

# EDA&Model

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```
library(dplyr)
```

```
##  
## Attaching package: 'dplyr'  
  
## The following objects are masked from 'package:stats':  
##  
##   filter, lag  
  
## The following objects are masked from 'package:base':  
##  
##   intersect, setdiff, setequal, union
```

```
library(ggplot2)  
library(WDI)
```

```
## Warning: package 'WDI' was built under R version 4.4.2
```

```
library(rstanarm)
```

```
## Loading required package: Rcpp  
  
## This is rstanarm version 2.32.1  
  
## - See https://mc-stan.org/rstanarm/articles/priors for changes to default priors!  
  
## - Default priors may change, so it's safest to specify priors, even if equivalent to the defaults.  
  
## - For execution on a local, multicore CPU with excess RAM we recommend calling  
  
##   options(mc.cores = parallel::detectCores())  
  
#EDA  
data clean GDP
```

```

gdp<- WDI(country = "NZ", indicator = "NY.GDP.MKTP.CD", start = 1983, end = 2022)
colnames(gdp) <- c("1","2","3", "year","gdp")
gdp1<-gdp%>% select(-1,-2,-3)
#reverse
gdp2<- gdp1[nrow(gdp1):1, ]
gdp_nz<-data.frame(gdp2)

```

income

```

income<- WDI(country = "NZ", indicator = "NY.GDP.PCAP.CD", start = 1983, end = 2022)
colnames(income) <- c("1","2","3", "4","income")
income1<-income%>% select(-1,-2,-3,-4)
#reverse
income2<-income1[nrow(income1):1, ]
income_nz<-data.frame(income2)

```

input&output

```

trade<- WDI(country = "NZ", indicator = c("NE.EXP.GNFS.CD", "NE.IMP.GNFS.CD"), start = 1983, end = 2022)
colnames(trade) <- c("1","2","3", "4","input","output")
trade1<-trade%>% select(-1,-2,-3,-4)
trade_nz<-data.frame(trade1)

```

population

```

#Get population data
population <- WDI(country = "NZ", indicator = "SP.POP.TOTL", start = 1983, end = 2022)
colnames(population) <- c("1","2","3", "4","population")
population1<-population%>% select(-1,-2,-3,-4)
#reverse
population2<- population1[nrow(population1):1, ]
population_nz<-data.frame(population2)

```

visitor

```

visitor<- WDI(country = "NZ", indicator = "ST.INT.ARVL", start = 1983, end = 2022)
colnames(visitor) <- c("1","2","3", "4","visitor")
visitor1<-visitor%>% select(-1,-2,-3,-4)
#reverse
visitor2<-visitor1[nrow(visitor1):1, ]
visitor_nz<-data.frame(visitor2)

```

inflation

```

inflation<- WDI(country = "NZ", indicator = "FP.CPI.TOTL.ZG", start = 1983, end = 2022)
colnames(inflation) <- c("1","2","3", "4","inflation")
inflation1<-inflation%>% select(-1,-2,-3,-4)
#reverse
inflation2<-inflation1[nrow(inflation1):1, ]
inflation_nz<-data.frame(inflation2)

```

dataframe

```
#combine all cleaned data
```

```
data_nz<-bind_cols(gdp_nz, income_nz,population_nz,trade_nz,visitor_nz,inflation_nz)
```

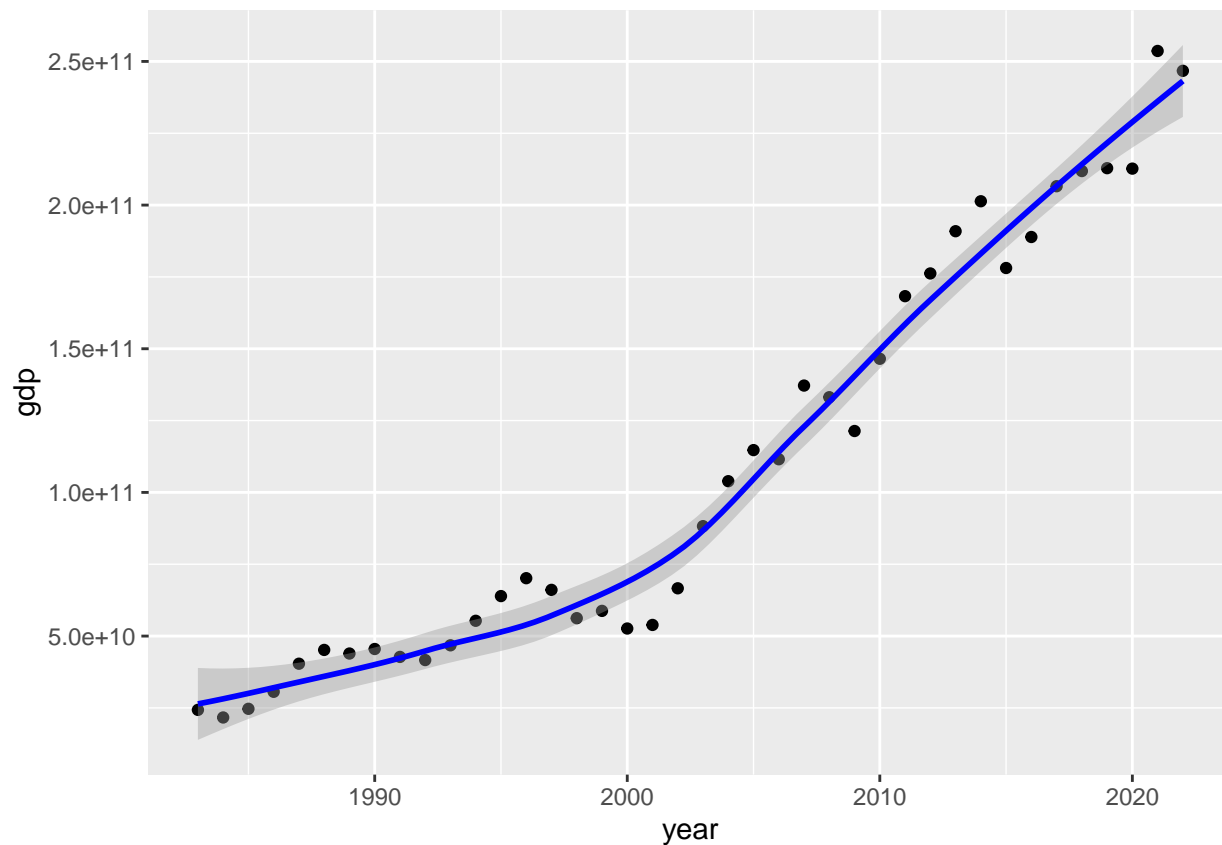
```
summary(data_nz)
```

```
##      year      gdp      income2      population2
## Min.   :1983   Min.   :2.167e+10   Min.    : 6714   Min.    :3199300
## 1st Qu.:1993   1st Qu.:4.646e+10   1st Qu.:13658   1st Qu.:3562075
## Median :2002   Median :7.920e+10   Median :20354   Median :3987850
## Mean   :2002   Mean   :1.089e+11   Mean    :25136   Mean    :4037638
## 3rd Qu.:2012   3rd Qu.:1.767e+11   3rd Qu.:38973   3rd Qu.:4416600
## Max.   :2022   Max.   :2.536e+11   Max.    :49624   Max.    :5117200
##
##      input      output      visitor2      inflation2
## Min.   :6.892e+09   Min.   :7.192e+09   Min.    : 996000   Min.    :-0.1143
## 1st Qu.:1.398e+10   1st Qu.:1.239e+10   1st Qu.:1817500   1st Qu.: 1.5208
## Median :2.411e+10   Median :2.232e+10   Median :2432000   Median : 2.3391
## Mean   :3.049e+10   Mean   :3.013e+10   Mean    :2394808   Mean    : 3.6627
## 3rd Qu.:4.992e+10   3rd Qu.:4.812e+10   3rd Qu.:2686750   3rd Qu.: 3.9762
## Max.   :6.019e+10   Max.   :7.326e+10   Max.    :3888000   Max.    :15.7443
##
##      NA's      :14
```

visualization

```
ggplot(data_nz, aes(x =year, y = gdp)) +
  geom_point() +
  geom_smooth(color = "blue")
```

```
## 'geom_smooth()' using method = 'loess' and formula = 'y ~ x'
```



```
theme_minimal() +
labs(title = "gdp change from1983-2023", x = "year", y = "gdp")
```

```
## List of 138
## $ line :List of 6
## ..$ colour : chr "black"
## ..$ linewidth : num 0.5
## ..$ linetype : num 1
## ..$ lineend : chr "butt"
## ..$ arrow : logi FALSE
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_line" "element"
## $ rect :List of 5
## ..$ fill : chr "white"
## ..$ colour : chr "black"
## ..$ linewidth : num 0.5
## ..$ linetype : num 1
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_rect" "element"
## $ text :List of 11
## ..$ family : chr ""
## ..$ face : chr "plain"
## ..$ colour : chr "black"
## ..$ size : num 11
## ..$ hjust : num 0.5
## ..$ vjust : num 0.5
```

```

## ..$ angle          : num 0
## ..$ lineheight     : num 0.9
## ..$ margin         : 'margin' num [1:4] 0points 0points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug          : logi FALSE
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ title             : chr "gdp change from1983-2023"
## $ aspect.ratio      : NULL
## $ axis.title        : NULL
## $ axis.title.x      :List of 11
## ..$ family         : NULL
## ..$ face           : NULL
## ..$ colour         : NULL
## ..$ size           : NULL
## ..$ hjust          : NULL
## ..$ vjust          : num 1
## ..$ angle          : NULL
## ..$ lineheight     : NULL
## ..$ margin         : 'margin' num [1:4] 2.75points 0points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug          : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.x.top  :List of 11
## ..$ family         : NULL
## ..$ face           : NULL
## ..$ colour         : NULL
## ..$ size           : NULL
## ..$ hjust          : NULL
## ..$ vjust          : num 0
## ..$ angle          : NULL
## ..$ lineheight     : NULL
## ..$ margin         : 'margin' num [1:4] 0points 0points 2.75points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug          : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.x.bottom : NULL
## $ axis.title.y      :List of 11
## ..$ family         : NULL
## ..$ face           : NULL
## ..$ colour         : NULL
## ..$ size           : NULL
## ..$ hjust          : NULL
## ..$ vjust          : num 1
## ..$ angle          : num 90
## ..$ lineheight     : NULL
## ..$ margin         : 'margin' num [1:4] 0points 2.75points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug          : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.y.left : NULL

```

```

## $ axis.title.y.right          :List of 11
## ..$ family                   : NULL
## ..$ face                     : NULL
## ..$ colour                   : NULL
## ..$ size                     : NULL
## ..$ hjust                    : NULL
## ..$ vjust                    : num 1
## ..$ angle                    : num -90
## ..$ lineheight               : NULL
## ..$ margin                   : 'margin' num [1:4] 0points 0points 0points 2.75points
## .. ..- attr(*, "unit")= int 8
## ..$ debug                    : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text                   :List of 11
## ..$ family                   : NULL
## ..$ face                     : NULL
## ..$ colour                   : chr "grey30"
## ..$ size                     : 'rel' num 0.8
## ..$ hjust                    : NULL
## ..$ vjust                    : NULL
## ..$ angle                    : NULL
## ..$ lineheight               : NULL
## ..$ margin                   : NULL
## ..$ debug                    : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.x                 :List of 11
## ..$ family                   : NULL
## ..$ face                     : NULL
## ..$ colour                   : NULL
## ..$ size                     : NULL
## ..$ hjust                    : NULL
## ..$ vjust                    : num 1
## ..$ angle                    : NULL
## ..$ lineheight               : NULL
## ..$ margin                   : 'margin' num [1:4] 2.2points 0points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug                    : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.x.top             :List of 11
## ..$ family                   : NULL
## ..$ face                     : NULL
## ..$ colour                   : NULL
## ..$ size                     : NULL
## ..$ hjust                    : NULL
## ..$ vjust                    : num 0
## ..$ angle                    : NULL
## ..$ lineheight               : NULL
## ..$ margin                   : 'margin' num [1:4] 0points 0points 2.2points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug                    : NULL
## ..$ inherit.blank: logi TRUE

```

```

##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##   $ axis.text.x.bottom      : NULL
##   $ axis.text.y             :List of 11
##   ..$ family                : NULL
##   ..$ face                  : NULL
##   ..$ colour                : NULL
##   ..$ size                  : NULL
##   ..$ hjust                 : num 1
##   ..$ vjust                 : NULL
##   ..$ angle                 : NULL
##   ..$ lineheight            : NULL
##   ..$ margin                : 'margin' num [1:4] 0points 2.2points 0points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug                 : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##   $ axis.text.y.left        : NULL
##   $ axis.text.y.right       :List of 11
##   ..$ family                : NULL
##   ..$ face                  : NULL
##   ..$ colour                : NULL
##   ..$ size                  : NULL
##   ..$ hjust                 : num 0
##   ..$ vjust                 : NULL
##   ..$ angle                 : NULL
##   ..$ lineheight            : NULL
##   ..$ margin                : 'margin' num [1:4] 0points 0points 0points 2.2points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug                 : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##   $ axis.text.theta         : NULL
##   $ axis.text.r              :List of 11
##   ..$ family                : NULL
##   ..$ face                  : NULL
##   ..$ colour                : NULL
##   ..$ size                  : NULL
##   ..$ hjust                 : num 0.5
##   ..$ vjust                 : NULL
##   ..$ angle                 : NULL
##   ..$ lineheight            : NULL
##   ..$ margin                : 'margin' num [1:4] 0points 2.2points 0points 2.2points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug                 : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##   $ axis.ticks              : list()
##   ..- attr(*, "class")= chr [1:2] "element_blank" "element"
##   $ axis.ticks.x            : NULL
##   $ axis.ticks.x.top        : NULL
##   $ axis.ticks.x.bottom     : NULL
##   $ axis.ticks.y            : NULL
##   $ axis.ticks.y.left       : NULL
##   $ axis.ticks.y.right      : NULL

```

