  
ORIGIN\_SZBDSZ04 2.0110410 0.0046344 433.940 < 2e-16 \*\*\*  
ORIGIN\_SZBDSZ05 1.0658940 0.0053976 197.477 < 2e-16 \*\*\*  
ORIGIN\_SZBDSZ06 1.2719222 0.0054774 232.213 < 2e-16 \*\*\*  
ORIGIN\_SZBDSZ07 -0.5053039 0.0111553 -45.297 < 2e-16 \*\*\*  
ORIGIN\_SZBDSZ08 -0.3556193 0.0102947 -34.544 < 2e-16 \*\*\*  
ORIGIN\_SZBKSZ01 -0.3606399 0.0075473 -47.784 < 2e-16 \*\*\*  
ORIGIN\_SZBKSZ02 0.1357265 0.0061394 22.107 < 2e-16 \*\*\*  
ORIGIN\_SZBKSZ03 0.4101999 0.0058983 69.545 < 2e-16 \*\*\*  
ORIGIN\_SZBKSZ04 -0.3418645 0.0070764 -48.310 < 2e-16 \*\*\*  
ORIGIN\_SZBKSZ05 -0.2986750 0.0074073 -40.322 < 2e-16 \*\*\*  
ORIGIN\_SZBKSZ06 -0.2637855 0.0068739 -38.375 < 2e-16 \*\*\*  
ORIGIN\_SZBKSZ07 0.5498323 0.0051476 106.813 < 2e-16 \*\*\*  
ORIGIN\_SZBKSZ08 -0.0527393 0.0061457 -8.582 < 2e-16 \*\*\*  
ORIGIN\_SZBKSZ09 -0.1564691 0.0067300 -23.249 < 2e-16 \*\*\*  
ORIGIN\_SZBLSZ01 -1.7551329 0.0176599 -99.385 < 2e-16 \*\*\*  
ORIGIN\_SZBLSZ02 -1.9493637 0.0213859 -91.152 < 2e-16 \*\*\*  
ORIGIN\_SZBLSZ03 -2.9057732 0.0535995 -54.213 < 2e-16 \*\*\*  
ORIGIN\_SZBLSZ04 -1.4672066 0.0254726 -57.599 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ01 0.1806064 0.0060563 29.821 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ02 -1.4026549 0.0078244 -179.267 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ03 -0.5976236 0.0063808 -93.660 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ04 -0.5456513 0.0059061 -92.388 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ05 -3.1095195 0.0188118 -165.297 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ06 -3.0273827 0.0194319 -155.794 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ07 -0.7378197 0.0066865 -110.345 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ08 -0.9306150 0.0067188 -138.510 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ09 -1.4137345 0.0101071 -139.876 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ10 -1.7054195 0.0101582 -167.886 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ11 -1.2418380 0.0076792 -161.714 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ12 -1.3746537 0.0109769 -125.231 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ13 -0.4339494 0.0069335 -62.587 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ14 -0.9950458 0.0076302 -130.410 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ15 -0.6544196 0.0068964 -94.892 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ16 -1.5193747 0.0105329 -144.250 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ17 -1.6536771 0.0180672 -91.529 < 2e-16 \*\*\*  
ORIGIN\_SZBPSZ01 0.1484355 0.0064734 22.930 < 2e-16 \*\*\*  
ORIGIN\_SZBPSZ02 -0.3602094 0.0073902 -48.741 < 2e-16 \*\*\*  
ORIGIN\_SZBPSZ03 -0.1567975 0.0072226 -21.709 < 2e-16 \*\*\*  
ORIGIN\_SZBPSZ04 0.4504873 0.0058418 77.115 < 2e-16 \*\*\*  
ORIGIN\_SZBPSZ05 0.5028646 0.0053682 93.675 < 2e-16 \*\*\*  
ORIGIN\_SZBPSZ06 -1.0125668 0.0105638 -95.853 < 2e-16 \*\*\*  
ORIGIN\_SZBPSZ07 -0.3859065 0.0098561 -39.154 < 2e-16 \*\*\*  
ORIGIN\_SZBSSZ01 0.1488497 0.0065504 22.724 < 2e-16 \*\*\*  
ORIGIN\_SZBSSZ02 0.4269498 0.0055893 76.387 < 2e-16 \*\*\*  
ORIGIN\_SZBSSZ03 -0.2437385 0.0062020 -39.300 < 2e-16 \*\*\*  
ORIGIN\_SZBTSZ01 0.1987940 0.0066672 29.817 < 2e-16 \*\*\*  
ORIGIN\_SZBTSZ02 -0.4571546 0.0090784 -50.356 < 2e-16 \*\*\*  
ORIGIN\_SZBTSZ03 -0.2697243 0.0077941 -34.606 < 2e-16 \*\*\*  
ORIGIN\_SZBTSZ04 -1.0997236 0.0115225 -95.441 < 2e-16 \*\*\*  
ORIGIN\_SZBTSZ05 -1.0053122 0.0132594 -75.819 < 2e-16 \*\*\*  
ORIGIN\_SZBTSZ06 -1.0841201 0.0102242 -106.035 < 2e-16 \*\*\*  
ORIGIN\_SZBTSZ07 -2.3134497 0.0158499 -145.960 < 2e-16 \*\*\*  
ORIGIN\_SZBTSZ08 -1.1581618 0.0121161 -95.589 < 2e-16 \*\*\*  
ORIGIN\_SZCBSZ01 -1.0805930 0.0577831 -18.701 < 2e-16 \*\*\*  
ORIGIN\_SZCCSZ01 -0.8145372 0.0152638 -53.364 < 2e-16 \*\*\*  
ORIGIN\_SZCHSZ01 0.0377079 0.0133240 2.830 0.004654 \*\*   
ORIGIN\_SZCHSZ02 -0.6209553 0.0096388 -64.422 < 2e-16 \*\*\*  
ORIGIN\_SZCHSZ03 1.6790244 0.0069559 241.381 < 2e-16 \*\*\*  
ORIGIN\_SZCKSZ01 0.0839586 0.0059934 14.008 < 2e-16 \*\*\*  
ORIGIN\_SZCKSZ02 0.4379511 0.0062289 70.309 < 2e-16 \*\*\*  
ORIGIN\_SZCKSZ03 0.7956950 0.0051892 153.335 < 2e-16 \*\*\*  
ORIGIN\_SZCKSZ04 1.2740323 0.0053165 239.637 < 2e-16 \*\*\*  
ORIGIN\_SZCKSZ05 0.9326213 0.0061807 150.893 < 2e-16 \*\*\*  
ORIGIN\_SZCKSZ06 0.3976273 0.0085639 46.431 < 2e-16 \*\*\*  
ORIGIN\_SZCLSZ01 -0.7522917 0.0094655 -79.477 < 2e-16 \*\*\*  
ORIGIN\_SZCLSZ02 -1.3937450 0.0153260 -90.940 < 2e-16 \*\*\*  
ORIGIN\_SZCLSZ03 -0.7898683 0.0091016 -86.784 < 2e-16 \*\*\*  
ORIGIN\_SZCLSZ04 0.8451512 0.0051258 164.882 < 2e-16 \*\*\*  
ORIGIN\_SZCLSZ05 -1.6573818 0.0166091 -99.788 < 2e-16 \*\*\*  
ORIGIN\_SZCLSZ06 0.9478181 0.0048182 196.716 < 2e-16 \*\*\*  
ORIGIN\_SZCLSZ07 -0.2499753 0.0064632 -38.677 < 2e-16 \*\*\*  
ORIGIN\_SZCLSZ08 0.1350119 0.0069296 19.483 < 2e-16 \*\*\*  
ORIGIN\_SZCLSZ09 -1.3868782 0.0192743 -71.955 < 2e-16 \*\*\*  
ORIGIN\_SZDTSZ02 -3.7535792 0.0871325 -43.079 < 2e-16 \*\*\*  
ORIGIN\_SZDTSZ03 -3.8462041 0.0840156 -45.780 < 2e-16 \*\*\*  
ORIGIN\_SZDTSZ13 -2.9738127 0.0349241 -85.151 < 2e-16 \*\*\*  
ORIGIN\_SZGLSZ01 -1.5175198 0.0110135 -137.787 < 2e-16 \*\*\*  
ORIGIN\_SZGLSZ02 0.2405712 0.0058742 40.954 < 2e-16 \*\*\*  
ORIGIN\_SZGLSZ03 0.1940241 0.0061989 31.300 < 2e-16 \*\*\*  
ORIGIN\_SZGLSZ04 1.0292572 0.0049028 209.931 < 2e-16 \*\*\*  
ORIGIN\_SZGLSZ05 0.9864552 0.0050898 193.811 < 2e-16 \*\*\*  
ORIGIN\_SZHGSZ01 0.3073609 0.0054307 56.597 < 2e-16 \*\*\*  
ORIGIN\_SZHGSZ02 0.3827293 0.0054555 70.154 < 2e-16 \*\*\*  
ORIGIN\_SZHGSZ03 0.2342580 0.0059240 39.544 < 2e-16 \*\*\*  
ORIGIN\_SZHGSZ04 0.8750090 0.0049639 176.275 < 2e-16 \*\*\*  
ORIGIN\_SZHGSZ05 1.1695280 0.0049468 236.420 < 2e-16 \*\*\*  
ORIGIN\_SZHGSZ06 -0.0462411 0.0063805 -7.247 4.25e-13 \*\*\*  
ORIGIN\_SZHGSZ07 0.4488583 0.0055139 81.404 < 2e-16 \*\*\*  
ORIGIN\_SZHGSZ08 0.2236095 0.0061279 36.490 < 2e-16 \*\*\*  
ORIGIN\_SZHGSZ09 -1.6376674 0.0084442 -193.941 < 2e-16 \*\*\*  
ORIGIN\_SZHGSZ10 -2.9849025 0.0501042 -59.574 < 2e-16 \*\*\*  
ORIGIN\_SZJESZ01 0.3926525 0.0056268 69.783 < 2e-16 \*\*\*  
ORIGIN\_SZJESZ02 0.1230160 0.0056864 21.633 < 2e-16 \*\*\*  
ORIGIN\_SZJESZ03 0.0188276 0.0061020 3.085 0.002032 \*\*   
ORIGIN\_SZJESZ04 -1.3611618 0.0117184 -116.156 < 2e-16 \*\*\*  
ORIGIN\_SZJESZ05 -2.0643662 0.0157083 -131.419 < 2e-16 \*\*\*  
ORIGIN\_SZJESZ06 0.1556368 0.0055245 28.172 < 2e-16 \*\*\*  
ORIGIN\_SZJESZ07 -1.7664532 0.0133171 -132.646 < 2e-16 \*\*\*  
ORIGIN\_SZJESZ08 -0.9115981 0.0138203 -65.961 < 2e-16 \*\*\*  
ORIGIN\_SZJESZ09 0.6121916 0.0060381 101.388 < 2e-16 \*\*\*  
ORIGIN\_SZJESZ10 -1.1953045 0.0233216 -51.253 < 2e-16 \*\*\*  
ORIGIN\_SZJESZ11 -1.4088748 0.0220921 -63.773 < 2e-16 \*\*\*  
ORIGIN\_SZJWSZ01 0.5759093 0.0077741 74.081 < 2e-16 \*\*\*  
ORIGIN\_SZJWSZ02 0.9769314 0.0053029 184.227 < 2e-16 \*\*\*  
ORIGIN\_SZJWSZ03 1.3242695 0.0049068 269.882 < 2e-16 \*\*\*  
ORIGIN\_SZJWSZ04 0.5621088 0.0057831 97.199 < 2e-16 \*\*\*  
ORIGIN\_SZJWSZ05 -1.5744341 0.0146904 -107.174 < 2e-16 \*\*\*  
ORIGIN\_SZJWSZ06 -0.9113320 0.0126913 -71.807 < 2e-16 \*\*\*  
ORIGIN\_SZJWSZ07 -2.3083419 0.0357843 -64.507 < 2e-16 \*\*\*  
ORIGIN\_SZJWSZ08 2.0114225 0.0047956 419.429 < 2e-16 \*\*\*  
ORIGIN\_SZJWSZ09 1.9086705 0.0045255 421.759 < 2e-16 \*\*\*  
ORIGIN\_SZKLSZ01 0.2743166 0.0056908 48.204 < 2e-16 \*\*\*  
ORIGIN\_SZKLSZ02 -0.6443386 0.0074521 -86.463 < 2e-16 \*\*\*  
ORIGIN\_SZKLSZ03 -0.3990113 0.0067213 -59.366 < 2e-16 \*\*\*  
ORIGIN\_SZKLSZ04 -2.1413876 0.0138405 -154.719 < 2e-16 \*\*\*  
ORIGIN\_SZKLSZ05 -1.0913697 0.0121512 -89.816 < 2e-16 \*\*\*  
ORIGIN\_SZKLSZ06 -5.6240764 0.1857405 -30.279 < 2e-16 \*\*\*  
ORIGIN\_SZKLSZ07 -1.1885897 0.0096830 -122.750 < 2e-16 \*\*\*  
ORIGIN\_SZKLSZ08 -1.7018593 0.0114317 -148.872 < 2e-16 \*\*\*  
ORIGIN\_SZLKSZ01 -1.6659670 0.0446420 -37.318 < 2e-16 \*\*\*  
ORIGIN\_SZMDSZ01 -1.1210505 0.0318834 -35.161 < 2e-16 \*\*\*  
ORIGIN\_SZMDSZ02 -0.5096299 0.0116645 -43.691 < 2e-16 \*\*\*  
ORIGIN\_SZMDSZ03 -1.9187039 0.0198291 -96.762 < 2e-16 \*\*\*  
ORIGIN\_SZMPSZ01 -0.5260512 0.0094201 -55.844 < 2e-16 \*\*\*  
ORIGIN\_SZMPSZ02 -0.2905084 0.0077974 -37.257 < 2e-16 \*\*\*  
ORIGIN\_SZMPSZ03 0.3342293 0.0063715 52.457 < 2e-16 \*\*\*  
ORIGIN\_SZMUSZ02 -3.8337096 0.1105053 -34.693 < 2e-16 \*\*\*  
ORIGIN\_SZNTSZ01 -2.9845040 0.0397028 -75.171 < 2e-16 \*\*\*  
ORIGIN\_SZNTSZ02 -3.1812985 0.0249470 -127.522 < 2e-16 \*\*\*  
ORIGIN\_SZNTSZ03 -0.9742991 0.0085424 -114.054 < 2e-16 \*\*\*  
ORIGIN\_SZNTSZ05 -4.2086932 0.0579737 -72.597 < 2e-16 \*\*\*  
ORIGIN\_SZNTSZ06 -4.5831822 0.0583494 -78.547 < 2e-16 \*\*\*  
ORIGIN\_SZNVSZ01 0.3186962 0.0052944 60.195 < 2e-16 \*\*\*  
ORIGIN\_SZNVSZ02 -0.5321136 0.0073747 -72.154 < 2e-16 \*\*\*  
ORIGIN\_SZNVSZ03 -0.9911852 0.0090560 -109.451 < 2e-16 \*\*\*  
ORIGIN\_SZNVSZ04 -0.8329721 0.0099590 -83.640 < 2e-16 \*\*\*  
ORIGIN\_SZNVSZ05 -2.1460777 0.0182401 -117.657 < 2e-16 \*\*\*  
ORIGIN\_SZPGSZ01 -0.5604078 0.0151515 -36.987 < 2e-16 \*\*\*  
ORIGIN\_SZPGSZ02 -0.4025139 0.0085135 -47.279 < 2e-16 \*\*\*  
ORIGIN\_SZPGSZ03 0.6975483 0.0055534 125.608 < 2e-16 \*\*\*  
ORIGIN\_SZPGSZ04 1.2175486 0.0051080 238.363 < 2e-16 \*\*\*  
ORIGIN\_SZPGSZ05 0.3895354 0.0069851 55.767 < 2e-16 \*\*\*  
ORIGIN\_SZPLSZ01 -0.5572701 0.0134473 -41.441 < 2e-16 \*\*\*  
ORIGIN\_SZPLSZ02 -0.9854214 0.0172337 -57.180 < 2e-16 \*\*\*  
ORIGIN\_SZPLSZ03 -1.6991954 0.0472629 -35.952 < 2e-16 \*\*\*  
ORIGIN\_SZPLSZ04 -2.2000217 0.0373580 -58.890 < 2e-16 \*\*\*  
ORIGIN\_SZPLSZ05 -1.7086663 0.0260920 -65.486 < 2e-16 \*\*\*  
ORIGIN\_SZPNSZ01 1.5292867 0.0055102 277.535 < 2e-16 \*\*\*  
ORIGIN\_SZPNSZ02 0.7457519 0.0127815 58.346 < 2e-16 \*\*\*  
ORIGIN\_SZPNSZ03 -1.3659046 0.0216180 -63.184 < 2e-16 \*\*\*  
ORIGIN\_SZPNSZ04 -2.0025379 0.0360655 -55.525 < 2e-16 \*\*\*  
ORIGIN\_SZPNSZ05 -0.9157959 0.0320955 -28.533 < 2e-16 \*\*\*  
ORIGIN\_SZPRSZ01 0.0522611 0.0139142 3.756 0.000173 \*\*\*  
ORIGIN\_SZPRSZ02 1.3063371 0.0053809 242.774 < 2e-16 \*\*\*  
ORIGIN\_SZPRSZ03 0.9963670 0.0054293 183.516 < 2e-16 \*\*\*  
ORIGIN\_SZPRSZ04 -0.0300950 0.0088010 -3.419 0.000627 \*\*\*  
ORIGIN\_SZPRSZ05 1.6840313 0.0050839 331.245 < 2e-16 \*\*\*  
ORIGIN\_SZPRSZ06 -0.8277202 0.0131296 -63.042 < 2e-16 \*\*\*  
ORIGIN\_SZPRSZ07 -2.1698449 0.0177362 -122.340 < 2e-16 \*\*\*  
ORIGIN\_SZPRSZ08 0.4559353 0.0072609 62.793 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ01 -0.3517047 0.0078770 -44.650 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ02 -0.8199353 0.0071544 -114.605 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ03 -0.2457614 0.0065555 -37.490 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ04 -1.2216614 0.0084050 -145.349 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ05 -0.7219952 0.0072360 -99.778 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ06 -0.6729363 0.0076658 -87.784 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ07 -1.4497690 0.0109365 -132.563 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ08 -0.2770151 0.0070193 -39.465 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ09 -0.6157554 0.0078739 -78.202 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ10 -0.3091547 0.0075471 -40.963 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ11 -1.9698881 0.0151247 -130.243 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ12 -2.6449643 0.0205857 -128.485 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ13 -0.3754107 0.0088433 -42.452 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ14 -1.6537473 0.0134378 -123.067 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ15 -0.3435351 0.0131956 -26.034 < 2e-16 \*\*\*  
ORIGIN\_SZRCSZ01 -1.7104390 0.0141179 -121.154 < 2e-16 \*\*\*  
ORIGIN\_SZRCSZ06 -1.1250727 0.0094909 -118.542 < 2e-16 \*\*\*  
ORIGIN\_SZRVSZ01 -3.0220116 0.0339694 -88.963 < 2e-16 \*\*\*  
ORIGIN\_SZRVSZ02 -3.6040075 0.0297641 -121.086 < 2e-16 \*\*\*  
ORIGIN\_SZRVSZ03 -3.2345594 0.0259149 -124.814 < 2e-16 \*\*\*  
ORIGIN\_SZRVSZ04 -3.6900313 0.0575908 -64.073 < 2e-16 \*\*\*  
ORIGIN\_SZRVSZ05 -2.9527570 0.0178582 -165.344 < 2e-16 \*\*\*  
ORIGIN\_SZSBSZ01 0.0238445 0.0078563 3.035 0.002405 \*\*   
ORIGIN\_SZSBSZ02 -0.5780602 0.0093054 -62.121 < 2e-16 \*\*\*  
ORIGIN\_SZSBSZ03 0.8961719 0.0054586 164.175 < 2e-16 \*\*\*  
ORIGIN\_SZSBSZ04 0.8421798 0.0061888 136.080 < 2e-16 \*\*\*  
ORIGIN\_SZSBSZ05 -0.1682984 0.0078342 -21.482 < 2e-16 \*\*\*  
ORIGIN\_SZSBSZ06 -1.1482701 0.0196421 -58.460 < 2e-16 \*\*\*  
ORIGIN\_SZSBSZ07 -0.8830317 0.0160709 -54.946 < 2e-16 \*\*\*  
ORIGIN\_SZSBSZ08 -1.1039492 0.0174602 -63.226 < 2e-16 \*\*\*  
ORIGIN\_SZSBSZ09 -0.5946691 0.0101961 -58.323 < 2e-16 \*\*\*  
ORIGIN\_SZSESZ02 1.1144933 0.0050948 218.749 < 2e-16 \*\*\*  
ORIGIN\_SZSESZ03 1.1058963 0.0049026 225.574 < 2e-16 \*\*\*  
ORIGIN\_SZSESZ04 0.7427975 0.0056948 130.433 < 2e-16 \*\*\*  
ORIGIN\_SZSESZ05 -0.2812684 0.0069596 -40.414 < 2e-16 \*\*\*  
ORIGIN\_SZSESZ06 0.8168315 0.0055800 146.387 < 2e-16 \*\*\*  
ORIGIN\_SZSESZ07 -2.2842043 0.0231232 -98.784 < 2e-16 \*\*\*  
ORIGIN\_SZSGSZ01 -0.7313790 0.0098957 -73.909 < 2e-16 \*\*\*  
ORIGIN\_SZSGSZ02 -1.1185406 0.0110919 -100.843 < 2e-16 \*\*\*  
ORIGIN\_SZSGSZ03 0.1752618 0.0060508 28.965 < 2e-16 \*\*\*  
ORIGIN\_SZSGSZ04 0.3764395 0.0056165 67.023 < 2e-16 \*\*\*  
ORIGIN\_SZSGSZ05 -1.7203916 0.0118945 -144.637 < 2e-16 \*\*\*  
ORIGIN\_SZSGSZ06 0.4630857 0.0052886 87.563 < 2e-16 \*\*\*  
ORIGIN\_SZSGSZ07 -0.7051233 0.0073133 -96.417 < 2e-16 \*\*\*  
ORIGIN\_SZSKSZ01 0.2053928 0.0100710 20.395 < 2e-16 \*\*\*  
ORIGIN\_SZSKSZ02 1.2630428 0.0063490 198.935 < 2e-16 \*\*\*  
ORIGIN\_SZSKSZ03 -0.3035297 0.0096788 -31.360 < 2e-16 \*\*\*  
ORIGIN\_SZSKSZ04 -1.7952886 0.0359225 -49.977 < 2e-16 \*\*\*  
ORIGIN\_SZSKSZ05 -0.3836861 0.0176686 -21.716 < 2e-16 \*\*\*  
ORIGIN\_SZSLSZ01 -2.5916326 0.0348001 -74.472 < 2e-16 \*\*\*  
ORIGIN\_SZSLSZ04 -0.2251549 0.0088517 -25.436 < 2e-16 \*\*\*  
ORIGIN\_SZSRSZ01 -2.9590365 0.0173638 -170.414 < 2e-16 \*\*\*  
ORIGIN\_SZTHSZ01 -1.9639893 0.0570321 -34.437 < 2e-16 \*\*\*  
ORIGIN\_SZTHSZ03 -1.7281304 0.0272797 -63.349 < 2e-16 \*\*\*  
ORIGIN\_SZTHSZ04 -2.7837906 0.0343179 -81.118 < 2e-16 \*\*\*  
ORIGIN\_SZTHSZ06 -2.1800693 0.0205491 -106.091 < 2e-16 \*\*\*  
ORIGIN\_SZTMSZ01 0.8228136 0.0066824 123.131 < 2e-16 \*\*\*  
ORIGIN\_SZTMSZ02 2.3174781 0.0044978 515.243 < 2e-16 \*\*\*  
ORIGIN\_SZTMSZ03 1.7061757 0.0048615 350.957 < 2e-16 \*\*\*  
ORIGIN\_SZTMSZ04 1.2407899 0.0058389 212.504 < 2e-16 \*\*\*  
ORIGIN\_SZTMSZ05 -0.1000526 0.0124079 -8.064 7.41e-16 \*\*\*  
ORIGIN\_SZTNSZ01 -2.0347519 0.0139596 -145.760 < 2e-16 \*\*\*  
ORIGIN\_SZTNSZ02 -1.8682671 0.0107901 -173.146 < 2e-16 \*\*\*  
ORIGIN\_SZTNSZ03 -2.1737183 0.0146759 -148.115 < 2e-16 \*\*\*  
ORIGIN\_SZTNSZ04 -0.5006452 0.0081501 -61.428 < 2e-16 \*\*\*  
ORIGIN\_SZTPSZ01 -0.6722487 0.0075606 -88.914 < 2e-16 \*\*\*  
ORIGIN\_SZTPSZ02 0.4552916 0.0050191 90.711 < 2e-16 \*\*\*  
ORIGIN\_SZTPSZ03 -0.7865781 0.0072250 -108.869 < 2e-16 \*\*\*  
ORIGIN\_SZTPSZ04 -0.7049044 0.0066456 -106.071 < 2e-16 \*\*\*  
ORIGIN\_SZTPSZ05 -0.5574925 0.0070366 -79.227 < 2e-16 \*\*\*  
ORIGIN\_SZTPSZ06 -0.4247282 0.0068709 -61.815 < 2e-16 \*\*\*  
ORIGIN\_SZTPSZ07 -0.2846984 0.0071030 -40.081 < 2e-16 \*\*\*  
ORIGIN\_SZTPSZ08 -1.0898051 0.0110046 -99.031 < 2e-16 \*\*\*  
ORIGIN\_SZTPSZ09 -0.8092746 0.0079160 -102.232 < 2e-16 \*\*\*  
ORIGIN\_SZTPSZ10 -0.9332072 0.0086809 -107.502 < 2e-16 \*\*\*  
ORIGIN\_SZTPSZ11 -0.0421981 0.0064343 -6.558 5.44e-11 \*\*\*  
ORIGIN\_SZTPSZ12 -0.6330081 0.0078324 -80.819 < 2e-16 \*\*\*  
ORIGIN\_SZTSSZ01 -1.7650409 0.0517357 -34.116 < 2e-16 \*\*\*  
ORIGIN\_SZTSSZ02 1.1707267 0.0094178 124.310 < 2e-16 \*\*\*  
ORIGIN\_SZTSSZ03 0.6581679 0.0095894 68.635 < 2e-16 \*\*\*  
ORIGIN\_SZTSSZ04 0.8736493 0.0104965 83.233 < 2e-16 \*\*\*  
ORIGIN\_SZTSSZ05 0.0957248 0.0178709 5.356 8.49e-08 \*\*\*  
ORIGIN\_SZTSSZ06 1.7581609 0.0206810 85.013 < 2e-16 \*\*\*  
ORIGIN\_SZWCSZ01 0.8097950 0.0105622 76.669 < 2e-16 \*\*\*  
ORIGIN\_SZWCSZ02 -1.9966163 0.0345747 -57.748 < 2e-16 \*\*\*  
ORIGIN\_SZWCSZ03 -5.0687420 0.1474971 -34.365 < 2e-16 \*\*\*  
ORIGIN\_SZWDSZ01 1.4926003 0.0047216 316.124 < 2e-16 \*\*\*  
ORIGIN\_SZWDSZ02 0.9916597 0.0055755 177.859 < 2e-16 \*\*\*  
ORIGIN\_SZWDSZ03 1.5918065 0.0052180 305.062 < 2e-16 \*\*\*  
ORIGIN\_SZWDSZ04 1.3717152 0.0060516 226.669 < 2e-16 \*\*\*  
ORIGIN\_SZWDSZ05 0.6700111 0.0062287 107.569 < 2e-16 \*\*\*  
ORIGIN\_SZWDSZ06 0.8115996 0.0060947 133.165 < 2e-16 \*\*\*  
ORIGIN\_SZWDSZ07 -0.6488914 0.0093567 -69.351 < 2e-16 \*\*\*  
ORIGIN\_SZWDSZ08 -0.3610234 0.0096440 -37.435 < 2e-16 \*\*\*  
ORIGIN\_SZWDSZ09 1.4445461 0.0052279 276.317 < 2e-16 \*\*\*  
ORIGIN\_SZYSSZ01 -0.2039272 0.0069548 -29.322 < 2e-16 \*\*\*  
ORIGIN\_SZYSSZ02 0.8707707 0.0058957 147.697 < 2e-16 \*\*\*  
ORIGIN\_SZYSSZ03 1.8348842 0.0050377 364.231 < 2e-16 \*\*\*  
ORIGIN\_SZYSSZ04 1.0780641 0.0052960 203.564 < 2e-16 \*\*\*  
ORIGIN\_SZYSSZ05 0.3222765 0.0069700 46.237 < 2e-16 \*\*\*  
ORIGIN\_SZYSSZ06 -0.4424689 0.0124866 -35.435 < 2e-16 \*\*\*  
ORIGIN\_SZYSSZ07 -1.0267883 0.0155821 -65.895 < 2e-16 \*\*\*  
ORIGIN\_SZYSSZ08 0.1833117 0.0070935 25.842 < 2e-16 \*\*\*  
ORIGIN\_SZYSSZ09 1.0766070 0.0050451 213.396 < 2e-16 \*\*\*  
log(DESTIN\_AGE25\_64) 0.0295428 0.0001051 280.998 < 2e-16 \*\*\*  
log(dist) -1.7024691 0.0004625 -3681.042 < 2e-16 \*\*\*  
---  
Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
  
