# AR1 Model

```
library('rjags')
```

```
## Loading required package: coda
```

```
## Linked to JAGS 4.3.2
```

```
## Loaded modules: basemod,bugs
```

```
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(tibble)
library(stringr)
```

## AR(1) MODEL

### Preprocess

**Load data** Loading data in as a wide data frame

With ~ rows (regions) x columns (weeks)

1st column is the region names

```
uecDf    = read.csv('data/wide_weekly_scaledPer10k.csv')
regions  = uecDf$Region # saving region names
n.region = length(uecDf$Region) # number of regions
uecDf    = uecDf %>% select(-Region) # remove region col
n.weeks  = length(names(uecDf))
head(uecDf)
```

```
##   X2023.01.01 X2023.01.08 X2023.01.15 X2023.01.22 X2023.01.29 X2023.02.05
## 1    2.227091   17.436266   14.197704   12.694418   10.504445   10.328134
## 2    1.398387   10.277302    6.781334    5.340827    4.599514    4.220433
## 3    2.461144   18.371052   11.667266   12.470484   12.305721   11.440717
## 4    1.162062    6.923950    3.776700    4.599827    3.921958    5.326116
## 5    1.066683    7.142722    4.982352    5.022859    5.914012    5.171385
## 6    1.276900   10.531138    6.002749    7.937845    6.489814    6.081732
##   X2023.02.12 X2023.02.19 X2023.02.26 X2023.03.05 X2023.03.12 X2023.03.19
## 1   12.675859   13.353266   14.095629   14.169866   18.271425   15.673152
## 2    4.085649    7.657432    7.640584    5.475612    4.944898    4.936474
```

```
## 3   12.233638   15.631870   15.415619   12.789712   14.808056   14.478531
## 4    6.439758    7.287095    7.819706    7.577610    7.432352    7.359723
## 5    3.807651    5.900510    5.860003    5.009357    7.412768    6.170556
## 6    5.699978    7.793042    7.977337    6.410830    7.635075    8.688189
##   X2023.03.26 X2023.04.02 X2023.04.09 X2023.04.16 X2023.04.23 X2023.04.30
## 1   17.278513   16.035054   10.272457   13.028482   14.550327   14.865832
## 2    6.259045    6.402254    4.995443    3.041070    4.380489    4.068801
## 3   16.486577   15.178773   13.294298   12.995666   14.262280   14.911033
## 4    8.715462    8.328108    8.037593    6.996579    8.110222    8.400737
## 5    6.373090    7.048206    5.846500    6.211063    6.589127    6.008528
## 6    9.543844    8.806664    9.267401    8.477566    8.082648    7.319141
##   X2023.05.07 X2023.05.14 X2023.05.21 X2023.05.28 X2023.06.04 X2023.06.11
## 1   17.436266   18.252866   11.849979   11.673668    9.771361    8.175279
## 2    5.745180    5.677788    4.953323    5.812572    3.765536    1.246755
## 3   15.580382   14.282875   13.139833   13.531145    9.031061    9.072252
## 4    8.884929    7.504981    7.311304    8.763881    7.747077    7.940754
## 5    5.887007    6.332584    6.062537    5.198389    3.564610    2.457420
## 6    8.819828    8.872484    7.740386    7.121682    5.805290    6.766256
##   X2023.06.18 X2023.06.25 X2023.07.02 X2023.07.09 X2023.07.16 X2023.07.23
## 1   10.894186   10.968423   12.035570  12.4345908   11.209691    6.839025
## 2    1.305723    1.945948    0.960338   0.8002817    1.701652    1.971220
## 3   10.925833   10.410949    8.886893   8.0630794    9.628326   10.338866
## 4    7.529191    8.134431    9.538589   8.8849293    8.545995    8.473366
## 5    3.888665    3.780647    2.700462   2.1198627    3.537605    3.821154
## 6    7.095354    7.911517    5.818454   4.3177666    5.884273    5.884273
##   X2023.07.30 X2023.08.06 X2023.08.13 X2023.08.20 X2023.08.27 X2023.09.03
## 1    7.980409    7.692743    7.432916   10.068307    8.973320    9.093954
## 2    1.659532    1.533171    4.228857    4.228857    3.630752    2.796774
## 3   11.512801   12.357210   10.637498   11.245061   13.572336   13.428168
## 4    9.175445    7.940754    7.771287    7.093418    7.553400    8.521785
## 5    4.509772    4.361246    2.497927    3.834656    5.846500    6.926685
## 6    6.200207    6.950551    7.845698    6.687273    6.331847    6.766256
##   X2023.09.10 X2023.09.17 X2023.09.24 X2023.10.01 X2023.10.08 X2023.10.15
## 1   10.884907   10.495166   11.024100   13.241911   12.527386   13.232632
## 2    3.344335    2.973678    3.959288    4.885930    4.961747    5.399795
## 3   13.232512   12.285126   14.354959   13.932754   13.634122   13.366382
## 4    9.804895    9.151235    9.320702   10.143829   10.095410    8.739672
## 5    5.954519    4.563781    5.319910    6.616132    5.535947    5.468436
## 6    7.924681    6.239699    5.410372    5.489356    6.134388    6.015913
##   X2023.10.22 X2023.10.29 X2023.11.05 X2023.11.12 X2023.11.19 X2023.11.26
## 1   10.903466   12.109807   13.418223   15.747389   14.049232   11.460239
## 2    4.313097    5.315555    6.334861    6.376982    6.604430    5.913661
## 3   12.171852   12.573461   13.211917   14.056326   14.787461   12.460187
## 4    