```

## $ axis.ticks.theta : NULL
## $ axis.ticks.r : NULL
## $ axis.minor.ticks.x.top : NULL
## $ axis.minor.ticks.x.bottom : NULL
## $ axis.minor.ticks.y.left : NULL
## $ axis.minor.ticks.y.right : NULL
## $ axis.minor.ticks.theta : NULL
## $ axis.minor.ticks.r : NULL
## $ axis.ticks.length : 'simpleUnit' num 2.75points
## .. attr(*, "unit")= int 8
## $ axis.ticks.length.x : NULL
## $ axis.ticks.length.x.top : NULL
## $ axis.ticks.length.x.bottom : NULL
## $ axis.ticks.length.y : NULL
## $ axis.ticks.length.y.left : NULL
## $ axis.ticks.length.y.right : NULL
## $ axis.ticks.length.theta : NULL
## $ axis.ticks.length.r : NULL
## $ axis.minor.ticks.length : 'rel' num 0.75
## $ axis.minor.ticks.length.x : NULL
## $ axis.minor.ticks.length.x.top : NULL
## $ axis.minor.ticks.length.x.bottom : NULL
## $ axis.minor.ticks.length.y : NULL
## $ axis.minor.ticks.length.y.left : NULL
## $ axis.minor.ticks.length.y.right : NULL
## $ axis.minor.ticks.length.theta : NULL
## $ axis.minor.ticks.length.r : NULL
## $ axis.line : list()
## .. attr(*, "class")= chr [1:2] "element_blank" "element"
## $ axis.line.x : NULL
## $ axis.line.x.top : NULL
## $ axis.line.x.bottom : NULL
## $ axis.line.y : NULL
## $ axis.line.y.left : NULL
## $ axis.line.y.right : NULL
## $ axis.line.theta : NULL
## $ axis.line.r : NULL
## $ legend.background : list()
## .. attr(*, "class")= chr [1:2] "element_blank" "element"
## $ legend.margin : 'margin' num [1:4] 5.5points 5.5points 5.5points 5.5points
## .. attr(*, "unit")= int 8
## $ legend.spacing : 'simpleUnit' num 11points
## .. attr(*, "unit")= int 8
## $ legend.spacing.x : NULL
## $ legend.spacing.y : NULL
## $ legend.key : list()
## .. attr(*, "class")= chr [1:2] "element_blank" "element"
## $ legend.key.size : 'simpleUnit' num 1.2lines
## .. attr(*, "unit")= int 3
## $ legend.key.height : NULL
## $ legend.key.width : NULL
## $ legend.key.spacing : 'simpleUnit' num 5.5points
## .. attr(*, "unit")= int 8
## $ legend.key.spacing.x : NULL

```



```

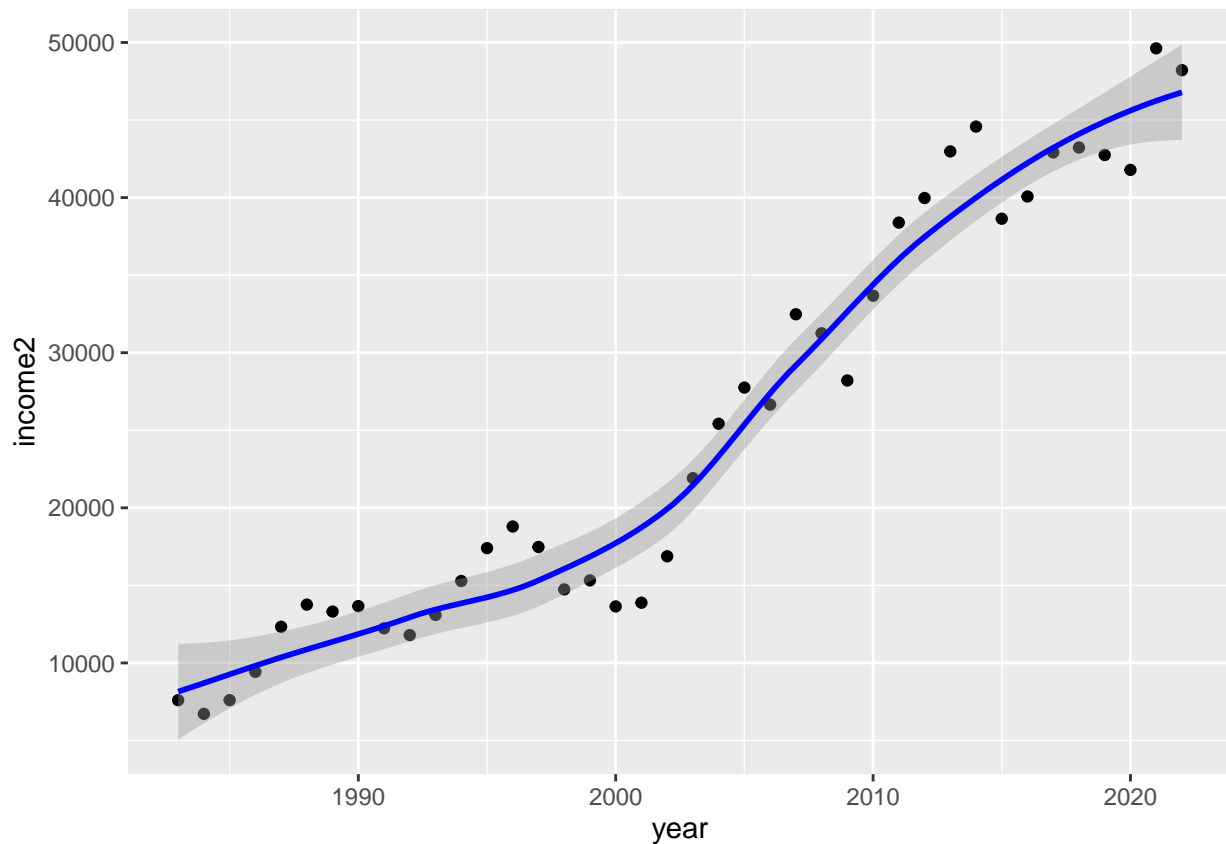
## $ legend.key.spacing.y          : NULL
## $ legend.frame                  : NULL
## $ legend.ticks                  : NULL
## $ legend.ticks.length           : 'rel' num 0.2
## $ legend.axis.line              : NULL
## $ legend.text                   :List of 11
##   ..$ family                   : NULL
##   ..$ face                      : NULL
##   ..$ colour                   : NULL
##   ..$ size                      : 'rel' num 0.8
##   ..$ hjust                    : NULL
##   ..$ vjust                    : NULL
##   ..$ angle                    : NULL
##   ..$ lineheight               : NULL
##   ..$ margin                   : NULL
##   ..$ debug                    : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ legend.text.position          : NULL
## $ legend.title                  :List of 11
##   ..$ family                   : NULL
##   ..$ face                      : NULL
##   ..$ colour                   : NULL
##   ..$ size                     : NULL
##   ..$ hjust                    : num 0
##   ..$ vjust                    : NULL
##   ..$ angle                    : NULL
##   ..$ lineheight               : NULL
##   ..$ margin                   : NULL
##   ..$ debug                    : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ legend.title.position         : NULL
## $ legend.position               : chr "right"
## $ legend.position.inside        : NULL
## $ legend.direction              : NULL
## $ legend.byrow                  : NULL
## $ legend.justification          : chr "center"
## $ legend.justification.top      : NULL
## $ legend.justification.bottom   : NULL
## $ legend.justification.left     : NULL
## $ legend.justification.right    : NULL
## $ legend.justification.inside   : NULL
## $ legend.location               : NULL
## $ legend.box                   : NULL
## $ legend.box.just               : NULL
## $ legend.box.margin             : 'margin' num [1:4] 0cm 0cm 0cm 0cm
##   ..- attr(*, "unit")= int 1
## $ legend.box.background         : list()
##   ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ legend.box.spacing            : 'simpleUnit' num 11points
##   ..- attr(*, "unit")= int 8
## [list output truncated]
## - attr(*, "class")= chr [1:2] "theme" "gg"

```

```
## - attr(*, "complete")= logi TRUE
## - attr(*, "validate")= logi TRUE
```

```
ggplot(data_nz, aes(x =year, y = income2)) +
  geom_point() +
  geom_smooth(color = "blue")
```

```
## 'geom_smooth()' using method = 'loess' and formula = 'y ~ x'
```



```
theme_minimal() +
  labs(title = "income change from1983-2023", x = "year", y = "income")
```

```
## List of 138
## $ line                                     :List of 6
## ..$ colour          : chr "black"
## ..$ linewidth       : num 0.5
## ..$ linetype        : num 1
## ..$ lineend         : chr "butt"
## ..$ arrow           : logi FALSE
## ..$ inherit.blank   : logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_line" "element"
## $ rect                                     :List of 5
## ..$ fill            : chr "white"
## ..$ colour          : chr "black"
## ..$ linewidth       : num 0.5
```

```

## ..$ linetype      : num 1
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_rect" "element"
## $ text              :List of 11
## ..$ family         : chr ""
## ..$ face            : chr "plain"
## ..$ colour          : chr "black"
## ..$ size            : num 11
## ..$ hjust           : num 0.5
## ..$ vjust           : num 0.5
## ..$ angle           : num 0
## ..$ lineheight      : num 0.9
## ..$ margin          : 'margin' num [1:4] 0points 0points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug           : logi FALSE
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ title              : chr "income change from1983-2023"
## $ aspect.ratio        : NULL
## $ axis.title          : NULL
## $ axis.title.x        :List of 11
## ..$ family          : NULL
## ..$ face             : NULL
## ..$ colour           : NULL
## ..$ size             : NULL
## ..$ hjust            : NULL
## ..$ vjust            : num 1
## ..$ angle            : NULL
## ..$ lineheight       : NULL
## ..$ margin           : 'margin' num [1:4] 2.75points 0points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug            : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.x.top    :List of 11
## ..$ family           : NULL
## ..$ face              : NULL
## ..$ colour            : NULL
## ..$ size              : NULL
## ..$ hjust             : NULL
## ..$ vjust             : num 0
## ..$ angle             : NULL
## ..$ lineheight        : NULL
## ..$ margin            : 'margin' num [1:4] 0points 0points 2.75points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug             : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.x.bottom : NULL
## $ axis.title.y         :List of 11
## ..$ family           : NULL
## ..$ face              : NULL
## ..$ colour            : NULL
## ..$ size              : NULL

```

```

## ..$ hjust      : NULL
## ..$ vjust      : num 1
## ..$ angle      : num 90
## ..$ lineheight : NULL
## ..$ margin      : 'margin' num [1:4] 0points 2.75points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug      : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.y.left      : NULL
## $ axis.title.y.right     :List of 11
## ..$ family      : NULL
## ..$ face        : NULL
## ..$ colour      : NULL
## ..$ size        : NULL
## ..$ hjust      : NULL
## ..$ vjust      : num 1
## ..$ angle      : num -90
## ..$ lineheight : NULL
## ..$ margin      : 'margin' num [1:4] 0points 0points 0points 2.75points
## .. ..- attr(*, "unit")= int 8
## ..$ debug      : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text      :List of 11
## ..$ family      : NULL
## ..$ face        : NULL
## ..$ colour      : chr "grey30"
## ..$ size        : 'rel' num 0.8
## ..$ hjust      : NULL
## ..$ vjust      : NULL
## ..$ angle      : NULL
## ..$ lineheight : NULL
## ..$ margin      : NULL
## ..$ debug      : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.x     :List of 11
## ..$ family      : NULL
## ..$ face        : NULL
## ..$ colour      : NULL
## ..$ size        : NULL
## ..$ hjust      : NULL
## ..$ vjust      : num 1
## ..$ angle      : NULL
## ..$ lineheight : NULL
## ..$ margin      : 'margin' num [1:4] 2.2points 0points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug      : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.x.top  :List of 11
## ..$ family      : NULL
## ..$ face        : NULL

```

```

## ..$ colour      : NULL
## ..$ size        : NULL
## ..$ hjust       : NULL
## ..$ vjust       : num 0
## ..$ angle       : NULL
## ..$ lineheight  : NULL
## ..$ margin      : 'margin' num [1:4] 0points 0points 2.2points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug       : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.x.bottom      : NULL
## $ axis.text.y             :List of 11
## ..$ family              : NULL
## ..$ face                : NULL
## ..$ colour              : NULL
## ..$ size                : NULL
## ..$ hjust               : num 1
## ..$ vjust               : NULL
## ..$ angle               : NULL
## ..$ lineheight          : NULL
## ..$ margin              : 'margin' num [1:4] 0points 2.2points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug               : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.y.left        : NULL
## $ axis.text.y.right       :List of 11
## ..$ family              : NULL
## ..$ face                : NULL
## ..$ colour              : NULL
## ..$ size                : NULL
## ..$ hjust               : num 0
## ..$ vjust               : NULL
## ..$ angle               : NULL
## ..$ lineheight          : NULL
## ..$ margin              : 'margin' num [1:4] 0points 0points 0points 2.2points
## .. ..- attr(*, "unit")= int 8
## ..$ debug               : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.theta         : NULL
## $ axis.text.r             :List of 11
## ..$ family              : NULL
## ..$ face                : NULL
## ..$ colour              : NULL
## ..$ size                : NULL
## ..$ hjust               : num 0.5
## ..$ vjust               : NULL
## ..$ angle               : NULL
## ..$ lineheight          : NULL
## ..$ margin              : 'margin' num [1:4] 0points 2.2points 0points 2.2points
## .. ..- attr(*, "unit")= int 8
## ..$ debug               : NULL

```

```

## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.ticks : list()
## ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ axis.ticks.x : NULL
## $ axis.ticks.x.top : NULL
## $ axis.ticks.x.bottom : NULL
## $ axis.ticks.y : NULL
## $ axis.ticks.y.left : NULL
## $ axis.ticks.y.right : NULL
## $ axis.ticks.theta : NULL
## $ axis.ticks.r : NULL
## $ axis.minor.ticks.x.top : NULL
## $ axis.minor.ticks.x.bottom : NULL
## $ axis.minor.ticks.y.left : NULL
## $ axis.minor.ticks.y.right : NULL
## $ axis.minor.ticks.theta : NULL
## $ axis.minor.ticks.r : NULL
## $ axis.ticks.length : 'simpleUnit' num 2.75points
## ..- attr(*, "unit")= int 8
## $ axis.ticks.length.x : NULL
## $ axis.ticks.length.x.top : NULL
## $ axis.ticks.length.x.bottom : NULL
## $ axis.ticks.length.y : NULL
## $ axis.ticks.length.y.left : NULL
## $ axis.ticks.length.y.right : NULL
## $ axis.ticks.length.theta : NULL
## $ axis.ticks.length.r : NULL
## $ axis.minor.ticks.length : 'rel' num 0.75
## $ axis.minor.ticks.length.x : NULL
## $ axis.minor.ticks.length.x.top : NULL
## $ axis.minor.ticks.length.x.bottom : NULL
## $ axis.minor.ticks.length.y : NULL
## $ axis.minor.ticks.length.y.left : NULL
## $ axis.minor.ticks.length.y.right : NULL
## $ axis.minor.ticks.length.theta : NULL
## $ axis.minor.ticks.length.r : NULL
## $ axis.line : list()
## ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ axis.line.x : NULL
## $ axis.line.x.top : NULL
## $ axis.line.x.bottom : NULL
## $ axis.line.y : NULL
## $ axis.line.y.left : NULL
## $ axis.line.y.right : NULL
## $ axis.line.theta : NULL
## $ axis.line.r : NULL
## $ legend.background : list()
## ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ legend.margin : 'margin' num [1:4] 5.5points 5.5points 5.5points 5.5points
## ..- attr(*, "unit")= int 8
## $ legend.spacing : 'simpleUnit' num 11points
## ..- attr(*, "unit")= int 8
## $ legend.spacing.x : NULL

```