(Dispersion parameter for poisson family taken to be 1)  
  
 Null deviance: 36117615 on 14273 degrees of freedom  
Residual deviance: 12983718 on 13993 degrees of freedom  
AIC: 13068835  
  
Number of Fisher Scoring iterations: 6

We can examine how the constraints hold for destinations this time.

CalcRSquared(orcSIM$data$TRIPS, orcSIM$fitted.values)

[1] 0.4029115

### Destination constrained

In this section, we will fit a destination constrained SIM by using the code chunk below.

The general formula of Destination Constrained Spatial Interaction Model



decSIM <- glm(formula = TRIPS ~   
 DESTIN\_SZ +   
 log(ORIGIN\_AGE25\_64) +   
 log(dist),  
 family = poisson(link = "log"),  
 data = SIM\_data,  
 na.action = na.exclude)  
summary(decSIM)

Call:  
glm(formula = TRIPS ~ DESTIN\_SZ + log(ORIGIN\_AGE25\_64) + log(dist),   
 family = poisson(link = "log"), data = SIM\_data, na.action = na.exclude)  
  
Coefficients:  
 Estimate Std. Error z value Pr(>|z|)   
(Intercept) 19.4822997 0.0050784 3836.298 < 2e-16 \*\*\*  
DESTIN\_SZAMSZ02 0.1263056 0.0049743 25.392 < 2e-16 \*\*\*  
DESTIN\_SZAMSZ03 0.0421788 0.0049859 8.460 < 2e-16 \*\*\*  
DESTIN\_SZAMSZ04 -1.1668479 0.0074254 -157.143 < 2e-16 \*\*\*  
DESTIN\_SZAMSZ05 -1.2586639 0.0075854 -165.931 < 2e-16 \*\*\*  
DESTIN\_SZAMSZ06 -1.1414791 0.0073474 -155.359 < 2e-16 \*\*\*  
DESTIN\_SZAMSZ07 -1.5565804 0.0109476 -142.185 < 2e-16 \*\*\*  
DESTIN\_SZAMSZ08 -0.3990754 0.0074159 -53.813 < 2e-16 \*\*\*  
DESTIN\_SZAMSZ09 -1.0109118 0.0076802 -131.626 < 2e-16 \*\*\*  
DESTIN\_SZAMSZ10 0.0159285 0.0051765 3.077 0.00209 \*\*   
DESTIN\_SZAMSZ11 -0.3653273 0.0094866 -38.510 < 2e-16 \*\*\*  
DESTIN\_SZAMSZ12 0.5297606 0.0053243 99.500 < 2e-16 \*\*\*  
DESTIN\_SZBDSZ01 1.0394822 0.0044226 235.037 < 2e-16 \*\*\*  
DESTIN\_SZBDSZ02 0.1956964 0.0059564 32.855 < 2e-16 \*\*\*  
DESTIN\_SZBDSZ03 0.3209267 0.0053718 59.742 < 2e-16 \*\*\*  
DESTIN\_SZBDSZ04 1.2429874 0.0043104 288.370 < 2e-16 \*\*\*  
DESTIN\_SZBDSZ05 0.8535842 0.0046360 184.122 < 2e-16 \*\*\*  
DESTIN\_SZBDSZ06 0.5181443 0.0053736 96.423 < 2e-16 \*\*\*  
DESTIN\_SZBDSZ07 -0.5849371 0.0110468 -52.951 < 2e-16 \*\*\*  
DESTIN\_SZBDSZ08 -1.2871050 0.0128623 -100.068 < 2e-16 \*\*\*  
DESTIN\_SZBKSZ01 -1.0633560 0.0077771 -136.730 < 2e-16 \*\*\*  
DESTIN\_SZBKSZ02 -0.4065316 0.0066712 -60.938 < 2e-16 \*\*\*  
DESTIN\_SZBKSZ03 -0.6815674 0.0066509 -102.477 < 2e-16 \*\*\*  
DESTIN\_SZBKSZ04 -0.4185485 0.0058306 -71.785 < 2e-16 \*\*\*  
DESTIN\_SZBKSZ05 -0.8887654 0.0073867 -120.319 < 2e-16 \*\*\*  
DESTIN\_SZBKSZ06 -0.9436078 0.0068625 -137.501 < 2e-16 \*\*\*  
DESTIN\_SZBKSZ07 -0.0067325 0.0048408 -1.391 0.16430   
DESTIN\_SZBKSZ08 -1.2680903 0.0079177 -160.160 < 2e-16 \*\*\*  
DESTIN\_SZBKSZ09 -0.0350151 0.0054287 -6.450 1.12e-10 \*\*\*  
DESTIN\_SZBLSZ01 -0.3045203 0.0081978 -37.146 < 2e-16 \*\*\*  
DESTIN\_SZBLSZ02 0.6432424 0.0074449 86.400 < 2e-16 \*\*\*  
DESTIN\_SZBLSZ03 1.9595113 0.0084705 231.333 < 2e-16 \*\*\*  
DESTIN\_SZBLSZ04 0.0149756 0.0172081 0.870 0.38415   
DESTIN\_SZBMSZ01 -0.0378127 0.0055294 -6.838 8.00e-12 \*\*\*  
DESTIN\_SZBMSZ02 -0.8458055 0.0054043 -156.505 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ03 -1.1334399 0.0063720 -177.878 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ04 -1.1164759 0.0057743 -193.353 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ05 -1.1078742 0.0078703 -140.766 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ06 -2.2787234 0.0155126 -146.895 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ07 -0.2739089 0.0051924 -52.752 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ08 -1.6825978 0.0071842 -234.209 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ09 -3.0047801 0.0159980 -187.823 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ10 -2.2232689 0.0096907 -229.423 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ11 -1.9657136 0.0086445 -227.394 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ12 -1.5359286 0.0089658 -171.310 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ13 -0.5657561 0.0059960 -94.355 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ14 -1.6904858 0.0084858 -199.214 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ15 -1.5268383 0.0079959 -190.953 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ16 -2.2045600 0.0130872 -168.452 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ17 -2.2992381 0.0184895 -124.353 < 2e-16 \*\*\*  
DESTIN\_SZBPSZ01 -0.8549497 0.0065168 -131.191 < 2e-16 \*\*\*  
DESTIN\_SZBPSZ02 -1.7470549 0.0095751 -182.457 < 2e-16 \*\*\*  
DESTIN\_SZBPSZ03 -1.4015145 0.0090888 -154.203 < 2e-16 \*\*\*  
DESTIN\_SZBPSZ04 -0.5250632 0.0066496 -78.962 < 2e-16 \*\*\*  
DESTIN\_SZBPSZ05 0.3413171 0.0046404 73.553 < 2e-16 \*\*\*  
DESTIN\_SZBPSZ06 -0.8569188 0.0090795 -94.380 < 2e-16 \*\*\*  
DESTIN\_SZBPSZ07 -0.0751284 0.0089704 -8.375 < 2e-16 \*\*\*  
DESTIN\_SZBSSZ01 0.1015228 0.0055735 18.215 < 2e-16 \*\*\*  
DESTIN\_SZBSSZ02 -0.7066412 0.0063845 -110.682 < 2e-16 \*\*\*  
DESTIN\_SZBSSZ03 0.1622730 0.0046689 34.756 < 2e-16 \*\*\*  
DESTIN\_SZBTSZ01 0.5470615 0.0047984 114.009 < 2e-16 \*\*\*  
DESTIN\_SZBTSZ02 -0.1393371 0.0078266 -17.803 < 2e-16 \*\*\*  
DESTIN\_SZBTSZ03 0.1474771 0.0059428 24.816 < 2e-16 \*\*\*  
DESTIN\_SZBTSZ04 -1.2857827 0.0122000 -105.392 < 2e-16 \*\*\*  
DESTIN\_SZBTSZ05 -0.2629188 0.0081769 -32.154 < 2e-16 \*\*\*  
DESTIN\_SZBTSZ06 -0.8319920 0.0081401 -102.209 < 2e-16 \*\*\*  
DESTIN\_SZBTSZ07 -1.8829448 0.0121227 -155.324 < 2e-16 \*\*\*  
DESTIN\_SZBTSZ08 -1.5732123 0.0116752 -134.748 < 2e-16 \*\*\*  
DESTIN\_SZCBSZ01 -3.5334327 0.3333510 -10.600 < 2e-16 \*\*\*  
DESTIN\_SZCCSZ01 -0.2129306 0.0093782 -22.705 < 2e-16 \*\*\*  
DESTIN\_SZCHSZ01 -0.1494972 0.0113078 -13.221 < 2e-16 \*\*\*  
DESTIN\_SZCHSZ02 0.0041774 0.0063195 0.661 0.50860   
DESTIN\_SZCHSZ03 2.5565450 0.0046495 549.857 < 2e-16 \*\*\*  
DESTIN\_SZCKSZ01 0.0489719 0.0053801 9.102 < 2e-16 \*\*\*  
DESTIN\_SZCKSZ02 -0.3548993 0.0060671 -58.496 < 2e-16 \*\*\*  
DESTIN\_SZCKSZ03 0.5386351 0.0044913 119.928 < 2e-16 \*\*\*  
DESTIN\_SZCKSZ04 -0.4425512 0.0073837 -59.936 < 2e-16 \*\*\*  
DESTIN\_SZCKSZ05 -0.4092591 0.0077267 -52.967 < 2e-16 \*\*\*  
DESTIN\_SZCKSZ06 0.2207041 0.0074252 29.724 < 2e-16 \*\*\*  
DESTIN\_SZCLSZ01 0.2851460 0.0052362 54.457 < 2e-16 \*\*\*  
DESTIN\_SZCLSZ02 -1.9270528 0.0147688 -130.482 < 2e-16 \*\*\*  
DESTIN\_SZCLSZ03 -0.6266521 0.0086780 -72.212 < 2e-16 \*\*\*  
DESTIN\_SZCLSZ04 -0.1335581 0.0054216 -24.634 < 2e-16 \*\*\*  
DESTIN\_SZCLSZ05 -0.8912963 0.0096015 -92.829 < 2e-16 \*\*\*  
DESTIN\_SZCLSZ06 0.1781234 0.0048150 36.993 < 2e-16 \*\*\*  
DESTIN\_SZCLSZ07 -0.5609619 0.0062277 -90.075 < 2e-16 \*\*\*  
DESTIN\_SZCLSZ08 -0.3875308 0.0068390 -56.665 < 2e-16 \*\*\*  
DESTIN\_SZCLSZ09 0.2539453 0.0072623 34.968 < 2e-16 \*\*\*  
DESTIN\_SZDTSZ02 -2.5036295 0.0373421 -67.046 < 2e-16 \*\*\*  
DESTIN\_SZDTSZ03 -0.8956407 0.0149971 -59.721 < 2e-16 \*\*\*  
DESTIN\_SZDTSZ13 -1.6562176 0.0175441 -94.403 < 2e-16 \*\*\*  
DESTIN\_SZGLSZ01 -0.2716152 0.0056553 -48.029 < 2e-16 \*\*\*  
DESTIN\_SZGLSZ02 -0.1735665 0.0055548 -31.246 < 2e-16 \*\*\*  
DESTIN\_SZGLSZ03 0.7029507 0.0044934 156.441 < 2e-16 \*\*\*  
DESTIN\_SZGLSZ04 0.5788027 0.0045449 127.351 < 2e-16 \*\*\*  
DESTIN\_SZGLSZ05 0.6865291 0.0045131 152.118 < 2e-16 \*\*\*  
DESTIN\_SZHGSZ01 0.3275950 0.0043866 74.681 < 2e-16 \*\*\*  
DESTIN\_SZHGSZ02 -0.6326974 0.0063517 -99.610 < 2e-16 \*\*\*  
DESTIN\_SZHGSZ03 -1.0597982 0.0073914 -143.382 < 2e-16 \*\*\*  
DESTIN\_SZHGSZ04 -0.2267013 0.0052178 -43.448 < 2e-16 \*\*\*  
DESTIN\_SZHGSZ05 -0.3063050 0.0055452 -55.238 < 2e-16 \*\*\*  
DESTIN\_SZHGSZ06 -0.7483961 0.0065544 -114.182 < 2e-16 \*\*\*  
DESTIN\_SZHGSZ07 0.1096958 0.0051309 21.379 < 2e-16 \*\*\*  
DESTIN\_SZHGSZ08 -0.1374201 0.0056692 -24.240 < 2e-16 \*\*\*  
DESTIN\_SZHGSZ09 0.0775400 0.0060230 12.874 < 2e-16 \*\*\*  
DESTIN\_SZHGSZ10 -3.3017475 0.0289292 -114.132 < 2e-16 \*\*\*  
DESTIN\_SZJESZ01 -0.0489065 0.0057246 -8.543 < 2e-16 \*\*\*  
DESTIN\_SZJESZ02 -0.5101614 0.0060074 -84.921 < 2e-16 \*\*\*  
DESTIN\_SZJESZ03 -0.5328921 0.0064129 -83.097 < 2e-16 \*\*\*  
DESTIN\_SZJESZ04 -0.7348953 0.0082249 -89.351 < 2e-16 \*\*\*  
DESTIN\_SZJESZ05 -1.0864570 0.0111740 -97.231 < 2e-16 \*\*\*  
DESTIN\_SZJESZ06 0.2407920 0.0046801 51.451 < 2e-16 \*\*\*  
DESTIN\_SZJESZ07 -1.1523093 0.0090103 -127.888 < 2e-16 \*\*\*  
DESTIN\_SZJESZ08 -0.4627356 0.0094529 -48.952 < 2e-16 \*\*\*  
DESTIN\_SZJESZ09 0.0528616 0.0068126 7.759 8.53e-15 \*\*\*  
DESTIN\_SZJESZ10 1.0240660 0.0084045 121.848 < 2e-16 \*\*\*  
DESTIN\_SZJESZ11 0.7875517 0.0076251 103.284 < 2e-16 \*\*\*  
DESTIN\_SZJWSZ01 -0.1533418 0.0076198 -20.124 < 2e-16 \*\*\*  
DESTIN\_SZJWSZ02 -0.0011019 0.0059389 -0.186 0.85280   
DESTIN\_SZJWSZ03 0.9063789 0.0046747 193.892 < 2e-16 \*\*\*  
DESTIN\_SZJWSZ04 0.7019286 0.0049743 141.112 < 2e-16 \*\*\*  
DESTIN\_SZJWSZ05 -0.5197057 0.0072971 -71.220 < 2e-16 \*\*\*  
DESTIN\_SZJWSZ06 0.3350986 0.0061171 54.780 < 2e-16 \*\*\*  
DESTIN\_SZJWSZ07 -0.5961960 0.0328336 -18.158 < 2e-16 \*\*\*  
DESTIN\_SZJWSZ08 0.8054662 0.0056006 143.819 < 2e-16 \*\*\*  
DESTIN\_SZJWSZ09 1.5860146 0.0040282 393.723 < 2e-16 \*\*\*  
DESTIN\_SZKLSZ01 -0.6500838 0.0063560 -102.279 < 2e-16 \*\*\*  
DESTIN\_SZKLSZ02 -0.7039434 0.0064465 -109.197 < 2e-16 \*\*\*  
DESTIN\_SZKLSZ03 -1.1972384 0.0075577 -158.413 < 2e-16 \*\*\*  
DESTIN\_SZKLSZ04 -1.7172228 0.0097573 -175.993 < 2e-16 \*\*\*  
DESTIN\_SZKLSZ05 -0.6042386 0.0093730 -64.466 < 2e-16 \*\*\*  
DESTIN\_SZKLSZ06 -3.0201496 0.0389503 -77.539 < 2e-16 \*\*\*  
DESTIN\_SZKLSZ07 -1.1522413 0.0076607 -150.409 < 2e-16 \*\*\*  
DESTIN\_SZKLSZ08 -0.6977825 0.0057610 -121.122 < 2e-16 \*\*\*  