9.441750    8.013383    6.923950    8.231270    9.659637    8.836510
## 5    4.860832    5.333413    5.981523    5.887007    6.251570    5.063366
## 6    5.397208    5.581503    5.805290    6.621453    7.253321    5.015454
##   X2023.12.03 X2023.12.10 X2023.12.17 X2023.12.24 X2023.12.31 X2024.01.07
## 1   10.578682   12.935686   12.972804    5.010955   2.1435750    8.128882
## 2    5.273435    6.570734    5.846268    2.072308   0.4296249    4.212009
## 3   11.224466    6.590512    7.373135    4.633954   1.7917954    2.986326
## 4   12.710049   23.555957   25.323259   14.913124   6.3671292   18.302470
## 5    8.155395    9.856686   13.205259    6.508114   3.9426746   13.718347
## 6    5.120766    8.043157    8.990959    4.989127   2.0535719    7.529764
##   X2024.01.14 X2024.01.21 X2024.01.28 X2024.02.04 X2024.02.11 X2024.02.18
```

```
## 1    7.869054    8.871245   10.281736    7.887614    9.428018    7.646345
## 2    6.200077    6.216925    5.879964    5.475612    6.756062    5.138651
## 3    5.210623    6.003544    5.313600    6.055033    7.671768    7.321647
## 4   18.810872   17.334085   20.384497   21.643397   24.258036   20.190820
## 5   12.962218   14.987564   14.879546    9.451617    8.506455    7.777331
## 6    7.134846   10.873400   13.611496   12.295104   13.453529   15.428117
##   X2024.02.25 X2024.03.03 X2024.03.10 X2024.03.17 X2024.03.24 X2024.03.31
## 1    9.168191   10.077586    9.502254    9.743523    7.998968    8.964041
## 2    6.570734    4.801690    4.666906    6.132685    5.425068    4.498426
## 3    5.231219    5.787293    5.900568    6.549321    4.881098    5.941758
## 4   18.738243   20.384497   19.270855   17.818278   20.336078   20.529755
## 5    6.805164    9.343599    7.210234    9.370603   10.153737    7.291248
## 6   12.479398    9.688647    8.293271    8.451238   11.136678    9.688647
##   X2024.04.07 X2024.04.14 X2024.04.21 X2024.04.28 X2024.05.05 X2024.05.12
## 1    9.502254   10.133264    9.075395    6.811186    7.015336    6.050264
## 2    4.329945    5.711484    5.896813    5.778876    4.363641    5.088107
## 3    7.239265    6.343368    6.703786    5.972651    5.529851    4.798716
## 4   17.527762   16.995151   19.464532   20.142401   15.784670   15.252058
## 5   10.612816   10.801848    6.562123    7.561294   10.153737    4.779818
## 6   13.479857   17.034116   12.084481    7.977337    7.819370   10.636449
##   X2024.05.19 X2024.05.26 X2024.06.02 X2024.06.09 X2024.06.16 X2024.06.23
## 1    8.685654    7.423636    9.001159    8.537182    7.683464    6.662714
## 2    5.930509    6.772910    4.161465    4.683754    5.644092    5.526156
## 3    4.005796    4.191154    3.027516    4.129368    4.314726    4.654549
## 4   20.868689   21.159205   20.432916   15.106801   14.671028   13.654224
## 5    5.103873    8.344428    8.074382   10.558807    9.775673    8.101386
## 6   13.032283    7.292813    9.767630    9.978253   15.164839   12.558382
##   X2024.06.30 X2024.07.07 X2024.07.14 X2024.07.21 X2024.07.28 X2024.08.04
## 1    6.143059    4.621214    4.788245    6.161618    7.089573    6.402886
## 2    5.947357    4.784842    2.864166    3.335911    3.420151    3.538088
## 3    5.128242    4.149963    4.860503    3.521805    3.377637    3.789544
## 4   17.576182   18.205632   22.466524   18.835082   15.494155   15.397316
## 5    6.697146    7.021201    9.046548    7.723321    8.533460    4.320739
## 6   12.110809    8.951467   11.399957   12.189792   11.821202   11.426285
##   X2024.08.11 X2024.08.18 X2024.08.25 X2024.09.01 X2024.09.08 X2024.09.15
## 1    6.217295    6.087382    4.862482    6.607036    5.437814    3.934527
## 2    3.639176    2.510357    3.605480    4.195161    4.784842    4.616362
## 3    4.530977    3.727758    5.066456    5.220921    5.323898    6.786168
## 4   18.060374    7.843916    0.000000    4.987181    9.587008   12.056389
## 5    6.373090    6.130049    4.698804    5.103873    5.427929    9.532631
## 6   11.110351   10.109892    9.346385    9.714975    9.504352   10.794416
##   X2024.09.22 X2024.09.29 X2024.10.06 X2024.10.13 X2024.10.20 X2024.10.27
## 1    6.477123    6.514241    7.683464    8.407268    6.365768    6.254414
## 2    4.464729    5.610396    6.688670    5.037563    5.239739    4.835386
## 3    6.652298    6.116819    6.961228    6.312475    6.291879    4.541275
## 4   13.508966   15.300478   18.835082   17.576182   16.172024   13.266870
## 5    9.424613    8.533460   10.720834    7.669312    6.103044    5.508943
## 6   13.269234   13.980086   13.479857   12.084481   11.136678   10.346843
##   X2024.11.03 X2024.11.10 X2024.11.17 X2024.11.24 X2024.12.01 X2024.12.08
## 1    5.976027    6.718391    7.516432    6.959659    9.038277    8.240236
## 2    5.509308    6.098989    5.020715    6.368558    8.019665    7.531072
## 3    4.098475    6.456642    5.313600    5.849079    7.692363    8.114568
## 4   18.060374   21.885493   19.270855   19.658209   17.430924   20.626593
## 5    5.941017    9.640650    6.373090    6.778160   10.018714    8.614474
```