```

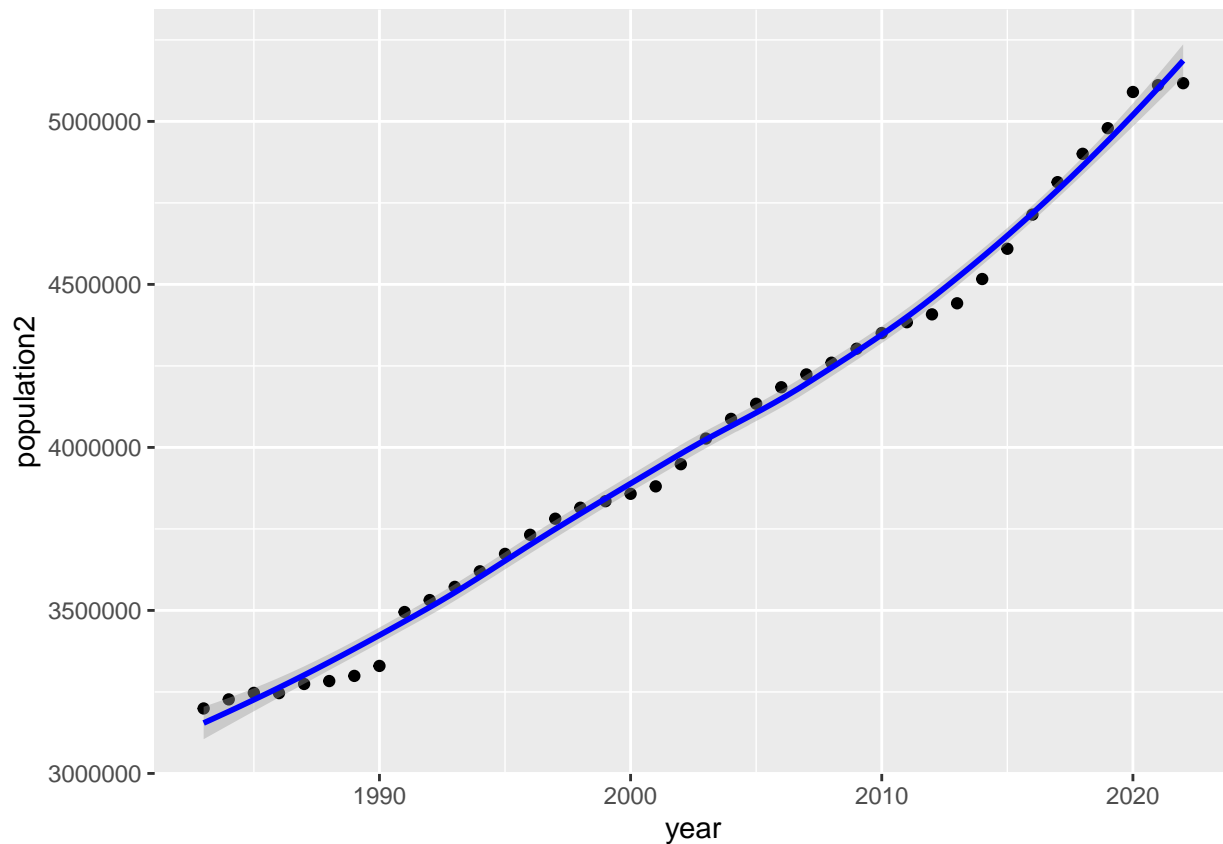
## $ legend.spacing.y           : NULL
## $ legend.key                 : list()
##   .. attr(*, "class")= chr [1:2] "element_blank" "element"
## $ legend.key.size            : 'simpleUnit' num 1.2lines
##   .. attr(*, "unit")= int 3
## $ legend.key.height          : NULL
## $ legend.key.width           : NULL
## $ legend.key.spacing         : 'simpleUnit' num 5.5points
##   .. attr(*, "unit")= int 8
## $ legend.key.spacing.x       : NULL
## $ legend.key.spacing.y       : NULL
## $ legend.frame               : NULL
## $ legend.ticks               : NULL
## $ legend.ticks.length        : 'rel' num 0.2
## $ legend.axis.line           : NULL
## $ legend.text                 :List of 11
##   ..$ family                 : NULL
##   ..$ face                   : NULL
##   ..$ colour                 : NULL
##   ..$ size                   : 'rel' num 0.8
##   ..$ hjust                  : NULL
##   ..$ vjust                  : NULL
##   ..$ angle                  : NULL
##   ..$ lineheight             : NULL
##   ..$ margin                 : NULL
##   ..$ debug                  : NULL
##   ..$ inherit.blank: logi TRUE
##   .. attr(*, "class")= chr [1:2] "element_text" "element"
## $ legend.text.position       : NULL
## $ legend.title               :List of 11
##   ..$ family                 : NULL
##   ..$ face                   : NULL
##   ..$ colour                 : NULL
##   ..$ size                   : NULL
##   ..$ hjust                  : num 0
##   ..$ vjust                  : NULL
##   ..$ angle                  : NULL
##   ..$ lineheight             : NULL
##   ..$ margin                 : NULL
##   ..$ debug                  : NULL
##   ..$ inherit.blank: logi TRUE
##   .. attr(*, "class")= chr [1:2] "element_text" "element"
## $ legend.title.position      : NULL
## $ legend.position            : chr "right"
## $ legend.position.inside     : NULL
## $ legend.direction           : NULL
## $ legend.byrow               : NULL
## $ legend.justification       : chr "center"
## $ legend.justification.top   : NULL
## $ legend.justification.bottom : NULL
## $ legend.justification.left  : NULL
## $ legend.justification.right : NULL
## $ legend.justification.inside : NULL
## $ legend.location            : NULL

```

```
## $ legend.box                : NULL
## $ legend.box.just           : NULL
## $ legend.box.margin         : 'margin' num [1:4] 0cm 0cm 0cm 0cm
##   .. attr(*, "unit")= int 1
## $ legend.box.background     : list()
##   .. attr(*, "class")= chr [1:2] "element_blank" "element"
## $ legend.box.spacing        : 'simpleUnit' num 11points
##   .. attr(*, "unit")= int 8
## [list output truncated]
## - attr(*, "class")= chr [1:2] "theme" "gg"
## - attr(*, "complete")= logi TRUE
## - attr(*, "validate")= logi TRUE
```

```
ggplot(data_nz, aes(x =year, y =population2)) +
  geom_point() +
  geom_smooth(color = "blue")
```

```
## 'geom_smooth()' using method = 'loess' and formula = 'y ~ x'
```



```
theme_minimal() +
  labs(title = "population change from1983-2023", x = "year", y = "population")
```

```
## List of 138
## $ line                :List of 6
##   ..$ colour          : chr "black"
```



```

## ..$ linewidth      : num 0.5
## ..$ linetype       : num 1
## ..$ lineend        : chr "butt"
## ..$ arrow          : logi FALSE
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_line" "element"
## $ rect              :List of 5
## ..$ fill           : chr "white"
## ..$ colour         : chr "black"
## ..$ linewidth      : num 0.5
## ..$ linetype       : num 1
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_rect" "element"
## $ text              :List of 11
## ..$ family         : chr ""
## ..$ face           : chr "plain"
## ..$ colour         : chr "black"
## ..$ size           : num 11
## ..$ hjust          : num 0.5
## ..$ vjust          : num 0.5
## ..$ angle          : num 0
## ..$ lineheight     : num 0.9
## ..$ margin         : 'margin' num [1:4] 0points 0points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug          : logi FALSE
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ title             : chr "population change from1983-2023"
## $ aspect.ratio      : NULL
## $ axis.title        : NULL
## $ axis.title.x      :List of 11
## ..$ family         : NULL
## ..$ face           : NULL
## ..$ colour         : NULL
## ..$ size           : NULL
## ..$ hjust          : NULL
## ..$ vjust          : num 1
## ..$ angle          : NULL
## ..$ lineheight     : NULL
## ..$ margin         : 'margin' num [1:4] 2.75points 0points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug          : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.x.top  :List of 11
## ..$ family         : NULL
## ..$ face           : NULL
## ..$ colour         : NULL
## ..$ size           : NULL
## ..$ hjust          : NULL
## ..$ vjust          : num 0
## ..$ angle          : NULL
## ..$ lineheight     : NULL
## ..$ margin         : 'margin' num [1:4] 0points 0points 2.75points 0points

```

```

## ..- attr(*, "unit")= int 8
## ..$ debug : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.x.bottom : NULL
## $ axis.title.y :List of 11
## ..$ family : NULL
## ..$ face : NULL
## ..$ colour : NULL
## ..$ size : NULL
## ..$ hjust : NULL
## ..$ vjust : num 1
## ..$ angle : num 90
## ..$ lineheight : NULL
## ..$ margin : 'margin' num [1:4] 0points 2.75points 0points 0points
## ..- attr(*, "unit")= int 8
## ..$ debug : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.y.left : NULL
## $ axis.title.y.right :List of 11
## ..$ family : NULL
## ..$ face : NULL
## ..$ colour : NULL
## ..$ size : NULL
## ..$ hjust : NULL
## ..$ vjust : num 1
## ..$ angle : num -90
## ..$ lineheight : NULL
## ..$ margin : 'margin' num [1:4] 0points 0points 0points 2.75points
## ..- attr(*, "unit")= int 8
## ..$ debug : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text :List of 11
## ..$ family : NULL
## ..$ face : NULL
## ..$ colour : chr "grey30"
## ..$ size : 'rel' num 0.8
## ..$ hjust : NULL
## ..$ vjust : NULL
## ..$ angle : NULL
## ..$ lineheight : NULL
## ..$ margin : NULL
## ..$ debug : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.x :List of 11
## ..$ family : NULL
## ..$ face : NULL
## ..$ colour : NULL
## ..$ size : NULL
## ..$ hjust : NULL
## ..$ vjust : num 1

```

```

## ..$ angle      : NULL
## ..$ lineheight : NULL
## ..$ margin      : 'margin' num [1:4] 2.2points 0points 0points 0points
## ..- attr(*, "unit")= int 8
## ..$ debug       : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.x.top      :List of 11
## ..$ family           : NULL
## ..$ face             : NULL
## ..$ colour           : NULL
## ..$ size             : NULL
## ..$ hjust            : NULL
## ..$ vjust            : num 0
## ..$ angle            : NULL
## ..$ lineheight       : NULL
## ..$ margin           : 'margin' num [1:4] 0points 0points 2.2points 0points
## ..- attr(*, "unit")= int 8
## ..$ debug           : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.x.bottom   : NULL
## $ axis.text.y          :List of 11
## ..$ family           : NULL
## ..$ face             : NULL
## ..$ colour           : NULL
## ..$ size             : NULL
## ..$ hjust            : num 1
## ..$ vjust            : NULL
## ..$ angle            : NULL
## ..$ lineheight       : NULL
## ..$ margin           : 'margin' num [1:4] 0points 2.2points 0points 0points
## ..- attr(*, "unit")= int 8
## ..$ debug           : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.y.left     : NULL
## $ axis.text.y.right    :List of 11
## ..$ family           : NULL
## ..$ face             : NULL
## ..$ colour           : NULL
## ..$ size             : NULL
## ..$ hjust            : num 0
## ..$ vjust            : NULL
## ..$ angle            : NULL
## ..$ lineheight       : NULL
## ..$ margin           : 'margin' num [1:4] 0points 0points 0points 2.2points
## ..- attr(*, "unit")= int 8
## ..$ debug           : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.theta      : NULL
## $ axis.text.r          :List of 11
## ..$ family           : NULL

```

```

## ..$ face          : NULL
## ..$ colour        : NULL
## ..$ size          : NULL
## ..$ hjust         : num 0.5
## ..$ vjust         : NULL
## ..$ angle         : NULL
## ..$ lineheight    : NULL
## ..$ margin        : 'margin' num [1:4] 0points 2.2points 0points 2.2points
## ..- attr(*, "unit")= int 8
## ..$ debug         : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.ticks      : list()
## ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ axis.ticks.x    : NULL
## $ axis.ticks.x.top : NULL
## $ axis.ticks.x.bottom : NULL
## $ axis.ticks.y    : NULL
## $ axis.ticks.y.left : NULL
## $ axis.ticks.y.right : NULL
## $ axis.ticks.theta : NULL
## $ axis.ticks.r    : NULL
## $ axis.minor.ticks.x.top : NULL
## $ axis.minor.ticks.x.bottom : NULL
## $ axis.minor.ticks.y.left : NULL
## $ axis.minor.ticks.y.right : NULL
## $ axis.minor.ticks.theta : NULL
## $ axis.minor.ticks.r    : NULL
## $ axis.ticks.length    : 'simpleUnit' num 2.75points
## ..- attr(*, "unit")= int 8
## $ axis.ticks.length.x : NULL
## $ axis.ticks.length.x.top : NULL
## $ axis.ticks.length.x.bottom : NULL
## $ axis.ticks.length.y : NULL
## $ axis.ticks.length.y.left : NULL
## $ axis.ticks.length.y.right : NULL
## $ axis.ticks.length.theta : NULL
## $ axis.ticks.length.r    : NULL
## $ axis.minor.ticks.length : 'rel' num 0.75
## $ axis.minor.ticks.length.x : NULL
## $ axis.minor.ticks.length.x.top : NULL
## $ axis.minor.ticks.length.x.bottom : NULL
## $ axis.minor.ticks.length.y : NULL
## $ axis.minor.ticks.length.y.left : NULL
## $ axis.minor.ticks.length.y.right : NULL
## $ axis.minor.ticks.length.theta : NULL
## $ axis.minor.ticks.length.r    : NULL
## $ axis.line                    : list()
## ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ axis.line.x                : NULL
## $ axis.line.x.top             : NULL
## $ axis.line.x.bottom         : NULL
## $ axis.line.y                 : NULL
## $ axis.line.y.left           : NULL

```