DESTIN\_SZLKSZ01 -0.6895952 0.0268661 -25.668 < 2e-16 \*\*\*  
DESTIN\_SZMDSZ01 -0.7155951 0.0228203 -31.358 < 2e-16 \*\*\*  
DESTIN\_SZMDSZ02 -0.8153643 0.0123003 -66.288 < 2e-16 \*\*\*  
DESTIN\_SZMDSZ03 -2.7745226 0.0301326 -92.077 < 2e-16 \*\*\*  
DESTIN\_SZMPSZ01 -0.5492095 0.0087198 -62.984 < 2e-16 \*\*\*  
DESTIN\_SZMPSZ02 -0.6104744 0.0069346 -88.033 < 2e-16 \*\*\*  
DESTIN\_SZMPSZ03 0.2775047 0.0054964 50.489 < 2e-16 \*\*\*  
DESTIN\_SZMUSZ02 -2.6322870 0.0214943 -122.464 < 2e-16 \*\*\*  
DESTIN\_SZNTSZ01 -4.0762008 0.0531046 -76.758 < 2e-16 \*\*\*  
DESTIN\_SZNTSZ02 -1.9765545 0.0125659 -157.296 < 2e-16 \*\*\*  
DESTIN\_SZNTSZ03 -1.4563069 0.0085433 -170.462 < 2e-16 \*\*\*  
DESTIN\_SZNTSZ05 -2.0125598 0.0270737 -74.336 < 2e-16 \*\*\*  
DESTIN\_SZNTSZ06 -3.0145357 0.0504986 -59.695 < 2e-16 \*\*\*  
DESTIN\_SZNVSZ01 -0.4693625 0.0053866 -87.135 < 2e-16 \*\*\*  
DESTIN\_SZNVSZ02 -0.4525631 0.0060428 -74.894 < 2e-16 \*\*\*  
DESTIN\_SZNVSZ03 -0.4821492 0.0064725 -74.492 < 2e-16 \*\*\*  
DESTIN\_SZNVSZ04 -1.8929756 0.0128397 -147.432 < 2e-16 \*\*\*  
DESTIN\_SZNVSZ05 -1.4501752 0.0099737 -145.400 < 2e-16 \*\*\*  
DESTIN\_SZPGSZ01 -1.2305867 0.0174321 -70.593 < 2e-16 \*\*\*  
DESTIN\_SZPGSZ02 -0.8232919 0.0080153 -102.715 < 2e-16 \*\*\*  
DESTIN\_SZPGSZ03 0.2138480 0.0050850 42.054 < 2e-16 \*\*\*  
DESTIN\_SZPGSZ04 0.1045757 0.0053579 19.518 < 2e-16 \*\*\*  
DESTIN\_SZPGSZ05 -0.7542450 0.0088883 -84.858 < 2e-16 \*\*\*  
DESTIN\_SZPLSZ01 -0.0098642 0.0080428 -1.226 0.22003   
DESTIN\_SZPLSZ02 -1.2630412 0.0152594 -82.771 < 2e-16 \*\*\*  
DESTIN\_SZPLSZ03 -0.1554479 0.0108611 -14.312 < 2e-16 \*\*\*  
DESTIN\_SZPLSZ04 -1.5505819 0.0114768 -135.105 < 2e-16 \*\*\*  
DESTIN\_SZPLSZ05 -0.2417805 0.0130391 -18.543 < 2e-16 \*\*\*  
DESTIN\_SZPNSZ01 0.7926715 0.0073628 107.659 < 2e-16 \*\*\*  
DESTIN\_SZPNSZ02 2.1914920 0.0073537 298.013 < 2e-16 \*\*\*  
DESTIN\_SZPNSZ03 1.0246845 0.0086874 117.951 < 2e-16 \*\*\*  
DESTIN\_SZPNSZ04 2.5522612 0.0091789 278.057 < 2e-16 \*\*\*  
DESTIN\_SZPNSZ05 1.7995301 0.0138562 129.872 < 2e-16 \*\*\*  
DESTIN\_SZPRSZ01 -0.6576686 0.0096037 -68.481 < 2e-16 \*\*\*  
DESTIN\_SZPRSZ02 0.3113532 0.0059851 52.021 < 2e-16 \*\*\*  
DESTIN\_SZPRSZ03 0.9255296 0.0044779 206.687 < 2e-16 \*\*\*  
DESTIN\_SZPRSZ04 -0.0028578 0.0093218 -0.307 0.75917   
DESTIN\_SZPRSZ05 0.2457863 0.0058261 42.187 < 2e-16 \*\*\*  
DESTIN\_SZPRSZ06 0.3692137 0.0064542 57.205 < 2e-16 \*\*\*  
DESTIN\_SZPRSZ07 -1.6733306 0.0138440 -120.871 < 2e-16 \*\*\*  
DESTIN\_SZPRSZ08 -0.2221048 0.0074846 -29.675 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ01 -1.0185488 0.0093179 -109.311 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ02 -1.2802688 0.0081670 -156.761 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ03 -1.3322708 0.0079106 -168.415 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ04 -1.1803631 0.0077366 -152.568 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ05 -1.2215818 0.0072829 -167.734 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ06 -1.3213145 0.0074858 -176.509 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ07 -1.6426306 0.0123347 -133.171 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ08 -0.2224169 0.0058405 -38.082 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ09 -0.8142678 0.0069796 -116.665 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ10 -0.1090496 0.0062573 -17.428 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ11 -0.0108951 0.0061145 -1.782 0.07477 .   
DESTIN\_SZQTSZ12 -0.8582515 0.0090243 -95.105 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ13 0.1834409 0.0065231 28.122 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ14 0.1994454 0.0073615 27.093 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ15 0.6740197 0.0088699 75.990 < 2e-16 \*\*\*  
DESTIN\_SZRCSZ01 -0.7746427 0.0079375 -97.593 < 2e-16 \*\*\*  
DESTIN\_SZRCSZ06 -1.4394098 0.0209931 -68.566 < 2e-16 \*\*\*  
DESTIN\_SZRVSZ01 -2.6060495 0.0175759 -148.274 < 2e-16 \*\*\*  
DESTIN\_SZRVSZ02 -2.5823769 0.0354706 -72.803 < 2e-16 \*\*\*  
DESTIN\_SZRVSZ03 -2.5890601 0.0152644 -169.614 < 2e-16 \*\*\*  
DESTIN\_SZRVSZ04 -2.2277482 0.0165661 -134.477 < 2e-16 \*\*\*  
DESTIN\_SZRVSZ05 -3.8610445 0.0298251 -129.456 < 2e-16 \*\*\*  
DESTIN\_SZSBSZ01 -1.2035529 0.0103954 -115.777 < 2e-16 \*\*\*  
DESTIN\_SZSBSZ02 -1.0267199 0.0085239 -120.452 < 2e-16 \*\*\*  
DESTIN\_SZSBSZ03 0.5977382 0.0050336 118.750 < 2e-16 \*\*\*  
DESTIN\_SZSBSZ04 0.5362769 0.0060573 88.534 < 2e-16 \*\*\*  
DESTIN\_SZSBSZ05 -1.0440525 0.0089622 -116.495 < 2e-16 \*\*\*  
DESTIN\_SZSBSZ06 -1.3939595 0.0246679 -56.509 < 2e-16 \*\*\*  
DESTIN\_SZSBSZ07 0.1029116 0.0235414 4.372 1.23e-05 \*\*\*  
DESTIN\_SZSBSZ08 1.3564902 0.0060529 224.105 < 2e-16 \*\*\*  
DESTIN\_SZSBSZ09 0.4573712 0.0056585 80.829 < 2e-16 \*\*\*  
DESTIN\_SZSESZ02 -0.1553609 0.0056716 -27.393 < 2e-16 \*\*\*  
DESTIN\_SZSESZ03 0.5412776 0.0043801 123.576 < 2e-16 \*\*\*  
DESTIN\_SZSESZ04 -0.6382091 0.0065411 -97.568 < 2e-16 \*\*\*  
DESTIN\_SZSESZ05 -0.3332093 0.0055002 -60.581 < 2e-16 \*\*\*  
DESTIN\_SZSESZ06 -0.3085951 0.0072340 -42.659 < 2e-16 \*\*\*  
DESTIN\_SZSESZ07 -2.6237684 0.0245753 -106.764 < 2e-16 \*\*\*  
DESTIN\_SZSGSZ01 -0.1062372 0.0066634 -15.943 < 2e-16 \*\*\*  
DESTIN\_SZSGSZ02 -0.0475568 0.0058908 -8.073 6.85e-16 \*\*\*  
DESTIN\_SZSGSZ03 -0.2118402 0.0055056 -38.477 < 2e-16 \*\*\*  
DESTIN\_SZSGSZ04 -0.1099618 0.0054841 -20.051 < 2e-16 \*\*\*  
DESTIN\_SZSGSZ05 -2.1556963 0.0113821 -189.394 < 2e-16 \*\*\*  
DESTIN\_SZSGSZ06 0.4416352 0.0043842 100.734 < 2e-16 \*\*\*  
DESTIN\_SZSGSZ07 -0.3949335 0.0059250 -66.655 < 2e-16 \*\*\*  
DESTIN\_SZSISZ01 -1.2847094 0.0288610 -44.514 < 2e-16 \*\*\*  
DESTIN\_SZSKSZ01 0.3089834 0.0082924 37.261 < 2e-16 \*\*\*  
DESTIN\_SZSKSZ02 1.4139309 0.0059981 235.729 < 2e-16 \*\*\*  
DESTIN\_SZSKSZ03 0.2427688 0.0067373 36.034 < 2e-16 \*\*\*  
DESTIN\_SZSKSZ04 -0.2527488 0.0161286 -15.671 < 2e-16 \*\*\*  
DESTIN\_SZSKSZ05 0.6046051 0.0122766 49.249 < 2e-16 \*\*\*  
DESTIN\_SZSLSZ01 -0.3927387 0.0099790 -39.356 < 2e-16 \*\*\*  
DESTIN\_SZSLSZ04 -0.5942110 0.0086225 -68.914 < 2e-16 \*\*\*  
DESTIN\_SZSRSZ01 -2.6855766 0.0138707 -193.615 < 2e-16 \*\*\*  
DESTIN\_SZTHSZ01 -3.2750084 0.0402668 -81.333 < 2e-16 \*\*\*  
DESTIN\_SZTHSZ03 -1.7964408 0.0261810 -68.616 < 2e-16 \*\*\*  
DESTIN\_SZTHSZ04 -2.6323994 0.0241831 -108.853 < 2e-16 \*\*\*  
DESTIN\_SZTHSZ06 -1.9444390 0.0166052 -117.098 < 2e-16 \*\*\*  
DESTIN\_SZTMSZ01 0.3856054 0.0063086 61.123 < 2e-16 \*\*\*  
DESTIN\_SZTMSZ02 1.8586526 0.0039229 473.790 < 2e-16 \*\*\*  
DESTIN\_SZTMSZ03 1.2601385 0.0044018 286.278 < 2e-16 \*\*\*  
DESTIN\_SZTMSZ04 1.5884327 0.0043362 366.316 < 2e-16 \*\*\*  
DESTIN\_SZTMSZ05 1.0377553 0.0063271 164.018 < 2e-16 \*\*\*  
DESTIN\_SZTNSZ01 -0.9954275 0.0080345 -123.895 < 2e-16 \*\*\*  
DESTIN\_SZTNSZ02 -2.1032696 0.0109228 -192.557 < 2e-16 \*\*\*  
DESTIN\_SZTNSZ03 -2.0044892 0.0129215 -155.128 < 2e-16 \*\*\*  
DESTIN\_SZTNSZ04 -0.9750326 0.0081677 -119.377 < 2e-16 \*\*\*  
DESTIN\_SZTPSZ01 -0.7788383 0.0068769 -113.254 < 2e-16 \*\*\*  
DESTIN\_SZTPSZ02 0.2866080 0.0042843 66.898 < 2e-16 \*\*\*  
DESTIN\_SZTPSZ03 -0.8749841 0.0065470 -133.646 < 2e-16 \*\*\*  
DESTIN\_SZTPSZ04 -1.6852792 0.0081488 -206.812 < 2e-16 \*\*\*  
DESTIN\_SZTPSZ05 -1.3721346 0.0068230 -201.104 < 2e-16 \*\*\*  
DESTIN\_SZTPSZ06 -0.7832133 0.0069164 -113.239 < 2e-16 \*\*\*  
DESTIN\_SZTPSZ07 -2.3109126 0.0130830 -176.635 < 2e-16 \*\*\*  
DESTIN\_SZTPSZ08 -1.6406531 0.0104897 -156.406 < 2e-16 \*\*\*  
DESTIN\_SZTPSZ09 -0.5636273 0.0076848 -73.343 < 2e-16 \*\*\*  
DESTIN\_SZTPSZ10 -1.5640843 0.0099984 -156.433 < 2e-16 \*\*\*  
DESTIN\_SZTPSZ11 -0.3700482 0.0059834 -61.846 < 2e-16 \*\*\*  
DESTIN\_SZTPSZ12 -0.8828228 0.0072302 -122.102 < 2e-16 \*\*\*  
DESTIN\_SZTSSZ01 0.3529526 0.0221887 15.907 < 2e-16 \*\*\*  
DESTIN\_SZTSSZ02 1.0265792 0.0153515 66.871 < 2e-16 \*\*\*  
DESTIN\_SZTSSZ03 1.9647347 0.0092388 212.662 < 2e-16 \*\*\*  
DESTIN\_SZTSSZ04 1.8649836 0.0089976 207.275 < 2e-16 \*\*\*  
DESTIN\_SZTSSZ05 2.8437058 0.0085738 331.673 < 2e-16 \*\*\*  
DESTIN\_SZTSSZ06 3.4238870 0.0161304 212.263 < 2e-16 \*\*\*  
DESTIN\_SZWCSZ01 2.9550693 0.0051690 571.689 < 2e-16 \*\*\*  
DESTIN\_SZWCSZ02 -0.8214103 0.0129213 -63.570 < 2e-16 \*\*\*  
DESTIN\_SZWCSZ03 -1.7393427 0.0347472 -50.057 < 2e-16 \*\*\*  
DESTIN\_SZWDSZ01 1.3424417 0.0039957 335.972 < 2e-16 \*\*\*  
DESTIN\_SZWDSZ02 -0.2103694 0.0068601 -30.666 < 2e-16 \*\*\*  
DESTIN\_SZWDSZ03 0.8268551 0.0051363 160.983 < 2e-16 \*\*\*  
DESTIN\_SZWDSZ04 -0.0643997 0.0079076 -8.144 3.82e-16 \*\*\*  
DESTIN\_SZWDSZ05 0.0451985 0.0075732 5.968 2.40e-09 \*\*\*  
DESTIN\_SZWDSZ06 0.6981330 0.0051936 134.423 < 2e-16 \*\*\*  
DESTIN\_SZWDSZ07 -0.0403233 0.0067749 -5.952 2.65e-09 \*\*\*  
DESTIN\_SZWDSZ08 0.2850631 0.0069225 41.179 < 2e-16 \*\*\*  
DESTIN\_SZWDSZ09 1.3016106 0.0050365 258.433 < 2e-16 \*\*\*  
DESTIN\_SZYSSZ01 0.7598564 0.0044144 172.133 < 2e-16 \*\*\*  
DESTIN\_SZYSSZ02 0.2648061 0.0058239 45.469 < 2e-16 \*\*\*  
DESTIN\_SZYSSZ03 -0.0412163 0.0068337 -6.031 1.63e-09 \*\*\*  
DESTIN\_SZYSSZ04 -0.0561054 0.0060829 -9.223 < 2e-16 \*\*\*  
DESTIN\_SZYSSZ05 -0.9970159 0.0121827 -81.839 < 2e-16 \*\*\*  
DESTIN\_SZYSSZ06 -1.3808376 0.0125738 -109.819 < 2e-16 \*\*\*  
DESTIN\_SZYSSZ07 -0.7128364 0.0165296 -43.125 < 2e-16 \*\*\*  
DESTIN\_SZYSSZ08 0.9409510 0.0045886 205.064 < 2e-16 \*\*\*  
DESTIN\_SZYSSZ09 0.3738436 0.0047971 77.930 < 2e-16 \*\*\*  
log(ORIGIN\_AGE25\_64) 0.1928847 0.0001667 1157.214 < 2e-16 \*\*\*  
log(dist) -1.7828141 0.0004794 -3718.501 < 2e-16 \*\*\*  
---  
Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
  