```
## 6    9.346385   12.479398   13.005955   12.216120   11.478940   11.005039
##   X2024.12.15 X2024.12.22 X2024.12.29 X2025.01.05 X2025.01.12 X2025.01.19
## 1    9.632168    9.279545    3.006573    7.850495   10.857068    8.852686
## 2    7.194111    5.930509    2.240789    3.588632    6.435950    6.402254
## 3    7.208372    4.201451    1.791795    6.539024    6.631703    6.981824
## 4   17.527762   20.384497    9.974362   21.159205   23.531747   22.321266
## 5    7.075211    9.667654    3.483596   10.585811   14.528486   14.042403
## 6   11.320973   10.557466    5.133930   14.348675   16.007330   16.454903
##   X2025.01.26 X2025.02.02 X2025.02.09 X2025.02.16 X2025.02.23 X2025.03.02
## 1    7.089573    8.722773    7.943291    8.889804    8.964041    9.001159
## 2    7.008783    8.171297    9.047395    7.615312    7.497376    5.155499
## 3    9.453266    7.156884    7.929210    4.911991    6.899442    5.035563
## 4   17.043570   19.028759   18.447728   16.898312   20.771851   19.948724
## 5   12.989222   12.665167    9.829682    8.425442    9.019543    9.451617
## 6   16.955132   19.271982   19.508933   14.427659   14.901560   16.955132
##   X2025.03.09 X2025.03.16 X2025.03.23 X2025.03.30 X2025.04.06 X2025.04.13
## 1    7.200927    6.235854    5.270782    6.736950    4.881041    6.681273
## 2    3.571784    3.824504    2.139701    5.206043    6.132685    2.965254
## 3    5.972651    4.582465    3.892521    2.636205    3.109898    3.140791
## 4   17.769859   15.784670   12.540581   18.641405   15.445735   15.203639
## 5    6.994197    4.185716    7.669312    9.478622    8.209405    4.617790
## 6   13.216578   12.426743    8.082648   11.689563    9.872942    8.872484
##   X2025.04.20 X2025.04.27 X2025.05.04 X2025.05.11 X2025.05.18 X2025.05.25
## 1    7.924732    7.720582    4.843923    4.788245    5.382136    6.143059
## 2    4.734298    2.544053    2.678838    2.392421    2.021764    3.032646
## 3    2.965730    3.377637    3.254065    3.789544    3.449721    4.428000
## 4   17.479343   19.222436   16.801474   16.995151   18.496147   17.043570
## 5    4.563781    5.292906    4.212721    5.346915    4.725809    4.401753
## 6    9.557008   11.031367    9.188418   10.847072   12.532054    9.320057
##   X2025.06.01 X2025.06.08 X2025.06.15 X2025.06.22 X2025.06.29 X2025.07.06
## 1    5.567727    3.359195    4.621214    7.367959    5.456373    5.270782
## 2    3.656024    3.891896    3.521239    3.133735    2.527205    3.184279
## 3    3.707163    3.871926    2.924540    3.181982    3.429126    3.315851
## 4   16.946732   16.268862   17.334085   13.170031   19.319274   17.866697
## 5    3.159541    4.212721    3.510601    4.941846    6.859174    5.941017
## 6   11.584252   12.242448   12.847988   11.821202   12.821660   11.215662
##   X2025.07.13 X2025.07.20 X2025.07.27 X2025.08.03 X2025.08.10 X2025.08.17
## 1    3.489109    3.971645    3.637582    4.045882    3.730377    5.048073
## 2    2.998950    3.049494    3.386455    1.903828    2.661990    3.706568
## 3    3.738056    4.592763    4.026391    3.583591    3.665972    4.314726
## 4   13.315289   15.590993   17.188828   18.883501   13.557385   11.136424
## 5    6.670141    4.941846    6.508114    6.319081    4.617790    5.887007
## 6    9.188418   14.138053   14.269692   13.874774   12.189792   15.480773
##   X2025.08.24 X2025.08.31 X2025.09.07 X2025.09.14 X2025.09.21 X2025.09.28
## 1    2.858100    5.140868    5.066632    3.600464    3.934527    3.414873
## 2    3.723416    3.251671    3.066343    3.487543    3.538088    3.773960
## 3    5.395982    4.664847    4.366214    5.952056    6.260986    4.500084
## 4   18.738243   18.399309   18.544566   15.929928   17.769859   18.641405
## 5    5.400924    7.183229    9.289589    6.265072    6.292077    8.506455
## 6   16.481231   15.902018   14.269692   17.165755   14.506643    8.161632
##   X2025.10.05 X2025.10.12 X2025.10.19 X2025.10.26 X2025.11.02 X2025.11.09
## 1    4.843923    4.936718    3.470550    3.433432    4.546977    5.493491
## 2    4.751146    3.285367    2.493509    2.560901    2.914710    4.127769
## 3    3.727758    5.117944    5.323898    5.025265    4.901693    8.021889
```

```
## 4   21.401301   13.944739    9.005977    7.456562    8.521785    8.473366
## 5    9.073552   10.423784   11.341941    8.641479   10.153737   12.395121
## 6   10.583794   13.769463    9.557008   11.136678    9.609663   12.953300
##   X2025.11.16
## 1    5.790436
## 2    3.992984
## 3    6.631703
## 4    8.134431
## 5    5.616961
## 6   11.241990
```