```

## $ axis.line.y.right      : NULL
## $ axis.line.theta       : NULL
## $ axis.line.r           : NULL
## $ legend.background     : list()
## ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ legend.margin         : 'margin' num [1:4] 5.5points 5.5points 5.5points 5.5points
## ..- attr(*, "unit")= int 8
## $ legend.spacing        : 'simpleUnit' num 11points
## ..- attr(*, "unit")= int 8
## $ legend.spacing.x      : NULL
## $ legend.spacing.y      : NULL
## $ legend.key            : list()
## ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ legend.key.size       : 'simpleUnit' num 1.2lines
## ..- attr(*, "unit")= int 3
## $ legend.key.height     : NULL
## $ legend.key.width      : NULL
## $ legend.key.spacing    : 'simpleUnit' num 5.5points
## ..- attr(*, "unit")= int 8
## $ legend.key.spacing.x  : NULL
## $ legend.key.spacing.y  : NULL
## $ legend.frame          : NULL
## $ legend.ticks          : NULL
## $ legend.ticks.length   : 'rel' num 0.2
## $ legend.axis.line      : NULL
## $ legend.text           :List of 11
## ..$ family             : NULL
## ..$ face                : NULL
## ..$ colour             : NULL
## ..$ size                : 'rel' num 0.8
## ..$ hjust              : NULL
## ..$ vjust              : NULL
## ..$ angle              : NULL
## ..$ lineheight         : NULL
## ..$ margin             : NULL
## ..$ debug              : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ legend.text.position   : NULL
## $ legend.title          :List of 11
## ..$ family             : NULL
## ..$ face                : NULL
## ..$ colour             : NULL
## ..$ size                : NULL
## ..$ hjust              : num 0
## ..$ vjust              : NULL
## ..$ angle              : NULL
## ..$ lineheight         : NULL
## ..$ margin             : NULL
## ..$ debug              : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ legend.title.position  : NULL
## $ legend.position        : chr "right"

```

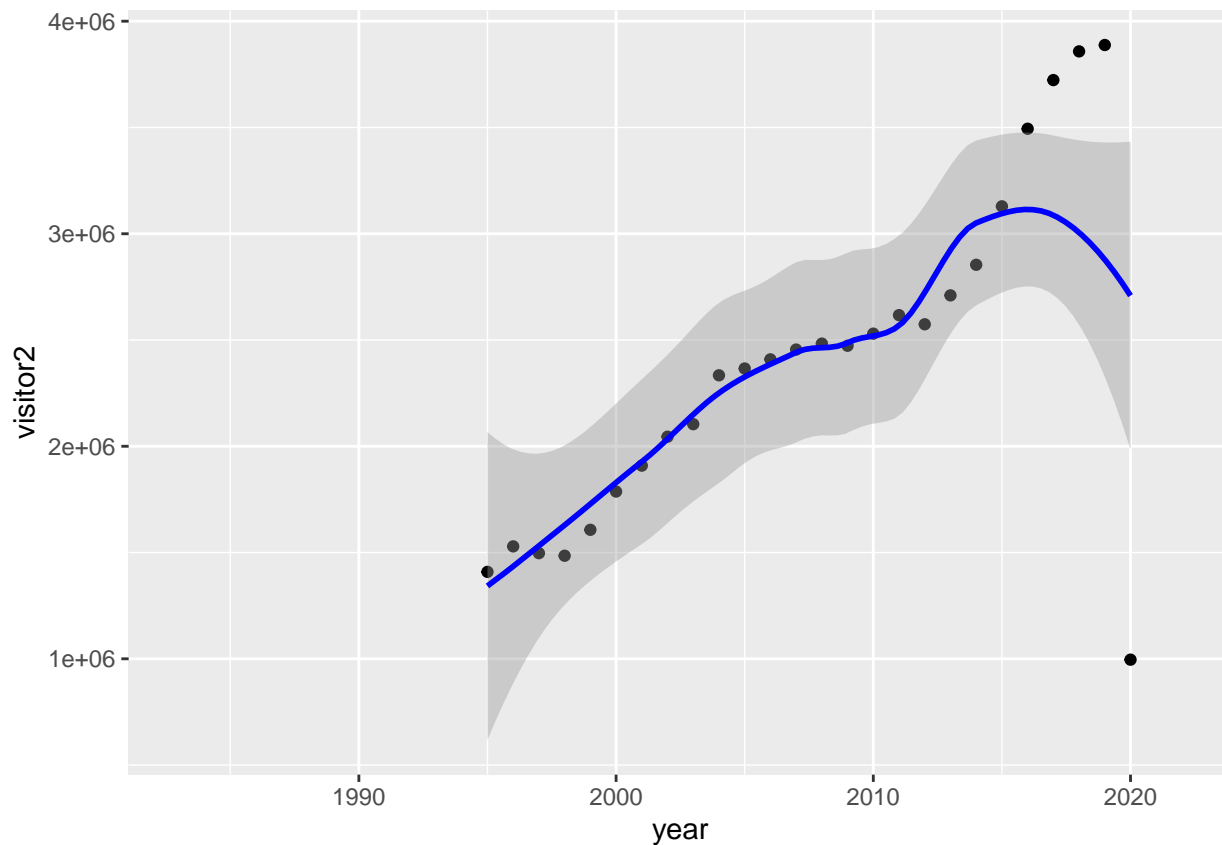
```
## $ legend.position.inside      : NULL
## $ legend.direction           : NULL
## $ legend.byrow               : NULL
## $ legend.justification       : chr "center"
## $ legend.justification.top    : NULL
## $ legend.justification.bottom : NULL
## $ legend.justification.left   : NULL
## $ legend.justification.right  : NULL
## $ legend.justification.inside : NULL
## $ legend.location            : NULL
## $ legend.box                 : NULL
## $ legend.box.just            : NULL
## $ legend.box.margin          : 'margin' num [1:4] 0cm 0cm 0cm 0cm
## .. attr(*, "unit")= int 1
## $ legend.box.background      : list()
## .. attr(*, "class")= chr [1:2] "element_blank" "element"
## $ legend.box.spacing         : 'simpleUnit' num 11points
## .. attr(*, "unit")= int 8
## [list output truncated]
## - attr(*, "class")= chr [1:2] "theme" "gg"
## - attr(*, "complete")= logi TRUE
## - attr(*, "validate")= logi TRUE
```

```
ggplot(data_nz, aes(x =year, y = visitor2)) +
  geom_point() +
  geom_smooth(color = "blue")
```

```
## 'geom_smooth()' using method = 'loess' and formula = 'y ~ x'
```

```
## Warning: Removed 14 rows containing non-finite outside the scale range
## ('stat_smooth()').
```

```
## Warning: Removed 14 rows containing missing values or values outside the scale range
## ('geom_point()').
```



```
theme_minimal() +
labs(title = "number of visitor change from1983-2023", x = "year", y = "visitor")
```

```
## List of 138
## $ line                                     :List of 6
## ..$ colour          : chr "black"
## ..$ linewidth       : num 0.5
## ..$ linetype        : num 1
## ..$ lineend         : chr "butt"
## ..$ arrow           : logi FALSE
## ..$ inherit.blank   : logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_line" "element"
## $ rect                                     :List of 5
## ..$ fill            : chr "white"
## ..$ colour          : chr "black"
## ..$ linewidth       : num 0.5
## ..$ linetype        : num 1
## ..$ inherit.blank   : logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_rect" "element"
## $ text                                     :List of 11
## ..$ family          : chr ""
## ..$ face            : chr "plain"
## ..$ colour          : chr "black"
## ..$ size            : num 11
## ..$ hjust           : num 0.5
## ..$ vjust           : num 0.5
```

```

## ..$ angle          : num 0
## ..$ lineheight     : num 0.9
## ..$ margin         : 'margin' num [1:4] 0points 0points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug          : logi FALSE
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ title             : chr "number of visitor change from1983-2023"
## $ aspect.ratio      : NULL
## $ axis.title         : NULL
## $ axis.title.x       :List of 11
## ..$ family         : NULL
## ..$ face           : NULL
## ..$ colour         : NULL
## ..$ size           : NULL
## ..$ hjust          : NULL
## ..$ vjust          : num 1
## ..$ angle          : NULL
## ..$ lineheight     : NULL
## ..$ margin         : 'margin' num [1:4] 2.75points 0points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug          : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.x.top   :List of 11
## ..$ family         : NULL
## ..$ face           : NULL
## ..$ colour         : NULL
## ..$ size           : NULL
## ..$ hjust          : NULL
## ..$ vjust          : num 0
## ..$ angle          : NULL
## ..$ lineheight     : NULL
## ..$ margin         : 'margin' num [1:4] 0points 0points 2.75points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug          : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.x.bottom : NULL
## $ axis.title.y       :List of 11
## ..$ family         : NULL
## ..$ face           : NULL
## ..$ colour         : NULL
## ..$ size           : NULL
## ..$ hjust          : NULL
## ..$ vjust          : num 1
## ..$ angle          : num 90
## ..$ lineheight     : NULL
## ..$ margin         : 'margin' num [1:4] 0points 2.75points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug          : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.y.left  : NULL

```



```

## $ axis.title.y.right          :List of 11
## ..$ family                   : NULL
## ..$ face                     : NULL
## ..$ colour                   : NULL
## ..$ size                     : NULL
## ..$ hjust                    : NULL
## ..$ vjust                    : num 1
## ..$ angle                    : num -90
## ..$ lineheight               : NULL
## ..$ margin                   : 'margin' num [1:4] 0points 0points 0points 2.75points
## ..- attr(*, "unit")= int 8
## ..$ debug                    : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text                   :List of 11
## ..$ family                   : NULL
## ..$ face                     : NULL
## ..$ colour                   : chr "grey30"
## ..$ size                     : 'rel' num 0.8
## ..$ hjust                    : NULL
## ..$ vjust                    : NULL
## ..$ angle                    : NULL
## ..$ lineheight               : NULL
## ..$ margin                   : NULL
## ..$ debug                    : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.x                 :List of 11
## ..$ family                   : NULL
## ..$ face                     : NULL
## ..$ colour                   : NULL
## ..$ size                     : NULL
## ..$ hjust                    : NULL
## ..$ vjust                    : num 1
## ..$ angle                    : NULL
## ..$ lineheight               : NULL
## ..$ margin                   : 'margin' num [1:4] 2.2points 0points 0points 0points
## ..- attr(*, "unit")= int 8
## ..$ debug                    : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.x.top             :List of 11
## ..$ family                   : NULL
## ..$ face                     : NULL
## ..$ colour                   : NULL
## ..$ size                     : NULL
## ..$ hjust                    : NULL
## ..$ vjust                    : num 0
## ..$ angle                    : NULL
## ..$ lineheight               : NULL
## ..$ margin                   : 'margin' num [1:4] 0points 0points 2.2points 0points
## ..- attr(*, "unit")= int 8
## ..$ debug                    : NULL
## ..$ inherit.blank: logi TRUE

```

```

##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##   $ axis.text.x.bottom      : NULL
##   $ axis.text.y             :List of 11
##   ..$ family                : NULL
##   ..$ face                  : NULL
##   ..$ colour                : NULL
##   ..$ size                  : NULL
##   ..$ hjust                 : num 1
##   ..$ vjust                 : NULL
##   ..$ angle                 : NULL
##   ..$ lineheight            : NULL
##   ..$ margin                : 'margin' num [1:4] 0points 2.2points 0points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug                 : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##   $ axis.text.y.left        : NULL
##   $ axis.text.y.right       :List of 11
##   ..$ family                : NULL
##   ..$ face                  : NULL
##   ..$ colour                : NULL
##   ..$ size                  : NULL
##   ..$ hjust                 : num 0
##   ..$ vjust                 : NULL
##   ..$ angle                 : NULL
##   ..$ lineheight            : NULL
##   ..$ margin                : 'margin' num [1:4] 0points 0points 0points 2.2points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug                 : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##   $ axis.text.theta         : NULL
##   $ axis.text.r              :List of 11
##   ..$ family                : NULL
##   ..$ face                  : NULL
##   ..$ colour                : NULL
##   ..$ size                  : NULL
##   ..$ hjust                 : num 0.5
##   ..$ vjust                 : NULL
##   ..$ angle                 : NULL
##   ..$ lineheight            : NULL
##   ..$ margin                : 'margin' num [1:4] 0points 2.2points 0points 2.2points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug                 : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##   $ axis.ticks              : list()
##   ..- attr(*, "class")= chr [1:2] "element_blank" "element"
##   $ axis.ticks.x            : NULL
##   $ axis.ticks.x.top        : NULL
##   $ axis.ticks.x.bottom     : NULL
##   $ axis.ticks.y            : NULL
##   $ axis.ticks.y.left       : NULL
##   $ axis.ticks.y.right      : NULL

```

```

## $ axis.ticks.theta : NULL
## $ axis.ticks.r : NULL
## $ axis.minor.ticks.x.top : NULL
## $ axis.minor.ticks.x.bottom : NULL
## $ axis.minor.ticks.y.left : NULL
## $ axis.minor.ticks.y.right : NULL
## $ axis.minor.ticks.theta : NULL
## $ axis.minor.ticks.r : NULL
## $ axis.ticks.length : 'simpleUnit' num 2.75points
## .. attr(*, "unit")= int 8
## $ axis.ticks.length.x : NULL
## $ axis.ticks.length.x.top : NULL
## $ axis.ticks.length.x.bottom : NULL
## $ axis.ticks.length.y : NULL
## $ axis.ticks.length.y.left : NULL
## $ axis.ticks.length.y.right : NULL
## $ axis.ticks.length.theta : NULL
## $ axis.ticks.length.r : NULL
## $ axis.minor.ticks.length : 'rel' num 0.75
## $ axis.minor.ticks.length.x : NULL
## $ axis.minor.ticks.length.x.top : NULL
## $ axis.minor.ticks.length.x.bottom : NULL
## $ axis.minor.ticks.length.y : NULL
## $ axis.minor.ticks.length.y.left : NULL
## $ axis.minor.ticks.length.y.right : NULL
## $ axis.minor.ticks.length.theta : NULL
## $ axis.minor.ticks.length.r : NULL
## $ axis.line : list()
## .. attr(*, "class")= chr [1:2] "element_blank" "element"
## $ axis.line.x : NULL
## $ axis.line.x.top : NULL
## $ axis.line.x.bottom : NULL
## $ axis.line.y : NULL
## $ axis.line.y.left : NULL
## $ axis.line.y.right : NULL
## $ axis.line.theta : NULL
## $ axis.line.r : NULL
## $ legend.background : list()
## .. attr(*, "class")= chr [1:2] "element_blank" "element"
## $ legend.margin : 'margin' num [1:4] 5.5points 5.5points 5.5points 5.5points
## .. attr(*, "unit")= int 8
## $ legend.spacing : 'simpleUnit' num 11points
## .. attr(*, "unit")= int 8
## $ legend.spacing.x : NULL
## $ legend.spacing.y : NULL
## $ legend.key : list()
## .. attr(*, "class")= chr [1:2] "element_blank" "element"
## $ legend.key.size : 'simpleUnit' num 1.2lines
## .. attr(*, "unit")= int 3
## $ legend.key.height : NULL
## $ legend.key.width : NULL
## $ legend.key.spacing : 'simpleUnit' num 5.5points
## .. attr(*, "unit")= int 8
## $ legend.key.spacing.x : NULL

```