(Dispersion parameter for poisson family taken to be 1)  
  
 Null deviance: 36117615 on 14273 degrees of freedom  
Residual deviance: 12319763 on 13992 degrees of freedom  
AIC: 12404881  
  
Number of Fisher Scoring iterations: 7

We can examine how the constraints hold for destinations this time.

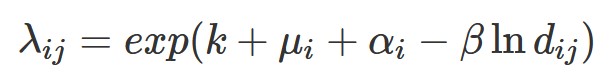
CalcRSquared(decSIM$data$TRIPS, decSIM$fitted.values)

[1] 0.496166

### Doubly constrained

In this section, we will fit a doubly constrained SIM by using the code chunk below.

The general formula of Doubly Constrained Spatial Interaction Model



dbcSIM <- glm(formula = TRIPS ~   
 ORIGIN\_SZ +   
 DESTIN\_SZ +   
 log(dist),  
 family = poisson(link = "log"),  
 data = SIM\_data,  
 na.action = na.exclude)  
summary(dbcSIM)

Call:  
glm(formula = TRIPS ~ ORIGIN\_SZ + DESTIN\_SZ + log(dist), family = poisson(link = "log"),   
 data = SIM\_data, na.action = na.exclude)  
  
Coefficients:  
 Estimate Std. Error z value Pr(>|z|)   
(Intercept) 21.9587595 0.0066831 3285.715 < 2e-16 \*\*\*  
ORIGIN\_SZAMSZ02 0.4778050 0.0054127 88.275 < 2e-16 \*\*\*  
ORIGIN\_SZAMSZ03 0.2895973 0.0055517 52.163 < 2e-16 \*\*\*  
ORIGIN\_SZAMSZ04 -0.2628080 0.0060720 -43.282 < 2e-16 \*\*\*  
ORIGIN\_SZAMSZ05 -0.2631404 0.0069008 -38.132 < 2e-16 \*\*\*  
ORIGIN\_SZAMSZ06 0.1722337 0.0062028 27.767 < 2e-16 \*\*\*  
ORIGIN\_SZAMSZ07 -0.9883200 0.0111224 -88.859 < 2e-16 \*\*\*  
ORIGIN\_SZAMSZ08 -0.4052821 0.0104095 -38.934 < 2e-16 \*\*\*  
ORIGIN\_SZAMSZ09 0.0356290 0.0064816 5.497 3.86e-08 \*\*\*  
ORIGIN\_SZAMSZ10 0.4815569 0.0055521 86.735 < 2e-16 \*\*\*  
ORIGIN\_SZAMSZ11 -1.4440079 0.0146079 -98.851 < 2e-16 \*\*\*  
ORIGIN\_SZAMSZ12 -1.7862677 0.0128071 -139.475 < 2e-16 \*\*\*  
ORIGIN\_SZBDSZ01 0.8653749 0.0054381 159.132 < 2e-16 \*\*\*  
ORIGIN\_SZBDSZ02 0.0841000 0.0062834 13.385 < 2e-16 \*\*\*  
ORIGIN\_SZBDSZ03 0.3158343 0.0057510 54.918 < 2e-16 \*\*\*  
ORIGIN\_SZBDSZ04 1.4556701 0.0049986 291.215 < 2e-16 \*\*\*  
ORIGIN\_SZBDSZ05 0.6363125 0.0057193 111.257 < 2e-16 \*\*\*  
ORIGIN\_SZBDSZ06 0.6749341 0.0058650 115.078 < 2e-16 \*\*\*  
ORIGIN\_SZBDSZ07 -1.2176407 0.0113698 -107.095 < 2e-16 \*\*\*  
ORIGIN\_SZBDSZ08 -0.9803580 0.0105604 -92.833 < 2e-16 \*\*\*  
ORIGIN\_SZBKSZ01 -0.2919642 0.0080763 -36.151 < 2e-16 \*\*\*  
ORIGIN\_SZBKSZ02 0.4609570 0.0067997 67.791 < 2e-16 \*\*\*  
ORIGIN\_SZBKSZ03 0.6273448 0.0065989 95.068 < 2e-16 \*\*\*  
ORIGIN\_SZBKSZ04 -0.2499063 0.0076555 -32.644 < 2e-16 \*\*\*  
ORIGIN\_SZBKSZ05 -0.2628428 0.0078905 -33.311 < 2e-16 \*\*\*  
ORIGIN\_SZBKSZ06 -0.2174034 0.0075134 -28.936 < 2e-16 \*\*\*  
ORIGIN\_SZBKSZ07 0.7094093 0.0058574 121.114 < 2e-16 \*\*\*  
ORIGIN\_SZBKSZ08 -0.1614362 0.0067626 -23.872 < 2e-16 \*\*\*  
ORIGIN\_SZBKSZ09 -0.2739085 0.0072969 -37.537 < 2e-16 \*\*\*  
ORIGIN\_SZBLSZ01 -2.4281074 0.0181172 -134.022 < 2e-16 \*\*\*  
ORIGIN\_SZBLSZ02 -2.7305447 0.0219341 -124.489 < 2e-16 \*\*\*  
ORIGIN\_SZBLSZ03 -3.3071431 0.0540398 -61.198 < 2e-16 \*\*\*  
ORIGIN\_SZBLSZ04 -2.4550671 0.0263946 -93.014 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ01 0.1198976 0.0065964 18.176 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ02 -1.3908667 0.0083230 -167.112 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ03 -0.6999122 0.0069754 -100.339 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ04 -0.2691159 0.0066184 -40.662 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ05 -2.6163780 0.0190989 -136.991 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ06 -2.9729956 0.0197182 -150.774 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ07 -0.7309916 0.0072407 -100.956 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ08 -1.0019514 0.0073169 -136.936 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ09 -1.3667460 0.0105325 -129.764 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ10 -1.6907268 0.0106687 -158.476 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ11 -1.2288802 0.0082919 -148.202 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ12 -1.6517767 0.0115101 -143.507 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ13 -0.7251351 0.0075289 -96.314 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ14 -1.1534912 0.0082629 -139.599 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ15 -0.5476774 0.0075710 -72.339 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ16 -1.5195034 0.0111459 -136.329 < 2e-16 \*\*\*  
ORIGIN\_SZBMSZ17 -1.6026767 0.0184419 -86.904 < 2e-16 \*\*\*  
ORIGIN\_SZBPSZ01 0.5571291 0.0071866 77.523 < 2e-16 \*\*\*  
ORIGIN\_SZBPSZ02 0.0523197 0.0082259 6.360 2.01e-10 \*\*\*  
ORIGIN\_SZBPSZ03 0.2942047 0.0080482 36.555 < 2e-16 \*\*\*  
ORIGIN\_SZBPSZ04 0.6246296 0.0065878 94.816 < 2e-16 \*\*\*  
ORIGIN\_SZBPSZ05 0.8663708 0.0060852 142.372 < 2e-16 \*\*\*  
ORIGIN\_SZBPSZ06 -0.9896182 0.0109551 -90.334 < 2e-16 \*\*\*  
ORIGIN\_SZBPSZ07 -0.5219250 0.0101830 -51.255 < 2e-16 \*\*\*  
ORIGIN\_SZBSSZ01 0.3299588 0.0066440 49.663 < 2e-16 \*\*\*  
ORIGIN\_SZBSSZ02 0.2851357 0.0057077 49.956 < 2e-16 \*\*\*  
ORIGIN\_SZBSSZ03 -0.2084740 0.0063364 -32.901 < 2e-16 \*\*\*  
ORIGIN\_SZBTSZ01 0.1425664 0.0071103 20.051 < 2e-16 \*\*\*  
ORIGIN\_SZBTSZ02 -0.5591999 0.0093616 -59.733 < 2e-16 \*\*\*  
ORIGIN\_SZBTSZ03 -0.3648190 0.0081677 -44.666 < 2e-16 \*\*\*  
ORIGIN\_SZBTSZ04 -1.4555078 0.0120138 -121.152 < 2e-16 \*\*\*  
ORIGIN\_SZBTSZ05 -0.8635510 0.0133848 -64.517 < 2e-16 \*\*\*  
ORIGIN\_SZBTSZ06 -1.1383111 0.0106421 -106.963 < 2e-16 \*\*\*  
ORIGIN\_SZBTSZ07 -2.3477669 0.0160858 -145.953 < 2e-16 \*\*\*  
ORIGIN\_SZBTSZ08 -1.2918779 0.0124862 -103.464 < 2e-16 \*\*\*  
ORIGIN\_SZCBSZ01 -3.3713588 0.0578683 -58.259 < 2e-16 \*\*\*  
ORIGIN\_SZCCSZ01 -0.6029242 0.0153385 -39.308 < 2e-16 \*\*\*  
ORIGIN\_SZCHSZ01 -0.7641380 0.0135100 -56.561 < 2e-16 \*\*\*  
ORIGIN\_SZCHSZ02 -0.8400736 0.0101951 -82.400 < 2e-16 \*\*\*  
ORIGIN\_SZCHSZ03 1.2753127 0.0072576 175.720 < 2e-16 \*\*\*  
ORIGIN\_SZCKSZ01 0.2470943 0.0067135 36.806 < 2e-16 \*\*\*  
ORIGIN\_SZCKSZ02 0.5793581 0.0070498 82.181 < 2e-16 \*\*\*  
ORIGIN\_SZCKSZ03 1.0795767 0.0060642 178.025 < 2e-16 \*\*\*  
ORIGIN\_SZCKSZ04 1.4947920 0.0063122 236.808 < 2e-16 \*\*\*  
ORIGIN\_SZCKSZ05 0.7457580 0.0074071 100.681 < 2e-16 \*\*\*  
ORIGIN\_SZCKSZ06 0.5760952 0.0094861 60.730 < 2e-16 \*\*\*  
ORIGIN\_SZCLSZ01 -0.9061335 0.0098617 -91.884 < 2e-16 \*\*\*  
ORIGIN\_SZCLSZ02 -1.7609479 0.0156124 -112.791 < 2e-16 \*\*\*  
ORIGIN\_SZCLSZ03 -1.0081325 0.0095171 -105.929 < 2e-16 \*\*\*  
ORIGIN\_SZCLSZ04 0.6181200 0.0057953 106.659 < 2e-16 \*\*\*  
ORIGIN\_SZCLSZ05 -2.0462335 0.0168934 -121.127 < 2e-16 \*\*\*  
ORIGIN\_SZCLSZ06 0.7902389 0.0055680 141.924 < 2e-16 \*\*\*  
ORIGIN\_SZCLSZ07 -0.5472929 0.0071001 -77.082 < 2e-16 \*\*\*  
ORIGIN\_SZCLSZ08 -0.2197650 0.0077460 -28.372 < 2e-16 \*\*\*  
ORIGIN\_SZCLSZ09 -1.8175782 0.0195989 -92.739 < 2e-16 \*\*\*  
ORIGIN\_SZDTSZ02 -3.7618796 0.0872098 -43.136 < 2e-16 \*\*\*  
ORIGIN\_SZDTSZ03 -3.4514766 0.0840812 -41.049 < 2e-16 \*\*\*  
ORIGIN\_SZDTSZ13 -3.0627578 0.0352485 -86.891 < 2e-16 \*\*\*  
ORIGIN\_SZGLSZ01 -1.8055929 0.0111938 -161.303 < 2e-16 \*\*\*  
ORIGIN\_SZGLSZ02 -0.1588829 0.0061413 -25.871 < 2e-16 \*\*\*  
ORIGIN\_SZGLSZ03 -0.2508524 0.0064276 -39.027 < 2e-16 \*\*\*  
ORIGIN\_SZGLSZ04 0.8819358 0.0051993 169.627 < 2e-16 \*\*\*  
ORIGIN\_SZGLSZ05 0.6062778 0.0053735 112.828 < 2e-16 \*\*\*  
ORIGIN\_SZHGSZ01 0.3841503 0.0056776 67.660 < 2e-16 \*\*\*  
ORIGIN\_SZHGSZ02 0.3962330 0.0057579 68.815 < 2e-16 \*\*\*  
ORIGIN\_SZHGSZ03 0.2159531 0.0061671 35.017 < 2e-16 \*\*\*  
ORIGIN\_SZHGSZ04 0.7831941 0.0052216 149.992 < 2e-16 \*\*\*  
ORIGIN\_SZHGSZ05 1.1741558 0.0051799 226.677 < 2e-16 \*\*\*  
ORIGIN\_SZHGSZ06 -0.1891403 0.0065556 -28.852 < 2e-16 \*\*\*  
ORIGIN\_SZHGSZ07 0.3105421 0.0057186 54.304 < 2e-16 \*\*\*  
ORIGIN\_SZHGSZ08 -0.0766364 0.0063474 -12.074 < 2e-16 \*\*\*  
ORIGIN\_SZHGSZ09 -1.2211107 0.0101434 -120.384 < 2e-16 \*\*\*  
ORIGIN\_SZHGSZ10 -3.4844709 0.0504793 -69.028 < 2e-16 \*\*\*  
ORIGIN\_SZJESZ01 0.4916496 0.0063444 77.493 < 2e-16 \*\*\*  
ORIGIN\_SZJESZ02 0.1343893 0.0063762 21.077 < 2e-16 \*\*\*  
ORIGIN\_SZJESZ03 -0.2761723 0.0068085 -40.563 < 2e-16 \*\*\*  
ORIGIN\_SZJESZ04 -1.5932744 0.0121402 -131.240 < 2e-16 \*\*\*  
ORIGIN\_SZJESZ05 -2.3041311 0.0160245 -143.788 < 2e-16 \*\*\*  
ORIGIN\_SZJESZ06 0.2811076 0.0062495 44.981 < 2e-16 \*\*\*  
ORIGIN\_SZJESZ07 -1.9413956 0.0136276 -142.461 < 2e-16 \*\*\*  
ORIGIN\_SZJESZ08 -1.3315645 0.0143168 -93.007 < 2e-16 \*\*\*  
ORIGIN\_SZJESZ09 0.4418314 0.0069208 63.841 < 2e-16 \*\*\*  
ORIGIN\_SZJESZ10 -1.5551555 0.0236523 -65.751 < 2e-16 \*\*\*  
ORIGIN\_SZJESZ11 -1.8888230 0.0224630 -84.086 < 2e-16 \*\*\*  
ORIGIN\_SZJWSZ01 0.2564586 0.0084699 30.279 < 2e-16 \*\*\*  
ORIGIN\_SZJWSZ02 0.6899398 0.0061751 111.729 < 2e-16 \*\*\*  
ORIGIN\_SZJWSZ03 1.4761229 0.0057392 257.198 < 2e-16 \*\*\*  
ORIGIN\_SZJWSZ04 0.5701272 0.0065749 86.713 < 2e-16 \*\*\*  
ORIGIN\_SZJWSZ05 -2.1253657 0.0150769 -140.968 < 2e-16 \*\*\*  
ORIGIN\_SZJWSZ06 -1.5307265 0.0131906 -116.047 < 2e-16 \*\*\*  
ORIGIN\_SZJWSZ07 -2.8801618 0.0360772 -79.833 < 2e-16 \*\*\*  
ORIGIN\_SZJWSZ08 1.4428820 0.0059638 241.938 < 2e-16 \*\*\*  
ORIGIN\_SZJWSZ09 1.8968475 0.0055649 340.860 < 2e-16 \*\*\*  
ORIGIN\_SZKLSZ01 0.1116580 0.0059844 18.658 < 2e-16 \*\*\*  
ORIGIN\_SZKLSZ02 -0.9618787 0.0077344 -124.364 < 2e-16 \*\*\*  
ORIGIN\_SZKLSZ03 -0.7070626 0.0070275 -100.613 < 2e-16 \*\*\*  
ORIGIN\_SZKLSZ04 -2.2742765 0.0139991 -162.459 < 2e-16 \*\*\*  
ORIGIN\_SZKLSZ05 -1.1907262 0.0123719 -96.244 < 2e-16 \*\*\*  
ORIGIN\_SZKLSZ06 -5.9774897 0.1857994 -32.172 < 2e-16 \*\*\*  
ORIGIN\_SZKLSZ07 -1.4258369 0.0103083 -138.320 < 2e-16 \*\*\*  
ORIGIN\_SZKLSZ08 -1.7625888 0.0116107 -151.808 < 2e-16 \*\*\*  
ORIGIN\_SZLKSZ01 -2.0541388 0.0448216 -45.829 < 2e-16 \*\*\*  
ORIGIN\_SZMDSZ01 -0.8571117 0.0321054 -26.697 < 2e-16 \*\*\*  
ORIGIN\_SZMDSZ02 -0.6034597 0.0120724 -49.987 < 2e-16 \*\*\*  
ORIGIN\_SZMDSZ03 -2.1681163 0.0201078 -107.825 < 2e-16 \*\*\*  
ORIGIN\_SZMPSZ01 -0.9331562 0.0096218 -96.984 < 2e-16 \*\*\*  
ORIGIN\_SZMPSZ02 -1.0268229 0.0081379 -126.178 < 2e-16 \*\*\*  
ORIGIN\_SZMPSZ03 0.0054001 0.0066875 0.807 0.419385   
ORIGIN\_SZMUSZ02 -3.6269863 0.1105492 -32.809 < 2e-16 \*\*\*  
ORIGIN\_SZNTSZ01 -3.0593717 0.0399843 -76.514 < 2e-16 \*\*\*  
ORIGIN\_SZNTSZ02 -3.3331415 0.0251754 -132.397 < 2e-16 \*\*\*  
ORIGIN\_SZNTSZ03 -0.8351522 0.0090372 -92.413 < 2e-16 \*\*\*  
ORIGIN\_SZNTSZ05 -4.2082472 0.0583343 -72.140 < 2e-16 \*\*\*  
ORIGIN\_SZNTSZ06 -3.8549296 0.0593793 -64.920 < 2e-16 \*\*\*  
ORIGIN\_SZNVSZ01 0.2789069 0.0056024 49.784 < 2e-16 \*\*\*  
ORIGIN\_SZNVSZ02 -0.6036857 0.0077126 -78.273 < 2e-16 \*\*\*  
ORIGIN\_SZNVSZ03 -1.0072683 0.0092678 -108.685 < 2e-16 \*\*\*  
ORIGIN\_SZNVSZ04 -0.8723996 0.0101399 -86.037 < 2e-16 \*\*\*  
ORIGIN\_SZNVSZ05 -2.1552928 0.0183064 -117.734 < 2e-16 \*\*\*  
ORIGIN\_SZPGSZ01 0.0520607 0.0157846 3.298 0.000973 \*\*\*  
ORIGIN\_SZPGSZ02 -0.3481687 0.0089328 -38.976 < 2e-16 \*\*\*  
ORIGIN\_SZPGSZ03 0.9095292 0.0058835 154.590 < 2e-16 \*\*\*  
ORIGIN\_SZPGSZ04 1.3653717 0.0054727 249.489 < 2e-16 \*\*\*  
ORIGIN\_SZPGSZ05 0.3762720 0.0073841 50.957 < 2e-16 \*\*\*  
ORIGIN\_SZPLSZ01 -0.9142754 0.0136552 -66.954 < 2e-16 \*\*\*  
ORIGIN\_SZPLSZ02 -1.0987582 0.0175891 -62.468 < 2e-16 \*\*\*  
ORIGIN\_SZPLSZ03 -2.3427113 0.0474176 -49.406 < 2e-16 \*\*\*  
ORIGIN\_SZPLSZ04 -2.9140779 0.0374458 -77.821 < 2e-16 \*\*\*  
ORIGIN\_SZPLSZ05 -2.2381965 0.0261572 -85.567 < 2e-16 \*\*\*  
ORIGIN\_SZPNSZ01 0.9659006 0.0075177 128.484 < 2e-16 \*\*\*  
ORIGIN\_SZPNSZ02 -0.0158348 0.0143869 -1.101 0.271053   
ORIGIN\_SZPNSZ03 -2.1837321 0.0224396 -97.316 < 2e-16 \*\*\*  
ORIGIN\_SZPNSZ04 -3.2481509 0.0370762 -87.608 < 2e-16 \*\*\*  
ORIGIN\_SZPNSZ05 -2.0450679 0.0328165 -62.318 < 2e-16 \*\*\*  
ORIGIN\_SZPRSZ01 -0.6701245 0.0141567 -47.336 < 2e-16 \*\*\*  
ORIGIN\_SZPRSZ02 0.7931907 0.0058079 136.570 < 2e-16 \*\*\*  
ORIGIN\_SZPRSZ03 0.4249094 0.0058610 72.498 < 2e-16 \*\*\*  
ORIGIN\_SZPRSZ04 -0.8529967 0.0090997 -93.739 < 2e-16 \*\*\*  
ORIGIN\_SZPRSZ05 0.7865479 0.0055282 142.278 < 2e-16 \*\*\*  
ORIGIN\_SZPRSZ06 -1.3303664 0.0134512 -98.903 < 2e-16 \*\*\*  
ORIGIN\_SZPRSZ07 -3.0458370 0.0181514 -167.802 < 2e-16 \*\*\*  
ORIGIN\_SZPRSZ08 -0.5342399 0.0075966 -70.327 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ01 -0.2548930 0.0086485 -29.473 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ02 -0.8662439 0.0076549 -113.162 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ03 -0.0890168 0.0072455 -12.286 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ04 -1.4634370 0.0089384 -163.724 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ05 -0.6535669 0.0077612 -84.210 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ06 -0.8275765 0.0081835 -101.128 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ07 -1.5369800 0.0112808 -136.248 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ08 -0.4437979 0.0075302 -58.936 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ09 -0.8184934 0.0083589 -97.918 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ10 -0.6906597 0.0080980 -85.288 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ11 -2.3251162 0.0154191 -150.795 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ12 -3.0442790 0.0208985 -145.670 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ13 -0.7241013 0.0093441 -77.493 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ14 -1.8225351 0.0138207 -131.870 < 2e-16 \*\*\*  
ORIGIN\_SZQTSZ15 -0.8720806 0.0138589 -62.926 < 2e-16 \*\*\*  
ORIGIN\_SZRCSZ01 -1.8063415 0.0144295 -125.184 < 2e-16 \*\*\*  
ORIGIN\_SZRCSZ06 -0.5370905 0.0101573 -52.877 < 2e-16 \*\*\*  
ORIGIN\_SZRVSZ01 -2.7426167 0.0341386 -80.338 < 2e-16 \*\*\*  
ORIGIN\_SZRVSZ02 -3.0827269 0.0302299 -101.976 < 2e-16 \*\*\*  
ORIGIN\_SZRVSZ03 -2.9133853 0.0262543 -110.968 < 2e-16 \*\*\*  
ORIGIN\_SZRVSZ04 -3.4220022 0.0582209 -58.776 < 2e-16 \*\*\*  
ORIGIN\_SZRVSZ05 -2.6206257 0.0197470 -132.710 < 2e-16 \*\*\*  
ORIGIN\_SZSBSZ01 0.1010337 0.0085117 11.870 < 2e-16 \*\*\*  
ORIGIN\_SZSBSZ02 -0.8810456 0.0098244 -89.680 < 2e-16 \*\*\*  
ORIGIN\_SZSBSZ03 0.8303668 0.0063009 131.785 < 2e-16 \*\*\*  
ORIGIN\_SZSBSZ04 0.3489128 0.0071456 48.829 < 2e-16 \*\*\*  
ORIGIN\_SZSBSZ05 -0.3182914 0.0085560 -37.201 < 2e-16 \*\*\*  
ORIGIN\_SZSBSZ06 -0.9074308 0.0200035 -45.364 < 2e-16 \*\*\*  
ORIGIN\_SZSBSZ07 -0.2217124 0.0167188 -13.261 < 2e-16 \*\*\*  
ORIGIN\_SZSBSZ08 -1.3007367 0.0178771 -72.760 < 2e-16 \*\*\*  
ORIGIN\_SZSBSZ09 -0.9813703 0.0107885 -90.965 < 2e-16 \*\*\*  
ORIGIN\_SZSESZ02 1.1283424 0.0054209 208.146 < 2e-16 \*\*\*  
ORIGIN\_SZSESZ03 1.2389996 0.0051926 238.610 < 2e-16 \*\*\*  
ORIGIN\_SZSESZ04 0.7535119 0.0060371 124.814 < 2e-16 \*\*\*  
ORIGIN\_SZSESZ05 -0.2347978 0.0071482 -32.847 < 2e-16 \*\*\*  
ORIGIN\_SZSESZ06 0.9520620 0.0057572 165.368 < 2e-16 \*\*\*  
ORIGIN\_SZSESZ07 -2.4296685 0.0231677 -104.873 < 2e-16 \*\*\*  
ORIGIN\_SZSGSZ01 -0.6995899 0.0099969 -69.980 < 2e-16 \*\*\*  
ORIGIN\_SZSGSZ02 -1.2602157 0.0111471 -113.053 < 2e-16 \*\*\*  
ORIGIN\_SZSGSZ03 0.0725860 0.0061970 11.713 < 2e-16 \*\*\*  
ORIGIN\_SZSGSZ04 0.2738315 0.0057524 47.603 < 2e-16 \*\*\*  
ORIGIN\_SZSGSZ05 -2.0207710 0.0119838 -168.625 < 2e-16 \*\*\*  
ORIGIN\_SZSGSZ06 0.4885608 0.0054646 89.404 < 2e-16 \*\*\*  
ORIGIN\_SZSGSZ07 -0.8892155 0.0075074 -118.445 < 2e-16 \*\*\*  
ORIGIN\_SZSKSZ01 -0.3682754 0.0108025 -34.092 < 2e-16 \*\*\*  
ORIGIN\_SZSKSZ02 1.1826086 0.0071388 165.659 < 2e-16 \*\*\*  
ORIGIN\_SZSKSZ03 -0.3230177 0.0101683 -31.767 < 2e-16 \*\*\*  
ORIGIN\_SZSKSZ04 -1.8504236 0.0362400 -51.060 < 2e-16 \*\*\*  
ORIGIN\_SZSKSZ05 -0.2759035 0.0185157 -14.901 < 2e-16 \*\*\*  
ORIGIN\_SZSLSZ01 -2.2757902 0.0348766 -65.253 < 2e-16 \*\*\*  
ORIGIN\_SZSLSZ04 -0.0899820 0.0090356 -9.959 < 2e-16 \*\*\*  
ORIGIN\_SZSRSZ01 -2.1460151 0.0187871 -114.228 < 2e-16 \*\*\*  
ORIGIN\_SZTHSZ01 -2.6851549 0.0571841 -46.956 < 2e-16 \*\*\*  
ORIGIN\_SZTHSZ03 -1.0121495 0.0275551 -36.732 < 2e-16 \*\*\*  
ORIGIN\_SZTHSZ04 -2.6129645 0.0345167 -75.701 < 2e-16 \*\*\*  
ORIGIN\_SZTHSZ06 -1.7229100 0.0208134 -82.779 < 2e-16 \*\*\*  
ORIGIN\_SZTMSZ01 -0.2254986 0.0070312 -32.071 < 2e-16 \*\*\*  
ORIGIN\_SZTMSZ02 1.7271575 0.0049219 350.914 < 2e-16 \*\*\*  
ORIGIN\_SZTMSZ03 0.9891319 0.0052266 189.250 < 2e-16 \*\*\*  
ORIGIN\_SZTMSZ04 0.2018090 0.0062114 32.490 < 2e-16 \*\*\*  
ORIGIN\_SZTMSZ05 -1.1882870 0.0125842 -94.427 < 2e-16 \*\*\*  
ORIGIN\_SZTNSZ01 -1.6122620 0.0141911 -113.611 < 2e-16 \*\*\*  
ORIGIN\_SZTNSZ02 -1.5630967 0.0112227 -139.280 < 2e-16 \*\*\*  
ORIGIN\_SZTNSZ03 -2.0739538 0.0149298 -138.914 < 2e-16 \*\*\*  
ORIGIN\_SZTNSZ04 -0.2816960 0.0085295 -33.026 < 2e-16 \*\*\*  
ORIGIN\_SZTPSZ01 -0.7822239 0.0077901 -100.412 < 2e-16 \*\*\*  
ORIGIN\_SZTPSZ02 0.5735478 0.0053042 108.131 < 2e-16 \*\*\*  
ORIGIN\_SZTPSZ03 -0.8748650 0.0074202 -117.903 < 2e-16 \*\*\*  
ORIGIN\_SZTPSZ04 -0.8537831 0.0069792 -122.332 < 2e-16 \*\*\*  
ORIGIN\_SZTPSZ05 -0.5581114 0.0077012 -72.471 < 2e-16 \*\*\*  
ORIGIN\_SZTPSZ06 0.0262001 0.0075241 3.482 0.000497 \*\*\*  
ORIGIN\_SZTPSZ07 -0.5969952 0.0074272 -80.380 < 2e-16 \*\*\*  
ORIGIN\_SZTPSZ08 -1.0537959 0.0111297 -94.683 < 2e-16 \*\*\*  
ORIGIN\_SZTPSZ09 -0.9588508 0.0081314 -117.920 < 2e-16 \*\*\*  
ORIGIN\_SZTPSZ10 -1.1177249 0.0089403 -125.021 < 2e-16 \*\*\*  
ORIGIN\_SZTPSZ11 -0.2799677 0.0067135 -41.702 < 2e-16 \*\*\*  
ORIGIN\_SZTPSZ12 -0.8898871 0.0080215 -110.938 < 2e-16 \*\*\*  
ORIGIN\_SZTSSZ01 -2.6146463 0.0521606 -50.127 < 2e-16 \*\*\*  
ORIGIN\_SZTSSZ02 0.1682588 0.0119965 14.026 < 2e-16 \*\*\*  
ORIGIN\_SZTSSZ03 0.2587653 0.0123809 20.900 < 2e-16 \*\*\*  
ORIGIN\_SZTSSZ04 -0.5473825 0.0135215 -40.482 < 2e-16 \*\*\*  
ORIGIN\_SZTSSZ05 -0.9967379 0.0206068 -48.369 < 2e-16 \*\*\*  
ORIGIN\_SZTSSZ06 0.4933147 0.0229597 21.486 < 2e-16 \*\*\*  
ORIGIN\_SZWCSZ01 1.2524706 0.0111133 112.700 < 2e-16 \*\*\*  
ORIGIN\_SZWCSZ02 -2.8544820 0.0347805 -82.071 < 2e-16 \*\*\*  
ORIGIN\_SZWCSZ03 -5.1277334 0.1475585 -34.751 < 2e-16 \*\*\*  
ORIGIN\_SZWDSZ01 1.4725308 0.0056496 260.645 < 2e-16 \*\*\*  
ORIGIN\_SZWDSZ02 0.1571680 0.0064909 24.214 < 2e-16 \*\*\*  
ORIGIN\_SZWDSZ03 1.2584097 0.0061471 204.717 < 2e-16 \*\*\*  
ORIGIN\_SZWDSZ04 0.8578765 0.0069277 123.833 < 2e-16 \*\*\*  
ORIGIN\_SZWDSZ05 0.1702728 0.0069687 24.434 < 2e-16 \*\*\*  
ORIGIN\_SZWDSZ06 0.1736910 0.0069507 24.989 < 2e-16 \*\*\*  
ORIGIN\_SZWDSZ07 -1.5610176 0.0100803 -154.859 < 2e-16 \*\*\*  
ORIGIN\_SZWDSZ08 -0.9490906 0.0102047 -93.005 < 2e-16 \*\*\*  
ORIGIN\_SZWDSZ09 1.2107011 0.0062294 194.354 < 2e-16 \*\*\*  
ORIGIN\_SZYSSZ01 -0.3324158 0.0074537 -44.598 < 2e-16 \*\*\*  
ORIGIN\_SZYSSZ02 0.8177113 0.0066108 123.693 < 2e-16 \*\*\*  