```

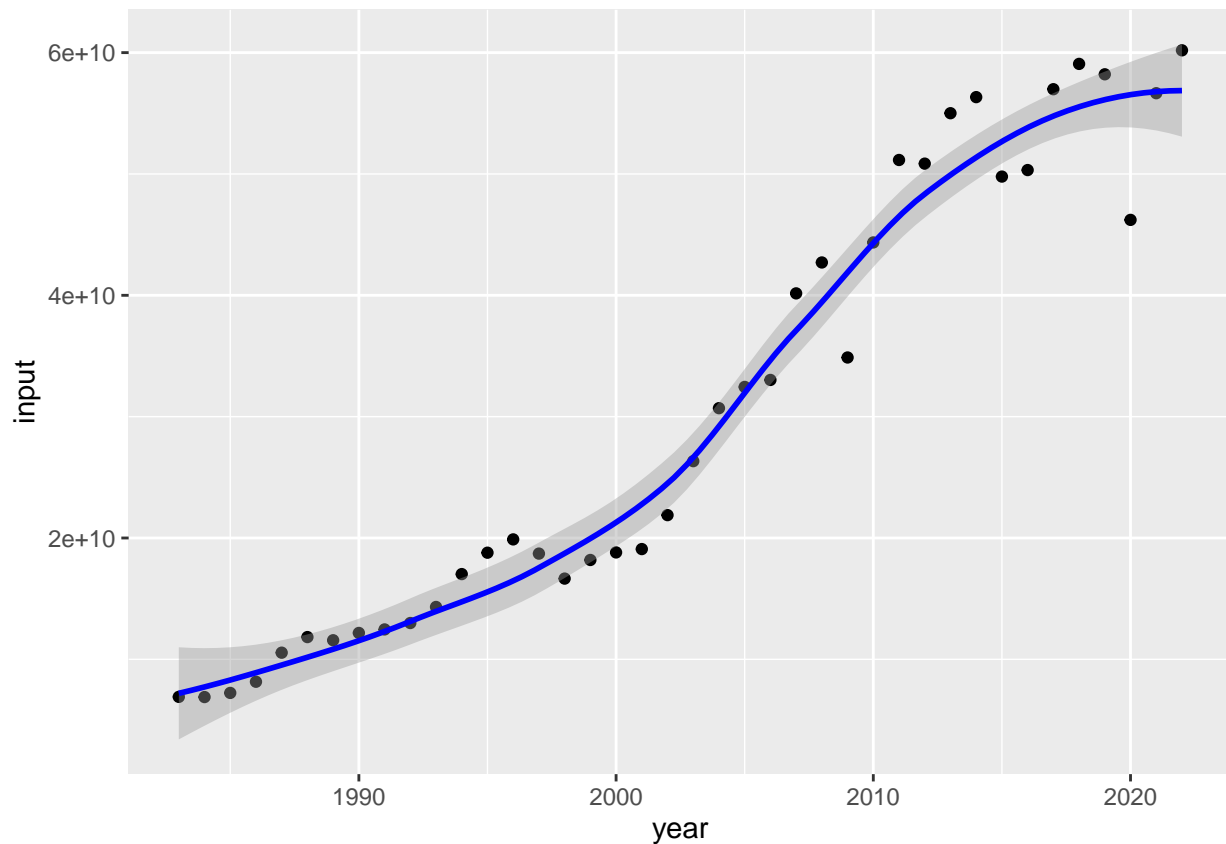
## $ legend.key.spacing.y          : NULL
## $ legend.frame                  : NULL
## $ legend.ticks                  : NULL
## $ legend.ticks.length          : 'rel' num 0.2
## $ legend.axis.line              : NULL
## $ legend.text                   :List of 11
##   ..$ family                   : NULL
##   ..$ face                     : NULL
##   ..$ colour                   : NULL
##   ..$ size                     : 'rel' num 0.8
##   ..$ hjust                   : NULL
##   ..$ vjust                   : NULL
##   ..$ angle                   : NULL
##   ..$ lineheight              : NULL
##   ..$ margin                  : NULL
##   ..$ debug                   : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ legend.text.position          : NULL
## $ legend.title                  :List of 11
##   ..$ family                   : NULL
##   ..$ face                     : NULL
##   ..$ colour                   : NULL
##   ..$ size                     : NULL
##   ..$ hjust                   : num 0
##   ..$ vjust                   : NULL
##   ..$ angle                   : NULL
##   ..$ lineheight              : NULL
##   ..$ margin                  : NULL
##   ..$ debug                   : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ legend.title.position        : NULL
## $ legend.position              : chr "right"
## $ legend.position.inside       : NULL
## $ legend.direction             : NULL
## $ legend.byrow                 : NULL
## $ legend.justification         : chr "center"
## $ legend.justification.top     : NULL
## $ legend.justification.bottom  : NULL
## $ legend.justification.left    : NULL
## $ legend.justification.right   : NULL
## $ legend.justification.inside  : NULL
## $ legend.location              : NULL
## $ legend.box                   : NULL
## $ legend.box.just              : NULL
## $ legend.box.margin            : 'margin' num [1:4] 0cm 0cm 0cm 0cm
##   ..- attr(*, "unit")= int 1
## $ legend.box.background        : list()
##   ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ legend.box.spacing           : 'simpleUnit' num 11points
##   ..- attr(*, "unit")= int 8
## [list output truncated]
## - attr(*, "class")= chr [1:2] "theme" "gg"

```

```
## - attr(*, "complete")= logi TRUE
## - attr(*, "validate")= logi TRUE
```

```
ggplot(data_nz, aes(x =year, y =input)) +
  geom_point() +
  geom_smooth(color = "blue")
```

```
## 'geom_smooth()' using method = 'loess' and formula = 'y ~ x'
```



```
theme_minimal() +
  labs(title = "input change from1983-2023", x = "year", y = "input")
```

```
## List of 138
## $ line                                     :List of 6
## ..$ colour      : chr "black"
## ..$ linewidth    : num 0.5
## ..$ linetype     : num 1
## ..$ lineend      : chr "butt"
## ..$ arrow        : logi FALSE
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_line" "element"
## $ rect                                     :List of 5
## ..$ fill         : chr "white"
## ..$ colour       : chr "black"
## ..$ linewidth    : num 0.5
```

```

## ..$ linetype      : num 1
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_rect" "element"
## $ text              :List of 11
## ..$ family        : chr ""
## ..$ face          : chr "plain"
## ..$ colour        : chr "black"
## ..$ size          : num 11
## ..$ hjust         : num 0.5
## ..$ vjust         : num 0.5
## ..$ angle         : num 0
## ..$ lineheight    : num 0.9
## ..$ margin        : 'margin' num [1:4] 0points 0points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug         : logi FALSE
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ title            : chr "input change from1983-2023"
## $ aspect.ratio     : NULL
## $ axis.title       : NULL
## $ axis.title.x     :List of 11
## ..$ family        : NULL
## ..$ face          : NULL
## ..$ colour        : NULL
## ..$ size          : NULL
## ..$ hjust         : NULL
## ..$ vjust         : num 1
## ..$ angle         : NULL
## ..$ lineheight    : NULL
## ..$ margin        : 'margin' num [1:4] 2.75points 0points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug         : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.x.top :List of 11
## ..$ family        : NULL
## ..$ face          : NULL
## ..$ colour        : NULL
## ..$ size          : NULL
## ..$ hjust         : NULL
## ..$ vjust         : num 0
## ..$ angle         : NULL
## ..$ lineheight    : NULL
## ..$ margin        : 'margin' num [1:4] 0points 0points 2.75points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug         : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.x.bottom : NULL
## $ axis.title.y       :List of 11
## ..$ family        : NULL
## ..$ face          : NULL
## ..$ colour        : NULL
## ..$ size          : NULL

```

```

## ..$ hjust      : NULL
## ..$ vjust      : num 1
## ..$ angle      : num 90
## ..$ lineheight : NULL
## ..$ margin     : 'margin' num [1:4] 0points 2.75points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug      : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.y.left      : NULL
## $ axis.title.y.right     :List of 11
## ..$ family      : NULL
## ..$ face        : NULL
## ..$ colour      : NULL
## ..$ size        : NULL
## ..$ hjust      : NULL
## ..$ vjust      : num 1
## ..$ angle      : num -90
## ..$ lineheight : NULL
## ..$ margin     : 'margin' num [1:4] 0points 0points 0points 2.75points
## .. ..- attr(*, "unit")= int 8
## ..$ debug      : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text      :List of 11
## ..$ family      : NULL
## ..$ face        : NULL
## ..$ colour      : chr "grey30"
## ..$ size        : 'rel' num 0.8
## ..$ hjust      : NULL
## ..$ vjust      : NULL
## ..$ angle      : NULL
## ..$ lineheight : NULL
## ..$ margin     : NULL
## ..$ debug      : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.x    :List of 11
## ..$ family      : NULL
## ..$ face        : NULL
## ..$ colour      : NULL
## ..$ size        : NULL
## ..$ hjust      : NULL
## ..$ vjust      : num 1
## ..$ angle      : NULL
## ..$ lineheight : NULL
## ..$ margin     : 'margin' num [1:4] 2.2points 0points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug      : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.x.top :List of 11
## ..$ family      : NULL
## ..$ face        : NULL

```

```

## ..$ colour      : NULL
## ..$ size        : NULL
## ..$ hjust       : NULL
## ..$ vjust       : num 0
## ..$ angle       : NULL
## ..$ lineheight  : NULL
## ..$ margin      : 'margin' num [1:4] 0points 0points 2.2points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug       : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.x.bottom      : NULL
## $ axis.text.y             :List of 11
## ..$ family              : NULL
## ..$ face                : NULL
## ..$ colour              : NULL
## ..$ size                : NULL
## ..$ hjust               : num 1
## ..$ vjust               : NULL
## ..$ angle               : NULL
## ..$ lineheight          : NULL
## ..$ margin              : 'margin' num [1:4] 0points 2.2points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug              : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.y.left       : NULL
## $ axis.text.y.right      :List of 11
## ..$ family              : NULL
## ..$ face                : NULL
## ..$ colour              : NULL
## ..$ size                : NULL
## ..$ hjust               : num 0
## ..$ vjust               : NULL
## ..$ angle               : NULL
## ..$ lineheight          : NULL
## ..$ margin              : 'margin' num [1:4] 0points 0points 0points 2.2points
## .. ..- attr(*, "unit")= int 8
## ..$ debug              : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.theta        : NULL
## $ axis.text.r            :List of 11
## ..$ family              : NULL
## ..$ face                : NULL
## ..$ colour              : NULL
## ..$ size                : NULL
## ..$ hjust               : num 0.5
## ..$ vjust               : NULL
## ..$ angle               : NULL
## ..$ lineheight          : NULL
## ..$ margin              : 'margin' num [1:4] 0points 2.2points 0points 2.2points
## .. ..- attr(*, "unit")= int 8
## ..$ debug              : NULL

```



```

## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.ticks : list()
## ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ axis.ticks.x : NULL
## $ axis.ticks.x.top : NULL
## $ axis.ticks.x.bottom : NULL
## $ axis.ticks.y : NULL
## $ axis.ticks.y.left : NULL
## $ axis.ticks.y.right : NULL
## $ axis.ticks.theta : NULL
## $ axis.ticks.r : NULL
## $ axis.minor.ticks.x.top : NULL
## $ axis.minor.ticks.x.bottom : NULL
## $ axis.minor.ticks.y.left : NULL
## $ axis.minor.ticks.y.right : NULL
## $ axis.minor.ticks.theta : NULL
## $ axis.minor.ticks.r : NULL
## $ axis.ticks.length : 'simpleUnit' num 2.75points
## ..- attr(*, "unit")= int 8
## $ axis.ticks.length.x : NULL
## $ axis.ticks.length.x.top : NULL
## $ axis.ticks.length.x.bottom : NULL
## $ axis.ticks.length.y : NULL
## $ axis.ticks.length.y.left : NULL
## $ axis.ticks.length.y.right : NULL
## $ axis.ticks.length.theta : NULL
## $ axis.ticks.length.r : NULL
## $ axis.minor.ticks.length : 'rel' num 0.75
## $ axis.minor.ticks.length.x : NULL
## $ axis.minor.ticks.length.x.top : NULL
## $ axis.minor.ticks.length.x.bottom : NULL
## $ axis.minor.ticks.length.y : NULL
## $ axis.minor.ticks.length.y.left : NULL
## $ axis.minor.ticks.length.y.right : NULL
## $ axis.minor.ticks.length.theta : NULL
## $ axis.minor.ticks.length.r : NULL
## $ axis.line : list()
## ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ axis.line.x : NULL
## $ axis.line.x.top : NULL
## $ axis.line.x.bottom : NULL
## $ axis.line.y : NULL
## $ axis.line.y.left : NULL
## $ axis.line.y.right : NULL
## $ axis.line.theta : NULL
## $ axis.line.r : NULL
## $ legend.background : list()
## ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ legend.margin : 'margin' num [1:4] 5.5points 5.5points 5.5points 5.5points
## ..- attr(*, "unit")= int 8
## $ legend.spacing : 'simpleUnit' num 11points
## ..- attr(*, "unit")= int 8
## $ legend.spacing.x : NULL

```

```

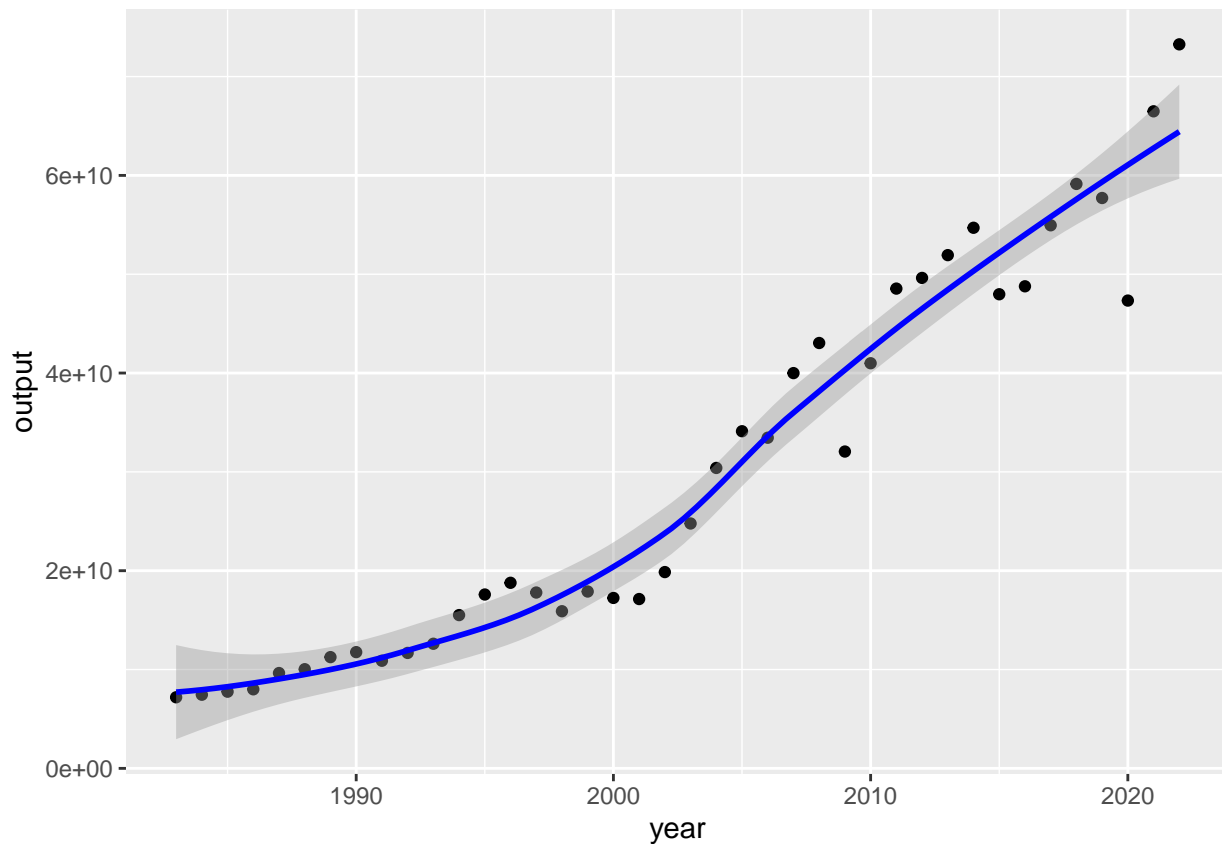
## $ legend.spacing.y           : NULL
## $ legend.key                 : list()
##   .. attr(*, "class")= chr [1:2] "element_blank" "element"
## $ legend.key.size            : 'simpleUnit' num 1.2lines
##   .. attr(*, "unit")= int 3
## $ legend.key.height          : NULL
## $ legend.key.width           : NULL
## $ legend.key.spacing         : 'simpleUnit' num 5.5points
##   .. attr(*, "unit")= int 8
## $ legend.key.spacing.x       : NULL
## $ legend.key.spacing.y       : NULL
## $ legend.frame               : NULL
## $ legend.ticks               : NULL
## $ legend.ticks.length        : 'rel' num 0.2
## $ legend.axis.line           : NULL
## $ legend.text                :List of 11
##   ..$ family                 : NULL
##   ..$ face                   : NULL
##   ..$ colour                 : NULL
##   ..$ size                   : 'rel' num 0.8
##   ..$ hjust                  : NULL
##   ..$ vjust                  : NULL
##   ..$ angle                  : NULL
##   ..$ lineheight             : NULL
##   ..$ margin                 : NULL
##   ..$ debug                  : NULL
##   ..$ inherit.blank: logi TRUE
##   .. attr(*, "class")= chr [1:2] "element_text" "element"
## $ legend.text.position       : NULL
## $ legend.title               :List of 11
##   ..$ family                 : NULL
##   ..$ face                   : NULL
##   ..$ colour                 : NULL
##   ..$ size                   : NULL
##   ..$ hjust                  : num 0
##   ..$ vjust                  : NULL
##   ..$ angle                  : NULL
##   ..$ lineheight             : NULL
##   ..$ margin                 : NULL
##   ..$ debug                  : NULL
##   ..$ inherit.blank: logi TRUE
##   .. attr(*, "class")= chr [1:2] "element_text" "element"
## $ legend.title.position      : NULL
## $ legend.position            : chr "right"
## $ legend.position.inside     : NULL
## $ legend.direction           : NULL
## $ legend.byrow               : NULL
## $ legend.justification       : chr "center"
## $ legend.justification.top    : NULL
## $ legend.justification.bottom : NULL
## $ legend.justification.left   : NULL
## $ legend.justification.right  : NULL
## $ legend.justification.inside : NULL
## $ legend.location            : NULL

```