ORIGIN\_SZYSSZ03 1.6751777 0.0058470 286.503 < 2e-16 \*\*\*  
ORIGIN\_SZYSSZ04 0.8130044 0.0059025 137.738 < 2e-16 \*\*\*  
ORIGIN\_SZYSSZ05 0.3678420 0.0072431 50.785 < 2e-16 \*\*\*  
ORIGIN\_SZYSSZ06 -0.6024384 0.0126722 -47.540 < 2e-16 \*\*\*  
ORIGIN\_SZYSSZ07 -0.7631918 0.0158478 -48.157 < 2e-16 \*\*\*  
ORIGIN\_SZYSSZ08 0.2141930 0.0076154 28.126 < 2e-16 \*\*\*  
ORIGIN\_SZYSSZ09 1.0809368 0.0057973 186.457 < 2e-16 \*\*\*  
DESTIN\_SZAMSZ02 0.0761304 0.0051207 14.867 < 2e-16 \*\*\*  
DESTIN\_SZAMSZ03 0.0143394 0.0050755 2.825 0.004724 \*\*   
DESTIN\_SZAMSZ04 -1.2516780 0.0074947 -167.008 < 2e-16 \*\*\*  
DESTIN\_SZAMSZ05 -1.2312375 0.0076598 -160.741 < 2e-16 \*\*\*  
DESTIN\_SZAMSZ06 -1.0333412 0.0075283 -137.261 < 2e-16 \*\*\*  
DESTIN\_SZAMSZ07 -1.5338249 0.0110036 -139.392 < 2e-16 \*\*\*  
DESTIN\_SZAMSZ08 -0.3751665 0.0075358 -49.784 < 2e-16 \*\*\*  
DESTIN\_SZAMSZ09 -1.1633493 0.0077556 -150.001 < 2e-16 \*\*\*  
DESTIN\_SZAMSZ10 0.1017717 0.0053151 19.148 < 2e-16 \*\*\*  
DESTIN\_SZAMSZ11 -0.8840362 0.0097007 -91.131 < 2e-16 \*\*\*  
DESTIN\_SZAMSZ12 0.1628123 0.0055220 29.484 < 2e-16 \*\*\*  
DESTIN\_SZBDSZ01 1.0040794 0.0047922 209.523 < 2e-16 \*\*\*  
DESTIN\_SZBDSZ02 -0.2478149 0.0063085 -39.283 < 2e-16 \*\*\*  
DESTIN\_SZBDSZ03 0.1016088 0.0057420 17.696 < 2e-16 \*\*\*  
DESTIN\_SZBDSZ04 1.1082928 0.0047747 232.116 < 2e-16 \*\*\*  
DESTIN\_SZBDSZ05 0.8737933 0.0050593 172.712 < 2e-16 \*\*\*  
DESTIN\_SZBDSZ06 0.2897032 0.0058244 49.740 < 2e-16 \*\*\*  
DESTIN\_SZBDSZ07 -0.9026193 0.0113656 -79.416 < 2e-16 \*\*\*  
DESTIN\_SZBDSZ08 -1.7063577 0.0131234 -130.024 < 2e-16 \*\*\*  
DESTIN\_SZBKSZ01 -1.3892839 0.0083307 -166.767 < 2e-16 \*\*\*  
DESTIN\_SZBKSZ02 -0.6661120 0.0073464 -90.672 < 2e-16 \*\*\*  
DESTIN\_SZBKSZ03 -0.9536826 0.0073196 -130.292 < 2e-16 \*\*\*  
DESTIN\_SZBKSZ04 -0.6655610 0.0065868 -101.044 < 2e-16 \*\*\*  
DESTIN\_SZBKSZ05 -0.9053119 0.0079264 -114.215 < 2e-16 \*\*\*  
DESTIN\_SZBKSZ06 -1.2622159 0.0075079 -168.119 < 2e-16 \*\*\*  
DESTIN\_SZBKSZ07 -0.0423370 0.0056686 -7.469 8.10e-14 \*\*\*  
DESTIN\_SZBKSZ08 -1.3811240 0.0084985 -162.515 < 2e-16 \*\*\*  
DESTIN\_SZBKSZ09 -0.0797012 0.0061428 -12.975 < 2e-16 \*\*\*  
DESTIN\_SZBLSZ01 -0.8859670 0.0088108 -100.555 < 2e-16 \*\*\*  
DESTIN\_SZBLSZ02 0.1362723 0.0082167 16.585 < 2e-16 \*\*\*  
DESTIN\_SZBLSZ03 1.2037396 0.0093508 128.732 < 2e-16 \*\*\*  
DESTIN\_SZBLSZ04 -0.9316219 0.0178080 -52.315 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ01 0.7188470 0.0061160 117.536 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ02 -0.0597895 0.0061206 -9.769 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ03 -0.2427075 0.0069937 -34.704 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ04 -0.0622494 0.0065569 -9.494 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ05 -0.2857019 0.0086450 -33.048 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ06 -1.3486558 0.0158904 -84.872 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ07 0.4549687 0.0058315 78.020 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ08 -0.8730268 0.0077814 -112.195 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ09 -2.0319890 0.0163038 -124.633 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ10 -1.4319101 0.0102616 -139.541 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ11 -1.2429176 0.0092250 -134.733 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ12 -0.8526549 0.0096009 -88.810 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ13 0.1399907 0.0066885 20.930 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ14 -1.0103155 0.0091377 -110.566 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ15 -0.6819769 0.0086179 -79.135 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ16 -1.4468308 0.0134051 -107.931 < 2e-16 \*\*\*  
DESTIN\_SZBMSZ17 -1.5312175 0.0186843 -81.952 < 2e-16 \*\*\*  
DESTIN\_SZBPSZ01 -1.1726725 0.0073257 -160.077 < 2e-16 \*\*\*  
DESTIN\_SZBPSZ02 -2.1072012 0.0103320 -203.949 < 2e-16 \*\*\*  
DESTIN\_SZBPSZ03 -1.6944911 0.0098520 -171.995 < 2e-16 \*\*\*  
DESTIN\_SZBPSZ04 -0.7664610 0.0074458 -102.939 < 2e-16 \*\*\*  
DESTIN\_SZBPSZ05 0.1358370 0.0056258 24.145 < 2e-16 \*\*\*  
DESTIN\_SZBPSZ06 -1.2425471 0.0096942 -128.175 < 2e-16 \*\*\*  
DESTIN\_SZBPSZ07 -0.1666192 0.0094969 -17.545 < 2e-16 \*\*\*  
DESTIN\_SZBSSZ01 0.3857894 0.0057261 67.374 < 2e-16 \*\*\*  
DESTIN\_SZBSSZ02 -0.5293265 0.0064886 -81.578 < 2e-16 \*\*\*  
DESTIN\_SZBSSZ03 0.3909966 0.0048540 80.551 < 2e-16 \*\*\*  
DESTIN\_SZBTSZ01 0.7114965 0.0054528 130.482 < 2e-16 \*\*\*  
DESTIN\_SZBTSZ02 -0.0487084 0.0082474 -5.906 3.51e-09 \*\*\*  
DESTIN\_SZBTSZ03 0.5539032 0.0064423 85.979 < 2e-16 \*\*\*  
DESTIN\_SZBTSZ04 -0.7120734 0.0128676 -55.339 < 2e-16 \*\*\*  
DESTIN\_SZBTSZ05 0.2176097 0.0086791 25.073 < 2e-16 \*\*\*  
DESTIN\_SZBTSZ06 -0.2167084 0.0084925 -25.518 < 2e-16 \*\*\*  
DESTIN\_SZBTSZ07 -1.4045618 0.0124363 -112.940 < 2e-16 \*\*\*  
DESTIN\_SZBTSZ08 -0.8213918 0.0120793 -68.000 < 2e-16 \*\*\*  
DESTIN\_SZCBSZ01 -5.7340877 0.3333916 -17.199 < 2e-16 \*\*\*  
DESTIN\_SZCCSZ01 -0.0304192 0.0095920 -3.171 0.001518 \*\*   
DESTIN\_SZCHSZ01 -0.2598507 0.0115311 -22.535 < 2e-16 \*\*\*  
DESTIN\_SZCHSZ02 0.3497750 0.0068334 51.186 < 2e-16 \*\*\*  
DESTIN\_SZCHSZ03 2.4550172 0.0050883 482.481 < 2e-16 \*\*\*  
DESTIN\_SZCKSZ01 -0.4691744 0.0063130 -74.319 < 2e-16 \*\*\*  
DESTIN\_SZCKSZ02 -0.9557084 0.0069331 -137.847 < 2e-16 \*\*\*  
DESTIN\_SZCKSZ03 0.0442112 0.0057117 7.740 9.91e-15 \*\*\*  
DESTIN\_SZCKSZ04 -0.8592063 0.0081238 -105.764 < 2e-16 \*\*\*  
DESTIN\_SZCKSZ05 -1.1745333 0.0087305 -134.532 < 2e-16 \*\*\*  
DESTIN\_SZCKSZ06 -0.4982877 0.0085514 -58.269 < 2e-16 \*\*\*  
DESTIN\_SZCLSZ01 0.2665065 0.0059712 44.632 < 2e-16 \*\*\*  
DESTIN\_SZCLSZ02 -1.9758876 0.0150823 -131.007 < 2e-16 \*\*\*  
DESTIN\_SZCLSZ03 -0.9051310 0.0091479 -98.944 < 2e-16 \*\*\*  
DESTIN\_SZCLSZ04 -0.0828732 0.0061559 -13.462 < 2e-16 \*\*\*  
DESTIN\_SZCLSZ05 -1.1414780 0.0100760 -113.287 < 2e-16 \*\*\*  
DESTIN\_SZCLSZ06 0.3229402 0.0056269 57.392 < 2e-16 \*\*\*  
DESTIN\_SZCLSZ07 -0.4833612 0.0069777 -69.272 < 2e-16 \*\*\*  
DESTIN\_SZCLSZ08 -0.3219670 0.0075615 -42.580 < 2e-16 \*\*\*  
DESTIN\_SZCLSZ09 0.0564166 0.0080703 6.991 2.74e-12 \*\*\*  
DESTIN\_SZDTSZ02 -1.6384236 0.0374725 -43.723 < 2e-16 \*\*\*  
DESTIN\_SZDTSZ03 -0.4021571 0.0152716 -26.334 < 2e-16 \*\*\*  
DESTIN\_SZDTSZ13 -1.2799441 0.0177095 -72.274 < 2e-16 \*\*\*  
DESTIN\_SZGLSZ01 -0.0190303 0.0060665 -3.137 0.001707 \*\*   
DESTIN\_SZGLSZ02 -0.0308469 0.0058724 -5.253 1.50e-07 \*\*\*  
DESTIN\_SZGLSZ03 0.6927638 0.0048456 142.969 < 2e-16 \*\*\*  
DESTIN\_SZGLSZ04 0.9325848 0.0049183 189.616 < 2e-16 \*\*\*  
DESTIN\_SZGLSZ05 0.8480056 0.0048801 173.768 < 2e-16 \*\*\*  
DESTIN\_SZHGSZ01 0.0652969 0.0047795 13.662 < 2e-16 \*\*\*  
DESTIN\_SZHGSZ02 -0.9498251 0.0066577 -142.667 < 2e-16 \*\*\*  
DESTIN\_SZHGSZ03 -1.4372499 0.0076387 -188.154 < 2e-16 \*\*\*  
DESTIN\_SZHGSZ04 -0.5236292 0.0055353 -94.599 < 2e-16 \*\*\*  
DESTIN\_SZHGSZ05 -0.5420295 0.0058099 -93.295 < 2e-16 \*\*\*  
DESTIN\_SZHGSZ06 -0.9054730 0.0067581 -133.983 < 2e-16 \*\*\*  
DESTIN\_SZHGSZ07 0.0215109 0.0054019 3.982 6.83e-05 \*\*\*  
DESTIN\_SZHGSZ08 -0.0490979 0.0059206 -8.293 < 2e-16 \*\*\*  
DESTIN\_SZHGSZ09 -0.0711560 0.0062875 -11.317 < 2e-16 \*\*\*  
DESTIN\_SZHGSZ10 -3.5807154 0.0290642 -123.200 < 2e-16 \*\*\*  
DESTIN\_SZJESZ01 -0.4023638 0.0065057 -61.848 < 2e-16 \*\*\*  
DESTIN\_SZJESZ02 -0.7654353 0.0067096 -114.081 < 2e-16 \*\*\*  
DESTIN\_SZJESZ03 -0.8778812 0.0071238 -123.232 < 2e-16 \*\*\*  
DESTIN\_SZJESZ04 -1.1998075 0.0088733 -135.215 < 2e-16 \*\*\*  
DESTIN\_SZJESZ05 -1.5623652 0.0116898 -133.652 < 2e-16 \*\*\*  
DESTIN\_SZJESZ06 0.2311474 0.0055595 41.577 < 2e-16 \*\*\*  
DESTIN\_SZJESZ07 -1.2753348 0.0094838 -134.475 < 2e-16 \*\*\*  
DESTIN\_SZJESZ08 -0.7654533 0.0099306 -77.081 < 2e-16 \*\*\*  
DESTIN\_SZJESZ09 0.1637628 0.0074164 22.081 < 2e-16 \*\*\*  
DESTIN\_SZJESZ10 0.7394958 0.0091249 81.041 < 2e-16 \*\*\*  
DESTIN\_SZJESZ11 0.5157364 0.0086546 59.591 < 2e-16 \*\*\*  
DESTIN\_SZJWSZ01 -1.0165204 0.0083025 -122.435 < 2e-16 \*\*\*  
DESTIN\_SZJWSZ02 -0.8530646 0.0067851 -125.727 < 2e-16 \*\*\*  
DESTIN\_SZJWSZ03 0.5176135 0.0056449 91.695 < 2e-16 \*\*\*  
DESTIN\_SZJWSZ04 0.3427105 0.0058499 58.584 < 2e-16 \*\*\*  
DESTIN\_SZJWSZ05 -1.1695940 0.0080069 -146.073 < 2e-16 \*\*\*  
DESTIN\_SZJWSZ06 -0.7466462 0.0070240 -106.299 < 2e-16 \*\*\*  
DESTIN\_SZJWSZ07 -3.0124535 0.0333481 -90.334 < 2e-16 \*\*\*  
DESTIN\_SZJWSZ08 -0.4253502 0.0066584 -63.881 < 2e-16 \*\*\*  
DESTIN\_SZJWSZ09 0.9428005 0.0053190 177.251 < 2e-16 \*\*\*  
DESTIN\_SZKLSZ01 -0.2965013 0.0066422 -44.639 < 2e-16 \*\*\*  
DESTIN\_SZKLSZ02 -0.4921137 0.0067689 -72.702 < 2e-16 \*\*\*  
DESTIN\_SZKLSZ03 -0.8489213 0.0078294 -108.427 < 2e-16 \*\*\*  
DESTIN\_SZKLSZ04 -1.2656342 0.0099918 -126.667 < 2e-16 \*\*\*  
DESTIN\_SZKLSZ05 -0.3570126 0.0096300 -37.073 < 2e-16 \*\*\*  
DESTIN\_SZKLSZ06 -2.4764906 0.0390868 -63.359 < 2e-16 \*\*\*  
DESTIN\_SZKLSZ07 -0.7316189 0.0080994 -90.330 < 2e-16 \*\*\*  
DESTIN\_SZKLSZ08 -0.1115398 0.0061168 -18.235 < 2e-16 \*\*\*  
DESTIN\_SZLKSZ01 -1.4940710 0.0271518 -55.027 < 2e-16 \*\*\*  
DESTIN\_SZMDSZ01 -1.6101440 0.0231238 -69.631 < 2e-16 \*\*\*  
DESTIN\_SZMDSZ02 -0.9339318 0.0126277 -73.959 < 2e-16 \*\*\*  
DESTIN\_SZMDSZ03 -3.4868547 0.0303657 -114.829 < 2e-16 \*\*\*  
DESTIN\_SZMPSZ01 -0.4518483 0.0089869 -50.279 < 2e-16 \*\*\*  
DESTIN\_SZMPSZ02 -0.5868264 0.0073193 -80.176 < 2e-16 \*\*\*  
DESTIN\_SZMPSZ03 0.4805365 0.0059041 81.391 < 2e-16 \*\*\*  
DESTIN\_SZMUSZ02 -1.3837581 0.0218713 -63.268 < 2e-16 \*\*\*  
DESTIN\_SZNTSZ01 -3.0694691 0.0533346 -57.551 < 2e-16 \*\*\*  
DESTIN\_SZNTSZ02 -1.4992973 0.0130358 -115.014 < 2e-16 \*\*\*  
DESTIN\_SZNTSZ03 -0.5221236 0.0089923 -58.064 < 2e-16 \*\*\*  
DESTIN\_SZNTSZ05 -1.9751162 0.0282369 -69.948 < 2e-16 \*\*\*  
DESTIN\_SZNTSZ06 -3.9959411 0.0511214 -78.166 < 2e-16 \*\*\*  
DESTIN\_SZNVSZ01 -0.1126966 0.0057077 -19.745 < 2e-16 \*\*\*  
DESTIN\_SZNVSZ02 -0.0259250 0.0064427 -4.024 5.72e-05 \*\*\*  
DESTIN\_SZNVSZ03 -0.0123214 0.0067692 -1.820 0.068725 .   
DESTIN\_SZNVSZ04 -1.3371298 0.0130261 -102.650 < 2e-16 \*\*\*  
DESTIN\_SZNVSZ05 -0.9686333 0.0101539 -95.395 < 2e-16 \*\*\*  
DESTIN\_SZPGSZ01 -1.1798309 0.0180543 -65.349 < 2e-16 \*\*\*  
DESTIN\_SZPGSZ02 -1.3289737 0.0085335 -155.736 < 2e-16 \*\*\*  
DESTIN\_SZPGSZ03 -0.1661373 0.0055166 -30.116 < 2e-16 \*\*\*  
DESTIN\_SZPGSZ04 -0.3046408 0.0058469 -52.103 < 2e-16 \*\*\*  
DESTIN\_SZPGSZ05 -1.5412612 0.0093261 -165.264 < 2e-16 \*\*\*  
DESTIN\_SZPLSZ01 -0.3439667 0.0083504 -41.192 < 2e-16 \*\*\*  
DESTIN\_SZPLSZ02 -1.7574919 0.0154244 -113.942 < 2e-16 \*\*\*  
DESTIN\_SZPLSZ03 -0.3455776 0.0112089 -30.831 < 2e-16 \*\*\*  
DESTIN\_SZPLSZ04 -2.0749385 0.0141153 -146.999 < 2e-16 \*\*\*  
DESTIN\_SZPLSZ05 -0.4855216 0.0134069 -36.214 < 2e-16 \*\*\*  
DESTIN\_SZPNSZ01 0.0117816 0.0083558 1.410 0.158543   
DESTIN\_SZPNSZ02 0.7389858 0.0089823 82.272 < 2e-16 \*\*\*  
DESTIN\_SZPNSZ03 -0.4708719 0.0098588 -47.761 < 2e-16 \*\*\*  
DESTIN\_SZPNSZ04 1.3156771 0.0111200 118.316 < 2e-16 \*\*\*  
DESTIN\_SZPNSZ05 0.9881886 0.0153169 64.516 < 2e-16 \*\*\*  
DESTIN\_SZPRSZ01 -1.0678999 0.0098295 -108.642 < 2e-16 \*\*\*  
DESTIN\_SZPRSZ02 0.0650279 0.0063927 10.172 < 2e-16 \*\*\*  
DESTIN\_SZPRSZ03 0.6348138 0.0050147 126.592 < 2e-16 \*\*\*  
DESTIN\_SZPRSZ04 -0.3640286 0.0097572 -37.309 < 2e-16 \*\*\*  
DESTIN\_SZPRSZ05 0.0380410 0.0062577 6.079 1.21e-09 \*\*\*  
DESTIN\_SZPRSZ06 0.3153712 0.0068742 45.877 < 2e-16 \*\*\*  
DESTIN\_SZPRSZ07 -1.6669973 0.0145573 -114.513 < 2e-16 \*\*\*  
DESTIN\_SZPRSZ08 -0.6170648 0.0078424 -78.683 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ01 -0.5496582 0.0098285 -55.925 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ02 -0.7318114 0.0086807 -84.303 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ03 -0.5893064 0.0084789 -69.503 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ04 -0.7103906 0.0085341 -83.242 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ05 -0.4721472 0.0078164 -60.405 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ06 -0.6591466 0.0080069 -82.322 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ07 -0.9540454 0.0126807 -75.236 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ08 0.4508867 0.0064870 69.507 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ09 -0.4061810 0.0075485 -53.810 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ10 0.1351889 0.0068202 19.822 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ11 0.3181553 0.0067958 46.816 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ12 -0.1055766 0.0095576 -11.046 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ13 0.5199663 0.0071928 72.290 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ14 0.6086332 0.0078537 77.496 < 2e-16 \*\*\*  
DESTIN\_SZQTSZ15 1.3906866 0.0092250 150.753 < 2e-16 \*\*\*  
DESTIN\_SZRCSZ01 -0.0862091 0.0085363 -10.099 < 2e-16 \*\*\*  
DESTIN\_SZRCSZ06 -1.0186282 0.0211113 -48.250 < 2e-16 \*\*\*  
DESTIN\_SZRVSZ01 -1.5294454 0.0179337 -85.283 < 2e-16 \*\*\*  
DESTIN\_SZRVSZ02 -2.3607754 0.0355628 -66.383 < 2e-16 \*\*\*  
DESTIN\_SZRVSZ03 -1.5266254 0.0156276 -97.688 < 2e-16 \*\*\*  
DESTIN\_SZRVSZ04 -1.0986565 0.0168695 -65.127 < 2e-16 \*\*\*  
DESTIN\_SZRVSZ05 -2.4004418 0.0320917 -74.799 < 2e-16 \*\*\*  
DESTIN\_SZSBSZ01 -1.4023966 0.0109496 -128.078 < 2e-16 \*\*\*  
DESTIN\_SZSBSZ02 -1.3899893 0.0090891 -152.929 < 2e-16 \*\*\*  
DESTIN\_SZSBSZ03 0.4509008 0.0059864 75.321 < 2e-16 \*\*\*  
DESTIN\_SZSBSZ04 0.1796309 0.0070142 25.610 < 2e-16 \*\*\*  
DESTIN\_SZSBSZ05 -1.3159699 0.0096485 -136.391 < 2e-16 \*\*\*  
DESTIN\_SZSBSZ06 -1.7705263 0.0253064 -69.964 < 2e-16 \*\*\*  
DESTIN\_SZSBSZ07 -0.7471529 0.0238628 -31.310 < 2e-16 \*\*\*  
DESTIN\_SZSBSZ08 0.7884520 0.0069638 113.221 < 2e-16 \*\*\*  
DESTIN\_SZSBSZ09 0.0131702 0.0066350 1.985 0.047150 \*   
DESTIN\_SZSESZ02 -0.7247347 0.0060626 -119.541 < 2e-16 \*\*\*  
DESTIN\_SZSESZ03 0.1032728 0.0048330 21.368 < 2e-16 \*\*\*  
DESTIN\_SZSESZ04 -1.0992420 0.0068328 -160.878 < 2e-16 \*\*\*  
DESTIN\_SZSESZ05 -0.8374712 0.0058155 -144.006 < 2e-16 \*\*\*  
DESTIN\_SZSESZ06 -0.5531619 0.0074766 -73.985 < 2e-16 \*\*\*  
DESTIN\_SZSESZ07 -3.0328672 0.0246371 -123.101 < 2e-16 \*\*\*  
DESTIN\_SZSGSZ01 -0.1933777 0.0068235 -28.340 < 2e-16 \*\*\*  
DESTIN\_SZSGSZ02 -0.3000845 0.0060284 -49.779 < 2e-16 \*\*\*  
DESTIN\_SZSGSZ03 -0.4322879 0.0057308 -75.433 < 2e-16 \*\*\*  
DESTIN\_SZSGSZ04 -0.1214792 0.0056548 -21.482 < 2e-16 \*\*\*  
DESTIN\_SZSGSZ05 -2.0309074 0.0114993 -176.611 < 2e-16 \*\*\*  
DESTIN\_SZSGSZ06 0.6592095 0.0046364 142.182 < 2e-16 \*\*\*  
DESTIN\_SZSGSZ07 -0.4618538 0.0062027 -74.460 < 2e-16 \*\*\*  
DESTIN\_SZSISZ01 -0.5227257 0.0293399 -17.816 < 2e-16 \*\*\*  
DESTIN\_SZSKSZ01 -0.4797341 0.0091087 -52.668 < 2e-16 \*\*\*  
DESTIN\_SZSKSZ02 0.8477357 0.0067821 124.996 < 2e-16 \*\*\*  
DESTIN\_SZSKSZ03 -0.2477566 0.0074817 -33.115 < 2e-16 \*\*\*  
DESTIN\_SZSKSZ04 -1.3315992 0.0167055 -79.710 < 2e-16 \*\*\*  
DESTIN\_SZSKSZ05 -0.3519096 0.0131326 -26.797 < 2e-16 \*\*\*  
DESTIN\_SZSLSZ01 -0.8570431 0.0102100 -83.941 < 2e-16 \*\*\*  
DESTIN\_SZSLSZ04 -0.9949105 0.0088280 -112.699 < 2e-16 \*\*\*  
DESTIN\_SZSRSZ01 -1.0260696 0.0154393 -66.458 < 2e-16 \*\*\*  
DESTIN\_SZTHSZ01 -4.2040410 0.0404795 -103.856 < 2e-16 \*\*\*  
DESTIN\_SZTHSZ03 -2.4907000 0.0264056 -94.325 < 2e-16 \*\*\*  
DESTIN\_SZTHSZ04 -3.0701470 0.0244975 -125.325 < 2e-16 \*\*\*  
DESTIN\_SZTHSZ06 -2.5308161 0.0169699 -149.135 < 2e-16 \*\*\*  
DESTIN\_SZTMSZ01 -0.2354889 0.0067201 -35.042 < 2e-16 \*\*\*  
DESTIN\_SZTMSZ02 1.7379292 0.0044573 389.906 < 2e-16 \*\*\*  
DESTIN\_SZTMSZ03 0.9112458 0.0048718 187.043 < 2e-16 \*\*\*  
DESTIN\_SZTMSZ04 1.0731075 0.0048626 220.685 < 2e-16 \*\*\*  
DESTIN\_SZTMSZ05 0.6398583 0.0067321 95.046 < 2e-16 \*\*\*  
DESTIN\_SZTNSZ01 -0.3500456 0.0083835 -41.754 < 2e-16 \*\*\*  
DESTIN\_SZTNSZ02 -1.0573515 0.0112412 -94.060 < 2e-16 \*\*\*  
DESTIN\_SZTNSZ03 -1.4069979 0.0132733 -106.002 < 2e-16 \*\*\*  
DESTIN\_SZTNSZ04 -0.3616604 0.0085207 -42.445 < 2e-16 \*\*\*  
DESTIN\_SZTPSZ01 -0.5919243 0.0071153 -83.190 < 2e-16 \*\*\*  
DESTIN\_SZTPSZ02 0.7083350 0.0046540 152.198 < 2e-16 \*\*\*  
DESTIN\_SZTPSZ03 -0.5746433 0.0069625 -82.534 < 2e-16 \*\*\*  
DESTIN\_SZTPSZ04 -1.5821259 0.0084517 -187.196 < 2e-16 \*\*\*  
DESTIN\_SZTPSZ05 -1.1796256 0.0073039 -161.505 < 2e-16 \*\*\*  
DESTIN\_SZTPSZ06 -0.3968272 0.0077295 -51.339 < 2e-16 \*\*\*  
DESTIN\_SZTPSZ07 -2.1796617 0.0135199 -161.219 < 2e-16 \*\*\*  
DESTIN\_SZTPSZ08 -1.2568483 0.0107267 -117.170 < 2e-16 \*\*\*  
DESTIN\_SZTPSZ09 -0.2446623 0.0080840 -30.265 < 2e-16 \*\*\*  
DESTIN\_SZTPSZ10 -1.2542191 0.0102049 -122.904 < 2e-16 \*\*\*  
DESTIN\_SZTPSZ11 -0.0886883 0.0062888 -14.102 < 2e-16 \*\*\*  
DESTIN\_SZTPSZ12 -0.7211823 0.0075086 -96.048 < 2e-16 \*\*\*  
DESTIN\_SZTSSZ01 -1.6271921 0.0238498 -68.227 < 2e-16 \*\*\*  
DESTIN\_SZTSSZ02 -0.3340439 0.0169137 -19.750 < 2e-16 \*\*\*  
DESTIN\_SZTSSZ03 0.3924580 0.0111060 35.338 < 2e-16 \*\*\*  
DESTIN\_SZTSSZ04 0.4169932 0.0114926 36.283 < 2e-16 \*\*\*  
DESTIN\_SZTSSZ05 1.3206287 0.0120381 109.704 < 2e-16 \*\*\*  
DESTIN\_SZTSSZ06 2.4023725 0.0192840 124.579 < 2e-16 \*\*\*  
DESTIN\_SZWCSZ01 2.0697378 0.0061379 337.206 < 2e-16 \*\*\*  
DESTIN\_SZWCSZ02 -2.0934025 0.0134782 -155.318 < 2e-16 \*\*\*  
DESTIN\_SZWCSZ03 -3.0670149 0.0349748 -87.692 < 2e-16 \*\*\*  
DESTIN\_SZWDSZ01 1.0113215 0.0051461 196.522 < 2e-16 \*\*\*  
DESTIN\_SZWDSZ02 -1.3383793 0.0076482 -174.993 < 2e-16 \*\*\*  
DESTIN\_SZWDSZ03 0.3394361 0.0060396 56.202 < 2e-16 \*\*\*  
DESTIN\_SZWDSZ04 -0.8324928 0.0086019 -96.780 < 2e-16 \*\*\*  
DESTIN\_SZWDSZ05 -0.8279090 0.0083251 -99.447 < 2e-16 \*\*\*  
DESTIN\_SZWDSZ06 -0.2252899 0.0061074 -36.888 < 2e-16 \*\*\*  
DESTIN\_SZWDSZ07 -1.3638599 0.0077990 -174.877 < 2e-16 \*\*\*  
DESTIN\_SZWDSZ08 -0.4350176 0.0077566 -56.083 < 2e-16 \*\*\*  
DESTIN\_SZWDSZ09 0.5461048 0.0060745 89.901 < 2e-16 \*\*\*  
DESTIN\_SZYSSZ01 0.0243093 0.0053476 4.546 5.47e-06 \*\*\*  
DESTIN\_SZYSSZ02 -0.3398962 0.0065947 -51.540 < 2e-16 \*\*\*  
DESTIN\_SZYSSZ03 -0.3694187 0.0074032 -49.900 < 2e-16 \*\*\*  
DESTIN\_SZYSSZ04 -0.5222848 0.0067396 -77.495 < 2e-16 \*\*\*  
DESTIN\_SZYSSZ05 -1.5460539 0.0124899 -123.784 < 2e-16 \*\*\*  
DESTIN\_SZYSSZ06 -1.5556892 0.0127640 -121.881 < 2e-16 \*\*\*  
DESTIN\_SZYSSZ07 -0.8673403 0.0167723 -51.713 < 2e-16 \*\*\*  
DESTIN\_SZYSSZ08 0.5389364 0.0052540 102.577 < 2e-16 \*\*\*  
DESTIN\_SZYSSZ09 0.1199483 0.0055235 21.716 < 2e-16 \*\*\*  
log(dist) -1.8906989 0.0005319 -3554.786 < 2e-16 \*\*\*  
---  
Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
  