```
## $ legend.box                : NULL
## $ legend.box.just           : NULL
## $ legend.box.margin         : 'margin' num [1:4] 0cm 0cm 0cm 0cm
##   .. attr(*, "unit")= int 1
## $ legend.box.background     : list()
##   .. attr(*, "class")= chr [1:2] "element_blank" "element"
## $ legend.box.spacing        : 'simpleUnit' num 11points
##   .. attr(*, "unit")= int 8
## [list output truncated]
## - attr(*, "class")= chr [1:2] "theme" "gg"
## - attr(*, "complete")= logi TRUE
## - attr(*, "validate")= logi TRUE
```

```
ggplot(data_nz, aes(x =year, y =output)) +
  geom_point() +
  geom_smooth(color = "blue")
```

```
## 'geom_smooth()' using method = 'loess' and formula = 'y ~ x'
```



```
theme_minimal() +
  labs(title = "input change from1983-2023", x = "year", y = "output")
```

```
## List of 138
## $ line                :List of 6
##   ..$ colour          : chr "black"
```

```

## ..$ linewidth      : num 0.5
## ..$ linetype       : num 1
## ..$ lineend        : chr "butt"
## ..$ arrow          : logi FALSE
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_line" "element"
## $ rect              :List of 5
## ..$ fill           : chr "white"
## ..$ colour         : chr "black"
## ..$ linewidth      : num 0.5
## ..$ linetype       : num 1
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_rect" "element"
## $ text              :List of 11
## ..$ family         : chr ""
## ..$ face           : chr "plain"
## ..$ colour         : chr "black"
## ..$ size           : num 11
## ..$ hjust          : num 0.5
## ..$ vjust          : num 0.5
## ..$ angle          : num 0
## ..$ lineheight     : num 0.9
## ..$ margin         : 'margin' num [1:4] 0points 0points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug          : logi FALSE
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ title             : chr "input change from1983-2023"
## $ aspect.ratio      : NULL
## $ axis.title        : NULL
## $ axis.title.x      :List of 11
## ..$ family         : NULL
## ..$ face           : NULL
## ..$ colour         : NULL
## ..$ size           : NULL
## ..$ hjust          : NULL
## ..$ vjust          : num 1
## ..$ angle          : NULL
## ..$ lineheight     : NULL
## ..$ margin         : 'margin' num [1:4] 2.75points 0points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug          : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.x.top  :List of 11
## ..$ family         : NULL
## ..$ face           : NULL
## ..$ colour         : NULL
## ..$ size           : NULL
## ..$ hjust          : NULL
## ..$ vjust          : num 0
## ..$ angle          : NULL
## ..$ lineheight     : NULL
## ..$ margin         : 'margin' num [1:4] 0points 0points 2.75points 0points

```

```

## ..- attr(*, "unit")= int 8
## ..$ debug : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.x.bottom : NULL
## $ axis.title.y :List of 11
## ..$ family : NULL
## ..$ face : NULL
## ..$ colour : NULL
## ..$ size : NULL
## ..$ hjust : NULL
## ..$ vjust : num 1
## ..$ angle : num 90
## ..$ lineheight : NULL
## ..$ margin : 'margin' num [1:4] 0points 2.75points 0points 0points
## ..- attr(*, "unit")= int 8
## ..$ debug : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.y.left : NULL
## $ axis.title.y.right :List of 11
## ..$ family : NULL
## ..$ face : NULL
## ..$ colour : NULL
## ..$ size : NULL
## ..$ hjust : NULL
## ..$ vjust : num 1
## ..$ angle : num -90
## ..$ lineheight : NULL
## ..$ margin : 'margin' num [1:4] 0points 0points 0points 2.75points
## ..- attr(*, "unit")= int 8
## ..$ debug : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text :List of 11
## ..$ family : NULL
## ..$ face : NULL
## ..$ colour : chr "grey30"
## ..$ size : 'rel' num 0.8
## ..$ hjust : NULL
## ..$ vjust : NULL
## ..$ angle : NULL
## ..$ lineheight : NULL
## ..$ margin : NULL
## ..$ debug : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.x :List of 11
## ..$ family : NULL
## ..$ face : NULL
## ..$ colour : NULL
## ..$ size : NULL
## ..$ hjust : NULL
## ..$ vjust : num 1

```

```

## ..$ angle          : NULL
## ..$ lineheight     : NULL
## ..$ margin         : 'margin' num [1:4] 2.2points 0points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug          : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.x.top           :List of 11
## ..$ family            : NULL
## ..$ face              : NULL
## ..$ colour           : NULL
## ..$ size              : NULL
## ..$ hjust            : NULL
## ..$ vjust            : num 0
## ..$ angle            : NULL
## ..$ lineheight       : NULL
## ..$ margin           : 'margin' num [1:4] 0points 0points 2.2points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug            : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.x.bottom       : NULL
## $ axis.text.y              :List of 11
## ..$ family            : NULL
## ..$ face              : NULL
## ..$ colour           : NULL
## ..$ size              : NULL
## ..$ hjust            : num 1
## ..$ vjust            : NULL
## ..$ angle            : NULL
## ..$ lineheight       : NULL
## ..$ margin           : 'margin' num [1:4] 0points 2.2points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug            : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.y.left        : NULL
## $ axis.text.y.right       :List of 11
## ..$ family            : NULL
## ..$ face              : NULL
## ..$ colour           : NULL
## ..$ size              : NULL
## ..$ hjust            : num 0
## ..$ vjust            : NULL
## ..$ angle            : NULL
## ..$ lineheight       : NULL
## ..$ margin           : 'margin' num [1:4] 0points 0points 0points 2.2points
## .. ..- attr(*, "unit")= int 8
## ..$ debug            : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.theta         : NULL
## $ axis.text.r             :List of 11
## ..$ family            : NULL

```

```

## ..$ face          : NULL
## ..$ colour        : NULL
## ..$ size          : NULL
## ..$ hjust         : num 0.5
## ..$ vjust         : NULL
## ..$ angle         : NULL
## ..$ lineheight    : NULL
## ..$ margin        : 'margin' num [1:4] 0points 2.2points 0points 2.2points
## ..- attr(*, "unit")= int 8
## ..$ debug         : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.ticks      : list()
## ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ axis.ticks.x     : NULL
## $ axis.ticks.x.top : NULL
## $ axis.ticks.x.bottom : NULL
## $ axis.ticks.y     : NULL
## $ axis.ticks.y.left : NULL
## $ axis.ticks.y.right : NULL
## $ axis.ticks.theta : NULL
## $ axis.ticks.r     : NULL
## $ axis.minor.ticks.x.top : NULL
## $ axis.minor.ticks.x.bottom : NULL
## $ axis.minor.ticks.y.left : NULL
## $ axis.minor.ticks.y.right : NULL
## $ axis.minor.ticks.theta : NULL
## $ axis.minor.ticks.r     : NULL
## $ axis.ticks.length     : 'simpleUnit' num 2.75points
## ..- attr(*, "unit")= int 8
## $ axis.ticks.length.x : NULL
## $ axis.ticks.length.x.top : NULL
## $ axis.ticks.length.x.bottom : NULL
## $ axis.ticks.length.y : NULL
## $ axis.ticks.length.y.left : NULL
## $ axis.ticks.length.y.right : NULL
## $ axis.ticks.length.theta : NULL
## $ axis.ticks.length.r : NULL
## $ axis.minor.ticks.length : 'rel' num 0.75
## $ axis.minor.ticks.length.x : NULL
## $ axis.minor.ticks.length.x.top : NULL
## $ axis.minor.ticks.length.x.bottom : NULL
## $ axis.minor.ticks.length.y : NULL
## $ axis.minor.ticks.length.y.left : NULL
## $ axis.minor.ticks.length.y.right : NULL
## $ axis.minor.ticks.length.theta : NULL
## $ axis.minor.ticks.length.r : NULL
## $ axis.line : list()
## ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ axis.line.x : NULL
## $ axis.line.x.top : NULL
## $ axis.line.x.bottom : NULL
## $ axis.line.y : NULL
## $ axis.line.y.left : NULL

```

```

## $ axis.line.y.right      : NULL
## $ axis.line.theta       : NULL
## $ axis.line.r           : NULL
## $ legend.background     : list()
##   ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ legend.margin         : 'margin' num [1:4] 5.5points 5.5points 5.5points 5.5points
##   ..- attr(*, "unit")= int 8
## $ legend.spacing        : 'simpleUnit' num 11points
##   ..- attr(*, "unit")= int 8
## $ legend.spacing.x      : NULL
## $ legend.spacing.y      : NULL
## $ legend.key            : list()
##   ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ legend.key.size       : 'simpleUnit' num 1.2lines
##   ..- attr(*, "unit")= int 3
## $ legend.key.height     : NULL
## $ legend.key.width      : NULL
## $ legend.key.spacing    : 'simpleUnit' num 5.5points
##   ..- attr(*, "unit")= int 8
## $ legend.key.spacing.x  : NULL
## $ legend.key.spacing.y  : NULL
## $ legend.frame          : NULL
## $ legend.ticks          : NULL
## $ legend.ticks.length   : 'rel' num 0.2
## $ legend.axis.line      : NULL
## $ legend.text           :List of 11
##   ..$ family           : NULL
##   ..$ face              : NULL
##   ..$ colour           : NULL
##   ..$ size              : 'rel' num 0.8
##   ..$ hjust            : NULL
##   ..$ vjust            : NULL
##   ..$ angle            : NULL
##   ..$ lineheight       : NULL
##   ..$ margin           : NULL
##   ..$ debug            : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ legend.text.position   : NULL
## $ legend.title          :List of 11
##   ..$ family           : NULL
##   ..$ face              : NULL
##   ..$ colour           : NULL
##   ..$ size              : NULL
##   ..$ hjust            : num 0
##   ..$ vjust            : NULL
##   ..$ angle            : NULL
##   ..$ lineheight       : NULL
##   ..$ margin           : NULL
##   ..$ debug            : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ legend.title.position  : NULL
## $ legend.position       : chr "right"

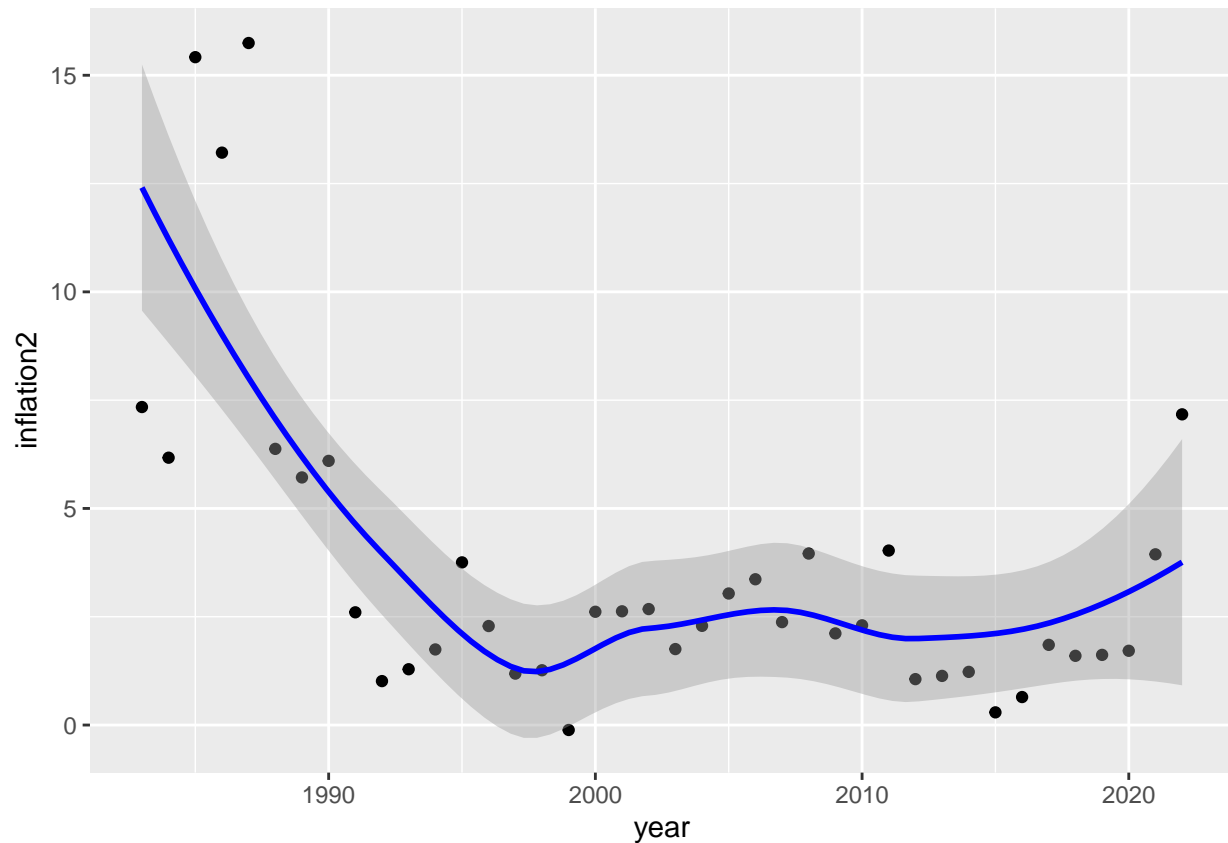
```



```
## $ legend.position.inside      : NULL
## $ legend.direction           : NULL
## $ legend.byrow               : NULL
## $ legend.justification       : chr "center"
## $ legend.justification.top    : NULL
## $ legend.justification.bottom : NULL
## $ legend.justification.left   : NULL
## $ legend.justification.right  : NULL
## $ legend.justification.inside : NULL
## $ legend.location            : NULL
## $ legend.box                 : NULL
## $ legend.box.just            : NULL
## $ legend.box.margin          : 'margin' num [1:4] 0cm 0cm 0cm 0cm
##   .. attr(*, "unit")= int 1
## $ legend.box.background      : list()
##   .. attr(*, "class")= chr [1:2] "element_blank" "element"
## $ legend.box.spacing         : 'simpleUnit' num 11points
##   .. attr(*, "unit")= int 8
## [list output truncated]
## - attr(*, "class")= chr [1:2] "theme" "gg"
## - attr(*, "complete")= logi TRUE
## - attr(*, "validate")= logi TRUE
```

```
ggplot(data_nz, aes(x =year, y =inflation2)) +
  geom_point() +
  geom_smooth(color = "blue")
```

```
## 'geom_smooth()' using method = 'loess' and formula = 'y ~ x'
```



```
theme_minimal() +
labs(title = "inflation from1983-2023", x = "year", y = "inflation")
```

```
## List of 138
## $ line                                     :List of 6
##   ..$ colour      : chr "black"
##   ..$ linewidth    : num 0.5
##   ..$ linetype     : num 1
##   ..$ lineend      : chr "butt"
##   ..$ arrow        : logi FALSE
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_line" "element"
## $ rect                                     :List of 5
##   ..$ fill         : chr "white"
##   ..$ colour       : chr "black"
##   ..$ linewidth    : num 0.5
##   ..$ linetype     : num 1
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_rect" "element"
## $ text                                    :List of 11
##   ..$ family       : chr ""
##   ..$ face         : chr "plain"
##   ..$ colour       : chr "black"
##   ..$ size         : num 11
##   ..$ hjust        : num 0.5
##   ..$ vjust        : num 0.5
```

```

## ..$ angle      : num 0
## ..$ lineheight  : num 0.9
## ..$ margin      : 'margin' num [1:4] 0points 0points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug       : logi FALSE
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ title         : chr "inflation from1983-2023"
## $ aspect.ratio   : NULL
## $ axis.title     : NULL
## $ axis.title.x    :List of 11
## ..$ family      : NULL
## ..$ face        : NULL
## ..$ colour      : NULL
## ..$ size        : NULL
## ..$ hjust       : NULL
## ..$ vjust       : num 1
## ..$ angle       : NULL
## ..$ lineheight  : NULL
## ..$ margin      : 'margin' num [1:4] 2.75points 0points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug       : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.x.top :List of 11
## ..$ family      : NULL
## ..$ face        : NULL
## ..$ colour      : NULL
## ..$ size        : NULL
## ..$ hjust       : NULL
## ..$ vjust       : num 0
## ..$ angle       : NULL
## ..$ lineheight  : NULL
## ..$ margin      : 'margin' num [1:4] 0points 0points 2.75points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug       : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.x.bottom : NULL
## $ axis.title.y        :List of 11
## ..$ family          : NULL
## ..$ face            : NULL
## ..$ colour          : NULL
## ..$ size            : NULL
## ..$ hjust           : NULL
## ..$ vjust           : num 1
## ..$ angle           : num 90
## ..$ lineheight      : NULL
## ..$ margin          : 'margin' num [1:4] 0points 2.75points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug           : NULL
## ..$ inherit.blank   : logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.y.left  : NULL

```

```

## $ axis.title.y.right          :List of 11
## ..$ family                   : NULL
## ..$ face                     : NULL
## ..$ colour                   : NULL
## ..$ size                     : NULL
## ..$ hjust                    : NULL
## ..$ vjust                    : num 1
## ..$ angle                    : num -90
## ..$ lineheight               : NULL
## ..$ margin                   : 'margin' num [1:4] 0points 0points 0points 2.75points
## .. ..- attr(*, "unit")= int 8
## ..$ debug                    : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text                   :List of 11
## ..$ family                   : NULL
## ..$ face                     : NULL
## ..$ colour                   : chr "grey30"
## ..$ size                     : 'rel' num 0.8
## ..$ hjust                    : NULL
## ..$ vjust                    : NULL
## ..$ angle                    : NULL
## ..$ lineheight               : NULL
## ..$ margin                   : NULL
## ..$ debug                    : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.x                 :List of 11
## ..$ family                   : NULL
## ..$ face                     : NULL
## ..$ colour                   : NULL
## ..$ size                     : NULL
## ..$ hjust                    : NULL
## ..$ vjust                    : num 1
## ..$ angle                    : NULL
## ..$ lineheight               : NULL
## ..$ margin                   : 'margin' num [1:4] 2.2points 0points 0points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug                    : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.x.top             :List of 11
## ..$ family                   : NULL
## ..$ face                     : NULL
## ..$ colour                   : NULL
## ..$ size                     : NULL
## ..$ hjust                    : NULL
## ..$ vjust                    : num 0
## ..$ angle                    : NULL
## ..$ lineheight               : NULL
## ..$ margin                   : 'margin' num [1:4] 0points 0points 2.2points 0points
## .. ..- attr(*, "unit")= int 8
## ..$ debug                    : NULL
## ..$ inherit.blank: logi TRUE

```

```

##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##   $ axis.text.x.bottom      : NULL
##   $ axis.text.y             :List of 11
##   ..$ family                : NULL
##   ..$ face                  : NULL
##   ..$ colour                : NULL
##   ..$ size                  : NULL
##   ..$ hjust                 : num 1
##   ..$ vjust                 : NULL
##   ..$ angle                 : NULL
##   ..$ lineheight            : NULL
##   ..$ margin                : 'margin' num [1:4] 0points 2.2points 0points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug                 : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##   $ axis.text.y.left        : NULL
##   $ axis.text.y.right       :List of 11
##   ..$ family                : NULL
##   ..$ face                  : NULL
##   ..$ colour                : NULL
##   ..$ size                  : NULL
##   ..$ hjust                 : num 0
##   ..$ vjust                 : NULL
##   ..$ angle                 : NULL
##   ..$ lineheight            : NULL
##   ..$ margin                : 'margin' num [1:4] 0points 0points 0points 2.2points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug                 : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##   $ axis.text.theta         : NULL
##   $ axis.text.r             :List of 11
##   ..$ family                : NULL
##   ..$ face                  : NULL
##   ..$ colour                : NULL
##   ..$ size                  : NULL
##   ..$ hjust                 : num 0.5
##   ..$ vjust                 : NULL
##   ..$ angle                 : NULL
##   ..$ lineheight            : NULL
##   ..$ margin                : 'margin' num [1:4] 0points 2.2points 0points 2.2points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug                 : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##   $ axis.ticks              : list()
##   ..- attr(*, "class")= chr [1:2] "element_blank" "element"
##   $ axis.ticks.x            : NULL
##   $ axis.ticks.x.top        : NULL
##   $ axis.ticks.x.bottom     : NULL
##   $ axis.ticks.y            : NULL
##   $ axis.ticks.y.left       : NULL
##   $ axis.ticks.y.right      : NULL

```

```

## $ axis.ticks.theta : NULL
## $ axis.ticks.r : NULL
## $ axis.minor.ticks.x.top : NULL
## $ axis.minor.ticks.x.bottom : NULL
## $ axis.minor.ticks.y.left : NULL
## $ axis.minor.ticks.y.right : NULL
## $ axis.minor.ticks.theta : NULL
## $ axis.minor.ticks.r : NULL
## $ axis.ticks.length : 'simpleUnit' num 2.75points
## ..- attr(*, "unit")= int 8
## $ axis.ticks.length.x : NULL
## $ axis.ticks.length.x.top : NULL
## $ axis.ticks.length.x.bottom : NULL
## $ axis.ticks.length.y : NULL
## $ axis.ticks.length.y.left : NULL
## $ axis.ticks.length.y.right : NULL
## $ axis.ticks.length.theta : NULL
## $ axis.ticks.length.r : NULL
## $ axis.minor.ticks.length : 'rel' num 0.75
## $ axis.minor.ticks.length.x : NULL
## $ axis.minor.ticks.length.x.top : NULL
## $ axis.minor.ticks.length.x.bottom : NULL
## $ axis.minor.ticks.length.y : NULL
## $ axis.minor.ticks.length.y.left : NULL
## $ axis.minor.ticks.length.y.right : NULL
## $ axis.minor.ticks.length.theta : NULL
## $ axis.minor.ticks.length.r : NULL
## $ axis.line : list()
## ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ axis.line.x : NULL
## $ axis.line.x.top : NULL
## $ axis.line.x.bottom : NULL
## $ axis.line.y : NULL
## $ axis.line.y.left : NULL
## $ axis.line.y.right : NULL
## $ axis.line.theta : NULL
## $ axis.line.r : NULL
## $ legend.background : list()
## ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ legend.margin : 'margin' num [1:4] 5.5points 5.5points 5.5points 5.5points
## ..- attr(*, "unit")= int 8
## $ legend.spacing : 'simpleUnit' num 11points
## ..- attr(*, "unit")= int 8
## $ legend.spacing.x : NULL
## $ legend.spacing.y : NULL
## $ legend.key : list()
## ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ legend.key.size : 'simpleUnit' num 1.2lines
## ..- attr(*, "unit")= int 3
## $ legend.key.height : NULL
## $ legend.key.width : NULL
## $ legend.key.spacing : 'simpleUnit' num 5.5points
## ..- attr(*, "unit")= int 8
## $ legend.key.spacing.x : NULL

```

```

## $ legend.key.spacing.y      : NULL
## $ legend.frame              : NULL
## $ legend.ticks              : NULL
## $ legend.ticks.length       : 'rel' num 0.2
## $ legend.axis.line          : NULL
## $ legend.text                :List of 11
##   ..$ family                : NULL
##   ..$ face                   : NULL
##   ..$ colour                 : NULL
##   ..$ size                   : 'rel' num 0.8
##   ..$ hjust                  : NULL
##   ..$ vjust                  : NULL
##   ..$ angle                  : NULL
##   ..$ lineheight             : NULL
##   ..$ margin                 : NULL
##   ..$ debug                  : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ legend.text.position       : NULL
## $ legend.title               :List of 11
##   ..$ family                : NULL
##   ..$ face                   : NULL
##   ..$ colour                 : NULL
##   ..$ size                   : NULL
##   ..$ hjust                  : num 0
##   ..$ vjust                  : NULL
##   ..$ angle                  : NULL
##   ..$ lineheight             : NULL
##   ..$ margin                 : NULL
##   ..$ debug                  : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ legend.title.position      : NULL
## $ legend.position            : chr "right"
## $ legend.position.inside     : NULL
## $ legend.direction           : NULL
## $ legend.byrow               : NULL
## $ legend.justification       : chr "center"
## $ legend.justification.top    : NULL
## $ legend.justification.bottom : NULL
## $ legend.justification.left   : NULL
## $ legend.justification.right  : NULL
## $ legend.justification.inside : NULL
## $ legend.location            : NULL
## $ legend.box                 : NULL
## $ legend.box.just            : NULL
## $ legend.box.margin          : 'margin' num [1:4] 0cm 0cm 0cm 0cm
##   ..- attr(*, "unit")= int 1
## $ legend.box.background      : list()
##   ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ legend.box.spacing         : 'simpleUnit' num 11points
##   ..- attr(*, "unit")= int 8
## [list output truncated]
## - attr(*, "class")= chr [1:2] "theme" "gg"

```

```
## - attr(*, "complete")= logi TRUE
## - attr(*, "validate")= logi TRUE
```

As we can see from the graphs,GDP,income,population,input,output are linear,which are upwards,and inflation show downwards trend.For visitor,standard error is too big,there are a lot of missing data,especially there is a outlier 2020(because of Covid) makes the curve downwards.These may affect the analyse,we will see in regression part.

Model

This should be a linear problem,so I will consider linear model.

linear model

```
regression1<-lm(gdp~income2+population2+input+output+visitor2+inflation2,data_nz)
summary(regression1)
```

```
##
## Call:
## lm(formula = gdp ~ income2 + population2 + input + output + visitor2 +
##      inflation2, data = data_nz)
##
## Residuals:
##      Min        1Q      Median        3Q       Max
## -4.394e+09 -2.268e+09  5.914e+07  1.511e+09  6.183e+09
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -1.516e+11  1.401e+10 -10.823  1.45e-09 ***
## income2      3.713e+06   5.079e+05   7.310  6.23e-07 ***
## population2  3.989e+04   3.849e+03  10.362  2.96e-09 ***
## input        9.429e-02   5.452e-01   0.173   0.865
## output       9.026e-02   5.456e-01   0.165   0.870
## visitor2     -1.338e+03   1.775e+03  -0.754   0.460
## inflation2   -8.582e+08   6.176e+08  -1.390   0.181
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.895e+09 on 19 degrees of freedom
## (14 observations deleted due to missingness)
## Multiple R-squared:  0.9982, Adjusted R-squared:  0.9976
## F-statistic: 1711 on 6 and 19 DF,  p-value: < 2.2e-16
```

From T test we can see intercept,GDP,income is small enough to indicate strong effect,for but rest of them might not enough,I might choose another model.

Then I use GLM and I remove visitor

```
regression<-stan_glm(gdp~income2+population2+input+output+inflation2,data_nz,family = gaussian)

##
## SAMPLING FOR MODEL 'continuous' NOW (CHAIN 1).
## Chain 1:
## Chain 1: Gradient evaluation took 6.1e-05 seconds
```



```

## Chain 1: 1000 transitions using 10 leapfrog steps per transition would take 0.61 seconds.
## Chain 1: Adjust your expectations accordingly!
## Chain 1:
## Chain 1:
## Chain 1: Iteration:    1 / 2000 [  0%] (Warmup)
## Chain 1: Iteration:   200 / 2000 [ 10%] (Warmup)
## Chain 1: Iteration:   400 / 2000 [ 20%] (Warmup)
## Chain 1: Iteration:   600 / 2000 [ 30%] (Warmup)
## Chain 1: Iteration:   800 / 2000 [ 40%] (Warmup)
## Chain 1: Iteration:  1000 / 2000 [ 50%] (Warmup)
## Chain 1: Iteration: 1001 / 2000 [ 50%] (Sampling)
## Chain 1: Iteration: 1200 / 2000 [ 60%] (Sampling)
## Chain 1: Iteration: 1400 / 2000 [ 70%] (Sampling)
## Chain 1: Iteration: 1600 / 2000 [ 80%] (Sampling)
## Chain 1: Iteration: 1800 / 2000 [ 90%] (Sampling)
## Chain 1: Iteration: 2000 / 2000 [100%] (Sampling)
## Chain 1:
## Chain 1: Elapsed Time: 8.985 seconds (Warm-up)
## Chain 1:           1.118 seconds (Sampling)
## Chain 1:           10.103 seconds (Total)
## Chain 1:
##
## SAMPLING FOR MODEL 'continuous' NOW (CHAIN 2).
## Chain 2:
## Chain 2: Gradient evaluation took 3.1e-05 seconds
## Chain 2: 1000 transitions using 10 leapfrog steps per transition would take 0.31 seconds.
## Chain 2: Adjust your expectations accordingly!
## Chain 2:
## Chain 2:
## Chain 2: Iteration:    1 / 2000 [  0%] (Warmup)
## Chain 2: Iteration:   200 / 2000 [ 10%] (Warmup)
## Chain 2: Iteration:   400 / 2000 [ 20%] (Warmup)
## Chain 2: Iteration:   600 / 2000 [ 30%] (Warmup)
## Chain 2: Iteration:   800 / 2000 [ 40%] (Warmup)
## Chain 2: Iteration:  1000 / 2000 [ 50%] (Warmup)
## Chain 2: Iteration: 1001 / 2000 [ 50%] (Sampling)
## Chain 2: Iteration: 1200 / 2000 [ 60%] (Sampling)
## Chain 2: Iteration: 1400 / 2000 [ 70%] (Sampling)
## Chain 2: Iteration: 1600 / 2000 [ 80%] (Sampling)
## Chain 2: Iteration: 1800 / 2000 [ 90%] (Sampling)
## Chain 2: Iteration: 2000 / 2000 [100%] (Sampling)
## Chain 2:
## Chain 2: Elapsed Time: 21.404 seconds (Warm-up)
## Chain 2:           0.993 seconds (Sampling)
## Chain 2:           22.397 seconds (Total)
## Chain 2:
##
## SAMPLING FOR MODEL 'continuous' NOW (CHAIN 3).
## Chain 3:
## Chain 3: Gradient evaluation took 3.2e-05 seconds
## Chain 3: 1000 transitions using 10 leapfrog steps per transition would take 0.32 seconds.
## Chain 3: Adjust your expectations accordingly!
## Chain 3:
## Chain 3:

```