(Dispersion parameter for poisson family taken to be 1)  
  
 Null deviance: 36117615 on 14273 degrees of freedom  
Residual deviance: 8091747 on 13715 degrees of freedom  
AIC: 8177420  
  
Number of Fisher Scoring iterations: 7

We can examine how the constraints hold for destinations this time.

CalcRSquared(dbcSIM$data$TRIPS, dbcSIM$fitted.values)

[1] 0.6883675

Notice that there is a relatively greater improvement in the R^2 value.

### Model comparison

Another useful model performance measure for continuous dependent variable is [Root Mean Squared Error](https://towardsdatascience.com/what-does-rmse-really-mean-806b65f2e48e). In this sub-section, you will learn how to use [compare\_performance()](https://easystats.github.io/performance/reference/compare_performance.html) of [**performance**](https://easystats.github.io/performance/index.html) package

First of all, let us create a list called *model\_list* by using the code chun below.

model\_list <- list(unconstrained=uncSIM,  
 originConstrained=orcSIM,  
 destinationConstrained=decSIM,  
 doublyConstrained=dbcSIM)

Next, we will compute the RMSE of all the models in *model\_list* file by using the code chunk below.

compare\_performance(model\_list,  
 metrics = "RMSE")

# Comparison of Model Performance Indices  
  
Name | Model | RMSE  
-----------------------------------------  
unconstrained | glm | 2429.978  
originConstrained | glm | 2057.579  
destinationConstrained | glm | 1891.724  
doublyConstrained | glm | 1487.111

The print above reveals that doubly constrained SIM is the best model among all the four SIMs because it has the smallest RMSE value of 1487.111.

### Visualising fitted

In this section, you will learn how to visualise the observed values and the fitted values.

Firstly we will extract the fitted values from each model by using the code chunk below.

df <- as.data.frame(uncSIM$fitted.values) %>%  
 round(digits = 0)

Next, we will join the values to *SIM\_data* data frame.

SIM\_data <- SIM\_data %>%  
 cbind(df) %>%  
 rename(uncTRIPS = "uncSIM$fitted.values")

Repeat the same step by for Origin Constrained SIM (i.e. orcSIM)

df <- as.data.frame(orcSIM$fitted.values) %>%  
 round(digits = 0)

SIM\_data <- SIM\_data %>%  
 cbind(df) %>%  
 rename(orcTRIPS = "orcSIM$fitted.values")

Repeat the same step by for Destination Constrained SIM (i.e. decSIM)

df <- as.data.frame(decSIM$fitted.values) %>%  
 round(digits = 0)

SIM\_data <- SIM\_data %>%  
 cbind(df) %>%  
 rename(decTRIPS = "decSIM$fitted.values")

Repeat the same step by for Doubly Constrained SIM (i.e. dbcSIM)

df <- as.data.frame(dbcSIM$fitted.values) %>%  
 round(digits = 0)

SIM\_data <- SIM\_data %>%  
 cbind(df) %>%  
 rename(dbcTRIPS = "dbcSIM$fitted.values")

unc\_p <- ggplot(data = SIM\_data,  
 aes(x = uncTRIPS,  
 y = TRIPS)) +  
 geom\_point() +  
 geom\_smooth(method = lm)  
  
orc\_p <- ggplot(data = SIM\_data,  
 aes(x = orcTRIPS,  
 y = TRIPS)) +  
 geom\_point() +  
 geom\_smooth(method = lm)  
  
dec\_p <- ggplot(data = SIM\_data,  
 aes(x = decTRIPS,  
 y = TRIPS)) +  
 geom\_point() +  
 geom\_smooth(method = lm)  
  
dbc\_p <- ggplot(data = SIM\_data,  
 aes(x = dbcTRIPS,  
 y = TRIPS)) +  
 geom\_point() +  
 geom\_smooth(method = lm)  
  
ggarrange(unc\_p, orc\_p, dec\_p, dbc\_p,  
 ncol = 2,  
 nrow = 2)