```

## Chain 3: Iteration:    1 / 2000 [ 0%] (Warmup)
## Chain 3: Iteration:   200 / 2000 [ 10%] (Warmup)
## Chain 3: Iteration:   400 / 2000 [ 20%] (Warmup)
## Chain 3: Iteration:   600 / 2000 [ 30%] (Warmup)
## Chain 3: Iteration:   800 / 2000 [ 40%] (Warmup)
## Chain 3: Iteration:  1000 / 2000 [ 50%] (Warmup)
## Chain 3: Iteration: 1001 / 2000 [ 50%] (Sampling)
## Chain 3: Iteration:  1200 / 2000 [ 60%] (Sampling)
## Chain 3: Iteration:  1400 / 2000 [ 70%] (Sampling)
## Chain 3: Iteration:  1600 / 2000 [ 80%] (Sampling)
## Chain 3: Iteration:  1800 / 2000 [ 90%] (Sampling)
## Chain 3: Iteration:  2000 / 2000 [100%] (Sampling)
## Chain 3:
## Chain 3: Elapsed Time: 12.395 seconds (Warm-up)
## Chain 3:                1.176 seconds (Sampling)
## Chain 3:                13.571 seconds (Total)
## Chain 3:
##
## SAMPLING FOR MODEL 'continuous' NOW (CHAIN 4).
## Chain 4:
## Chain 4: Gradient evaluation took 3.1e-05 seconds
## Chain 4: 1000 transitions using 10 leapfrog steps per transition would take 0.31 seconds.
## Chain 4: Adjust your expectations accordingly!
## Chain 4:
## Chain 4:
## Chain 4: Iteration:    1 / 2000 [ 0%] (Warmup)
## Chain 4: Iteration:   200 / 2000 [ 10%] (Warmup)
## Chain 4: Iteration:   400 / 2000 [ 20%] (Warmup)
## Chain 4: Iteration:   600 / 2000 [ 30%] (Warmup)
## Chain 4: Iteration:   800 / 2000 [ 40%] (Warmup)
## Chain 4: Iteration:  1000 / 2000 [ 50%] (Warmup)
## Chain 4: Iteration: 1001 / 2000 [ 50%] (Sampling)
## Chain 4: Iteration:  1200 / 2000 [ 60%] (Sampling)
## Chain 4: Iteration:  1400 / 2000 [ 70%] (Sampling)
## Chain 4: Iteration:  1600 / 2000 [ 80%] (Sampling)
## Chain 4: Iteration:  1800 / 2000 [ 90%] (Sampling)
## Chain 4: Iteration:  2000 / 2000 [100%] (Sampling)
## Chain 4:
## Chain 4: Elapsed Time: 11.262 seconds (Warm-up)
## Chain 4:                0.468 seconds (Sampling)
## Chain 4:                11.73 seconds (Total)
## Chain 4:

```

```
summary(regression)
```

```

##
## Model Info:
## function:    stan_glm
## family:      gaussian [identity]
## formula:     gdp ~ income2 + population2 + input + output + inflation2
## algorithm:    sampling
## sample:      4000 (posterior sample size)
## priors:      see help('prior_summary')
## observations: 40

```

```
## predictors: 6
##
## Estimates:
##      mean      sd      10%      50%
## (Intercept) -1.095927e+11 1.903412e+10 -1.338097e+11 -1.099084e+11
## income2      4.474931e+06 4.868262e+05 3.851158e+06 4.487918e+06
## population2  2.756450e+04 5.666300e+03 2.023930e+04 2.763360e+04
## input        -1.100000e+00 4.000000e-01 -1.600000e+00 -1.100000e+00
## output        9.000000e-01 4.000000e-01 4.000000e-01 9.000000e-01
## inflation2    7.400877e+08 3.029213e+08 3.590929e+08 7.388322e+08
## sigma        4.974007e+09 6.355312e+08 4.223949e+09 4.912759e+09
##      90%
## (Intercept) -8.488444e+10
## income2      5.085041e+06
## population2  3.467850e+04
## input        -6.000000e-01
## output        1.400000e+00
## inflation2    1.119239e+09
## sigma        5.787571e+09
##
## Fit Diagnostics:
##      mean      sd      10%      50%
## mean_PPD 108895748707.4 1111831449.3 107504821380.7 108876904859.5
##      90%
## mean_PPD 110323980556.5
##
## The mean_ppd is the sample average posterior predictive distribution of the outcome variable (for de
##
## MCMC diagnostics
##      mcse      Rhat      n_eff
## (Intercept) 457717153.3      1.0 1729
## income2      10008.4      1.0 2366
## population2   130.2      1.0 1895
## input         0.0      1.0 2020
## output        0.0      1.0 1355
## inflation2    6868172.9      1.0 1945
## sigma      12661022.8      1.0 2520
## mean_PPD    19127508.9      1.0 3379
## log-posterior 0.1      1.0 1259
##
## For each parameter, mcse is Monte Carlo standard error, n_eff is a crude measure of effective sample
```

Since  $Rhat = 1.0$ , it indicates that the model has converged and the model's stability is good.

Prediction First I get 2023 economic informations

```
data_2023_nz<-data.frame(income2=48527.83,population2=5223100,input=5077000000,output=4221000000,infl1.

predicted_GDP_2023<- posterior_predict(regression, newdata = data_2023_nz)
gdp_2023<-mean(predicted_GDP_2023)
gdp_2023
```

```
## [1] 235476188054
```

Seem its not close,maybe input and output are too much partial in this model,and in 2023,input and out put decreased a lot,made the model not accuracy.I try to remove input and out put

```
regression2<-stan_glm(gdp~income2+population2+inflation2,data_nz,family = gaussian)
```

```
##
## SAMPLING FOR MODEL 'continuous' NOW (CHAIN 1).
## Chain 1:
## Chain 1: Gradient evaluation took 1.4e-05 seconds
## Chain 1: 1000 transitions using 10 leapfrog steps per transition would take 0.14 seconds.
## Chain 1: Adjust your expectations accordingly!
## Chain 1:
## Chain 1:
## Chain 1: Iteration:    1 / 2000 [  0%] (Warmup)
## Chain 1: Iteration:   200 / 2000 [ 10%] (Warmup)
## Chain 1: Iteration:   400 / 2000 [ 20%] (Warmup)
## Chain 1: Iteration:   600 / 2000 [ 30%] (Warmup)
## Chain 1: Iteration:   800 / 2000 [ 40%] (Warmup)
## Chain 1: Iteration:  1000 / 2000 [ 50%] (Warmup)
## Chain 1: Iteration:  1001 / 2000 [ 50%] (Sampling)
## Chain 1: Iteration:  1200 / 2000 [ 60%] (Sampling)
## Chain 1: Iteration:  1400 / 2000 [ 70%] (Sampling)
## Chain 1: Iteration:  1600 / 2000 [ 80%] (Sampling)
## Chain 1: Iteration:  1800 / 2000 [ 90%] (Sampling)
## Chain 1: Iteration:  2000 / 2000 [100%] (Sampling)
## Chain 1:
## Chain 1: Elapsed Time: 5.36 seconds (Warm-up)
## Chain 1:                0.106 seconds (Sampling)
## Chain 1:                5.466 seconds (Total)
## Chain 1:
##
## SAMPLING FOR MODEL 'continuous' NOW (CHAIN 2).
## Chain 2:
## Chain 2: Gradient evaluation took 9e-06 seconds
## Chain 2: 1000 transitions using 10 leapfrog steps per transition would take 0.09 seconds.
## Chain 2: Adjust your expectations accordingly!
## Chain 2:
## Chain 2:
## Chain 2: Iteration:    1 / 2000 [  0%] (Warmup)
## Chain 2: Iteration:   200 / 2000 [ 10%] (Warmup)
## Chain 2: Iteration:   400 / 2000 [ 20%] (Warmup)
## Chain 2: Iteration:   600 / 2000 [ 30%] (Warmup)
## Chain 2: Iteration:   800 / 2000 [ 40%] (Warmup)
## Chain 2: Iteration:  1000 / 2000 [ 50%] (Warmup)
## Chain 2: Iteration:  1001 / 2000 [ 50%] (Sampling)
## Chain 2: Iteration:  1200 / 2000 [ 60%] (Sampling)
## Chain 2: Iteration:  1400 / 2000 [ 70%] (Sampling)
## Chain 2: Iteration:  1600 / 2000 [ 80%] (Sampling)
## Chain 2: Iteration:  1800 / 2000 [ 90%] (Sampling)
## Chain 2: Iteration:  2000 / 2000 [100%] (Sampling)
## Chain 2:
## Chain 2: Elapsed Time: 6.191 seconds (Warm-up)
## Chain 2:                0.11 seconds (Sampling)
## Chain 2:                6.301 seconds (Total)
```

```

## Chain 2:
##
## SAMPLING FOR MODEL 'continuous' NOW (CHAIN 3).
## Chain 3:
## Chain 3: Gradient evaluation took 1.3e-05 seconds
## Chain 3: 1000 transitions using 10 leapfrog steps per transition would take 0.13 seconds.
## Chain 3: Adjust your expectations accordingly!
## Chain 3:
## Chain 3:
## Chain 3: Iteration:    1 / 2000 [  0%] (Warmup)
## Chain 3: Iteration:   200 / 2000 [ 10%] (Warmup)
## Chain 3: Iteration:   400 / 2000 [ 20%] (Warmup)
## Chain 3: Iteration:   600 / 2000 [ 30%] (Warmup)
## Chain 3: Iteration:   800 / 2000 [ 40%] (Warmup)
## Chain 3: Iteration:  1000 / 2000 [ 50%] (Warmup)
## Chain 3: Iteration:  1001 / 2000 [ 50%] (Sampling)
## Chain 3: Iteration:  1200 / 2000 [ 60%] (Sampling)
## Chain 3: Iteration:  1400 / 2000 [ 70%] (Sampling)
## Chain 3: Iteration:  1600 / 2000 [ 80%] (Sampling)
## Chain 3: Iteration:  1800 / 2000 [ 90%] (Sampling)
## Chain 3: Iteration:  2000 / 2000 [100%] (Sampling)
## Chain 3:
## Chain 3: Elapsed Time: 8.246 seconds (Warm-up)
## Chain 3:                0.079 seconds (Sampling)
## Chain 3:                8.325 seconds (Total)
## Chain 3:
##
## SAMPLING FOR MODEL 'continuous' NOW (CHAIN 4).
## Chain 4:
## Chain 4: Gradient evaluation took 1e-05 seconds
## Chain 4: 1000 transitions using 10 leapfrog steps per transition would take 0.1 seconds.
## Chain 4: Adjust your expectations accordingly!
## Chain 4:
## Chain 4:
## Chain 4: Iteration:    1 / 2000 [  0%] (Warmup)
## Chain 4: Iteration:   200 / 2000 [ 10%] (Warmup)
## Chain 4: Iteration:   400 / 2000 [ 20%] (Warmup)
## Chain 4: Iteration:   600 / 2000 [ 30%] (Warmup)
## Chain 4: Iteration:   800 / 2000 [ 40%] (Warmup)
## Chain 4: Iteration:  1000 / 2000 [ 50%] (Warmup)
## Chain 4: Iteration:  1001 / 2000 [ 50%] (Sampling)
## Chain 4: Iteration:  1200 / 2000 [ 60%] (Sampling)
## Chain 4: Iteration:  1400 / 2000 [ 70%] (Sampling)
## Chain 4: Iteration:  1600 / 2000 [ 80%] (Sampling)
## Chain 4: Iteration:  1800 / 2000 [ 90%] (Sampling)
## Chain 4: Iteration:  2000 / 2000 [100%] (Sampling)
## Chain 4:
## Chain 4: Elapsed Time: 16.899 seconds (Warm-up)
## Chain 4:                0.296 seconds (Sampling)
## Chain 4:                17.195 seconds (Total)
## Chain 4:

```

```
summary(regression)
```

```

##
## Model Info:
## function:      stan_glm
## family:        gaussian [identity]
## formula:       gdp ~ income2 + population2 + input + output + inflation2
## algorithm:     sampling
## sample:        4000 (posterior sample size)
## priors:        see help('prior_summary')
## observations:  40
## predictors:    6
##
## Estimates:
##              mean          sd      10%      50%
## (Intercept) -1.095927e+11  1.903412e+10 -1.338097e+11 -1.099084e+11
## income2      4.474931e+06  4.868262e+05  3.851158e+06  4.487918e+06
## population2  2.756450e+04  5.666300e+03  2.023930e+04  2.763360e+04
## input        -1.100000e+00  4.000000e-01 -1.600000e+00 -1.100000e+00
## output       9.000000e-01  4.000000e-01  4.000000e-01  9.000000e-01
## inflation2   7.400877e+08  3.029213e+08  3.590929e+08  7.388322e+08
## sigma        4.974007e+09  6.355312e+08  4.223949e+09  4.912759e+09
##              90%
## (Intercept) -8.488444e+10
## income2      5.085041e+06
## population2  3.467850e+04
## input        -6.000000e-01
## output       1.400000e+00
## inflation2   1.119239e+09
## sigma        5.787571e+09
##
## Fit Diagnostics:
##              mean          sd      10%      50%
## mean_PPD 108895748707.4  1111831449.3 107504821380.7 108876904859.5
##              90%
## mean_PPD 110323980556.5
##
## The mean_ppd is the sample average posterior predictive distribution of the outcome variable (for de
##
## MCMC diagnostics
##              mcse          Rhat      n_eff
## (Intercept)  457717153.3          1.0 1729
## income2      10008.4          1.0 2366
## population2   130.2          1.0 1895
## input         0.0          1.0 2020
## output        0.0          1.0 1355
## inflation2    6868172.9          1.0 1945
## sigma        12661022.8          1.0 2520
## mean_PPD     19127508.9          1.0 3379
## log-posterior 0.1          1.0 1259
##
## For each parameter, mcse is Monte Carlo standard error, n_eff is a crude measure of effective sample

```

```

predicted_gdp_2023<- posterior_predict(regression2, newdata = data_2023_nz)
GDP_2023<-mean(predicted_gdp_2023)
GDP_2023

```

```
## [1] 244192649226
```

This model is better

Prediction of 2024 GDP

```
data_2024_nz<-data.frame(income2=47549.65,population2=5338500,inflation2=5.756)
```

```
predicted_gdp_2024<- posterior_predict(regression2, newdata = data_2024_nz)
GDP_2024<-mean(predicted_gdp_2024)
GDP_2024
```

```
## [1] 243957133689
```