**Reformat Dataframe to Matrix** Formatting as matrix with ~ rows (regions) x columns (weeks)

```
uecMat = as.matrix(uecDf)
```

### JAGs Model

```
model=
"
model{
  # Iterate through the regions
  for(i in 1:I){

    #------------
    #Likelihood
    #------------

    # Set first data point in region i to normal
    y[i,1] ~ dnorm(mu[i,1], tau[i])

    # Set second on data points to the AR1 model with a mean with a seasonal component
    for(t in 2:T){
      y[i,t] ~ dnorm(mu[i,t] + (phi * (y[i,t-1] - mu[i,t-1])), tau[i])
    }

    # Assign mean to each time point
    # Beta  ~ cosine coeffecient scaler
    # Gamma ~ sine coeffecient scaler
    for(t in 1:T){
      mu[i,t] <- alpha[i] +
                 beta[i]  * cos((2 * pi) * (t/52)) +
                 gamma[i] * sin((2 * pi) * (t/52))
    }

    #------------
    #Uninformative Priors
    #------------

    alpha[i] ~ dnorm(0, 0.001)
    beta[i]  ~ dnorm(0, 0.001)
    gamma[i] ~ dnorm(0, 0.001)
    tau[i]   ~ dgamma(0.001, 0.001)
  }
  phi ~ dunif(-1, 1)
```

```
}
"
```

| Variable | Definition |
|---|---|
| y | trollies per 10,000 population |
| i | Region |
| t | Week |
| alpha | Auto correlation model parameter |
| beta | seasonal effect (sin wave) |
| gamma | seasonal effect (cos wave) |
| tau | |
| phi | autocorrelation coeffecent (t-1 dependence) |

```
exp_jags = jags.model(textConnection(model),
                      list(y  = uecMat,
                           I  = n.region,
                           T  = n.weeks,
                           pi = pi), n.chains = 4)
```

```
## Compiling model graph
##    Resolving undeclared variables
##    Allocating nodes
## Graph information:
##    Observed stochastic nodes: 906
##    Unobserved stochastic nodes: 25
##    Total graph size: 5026
##
## Initializing model
```

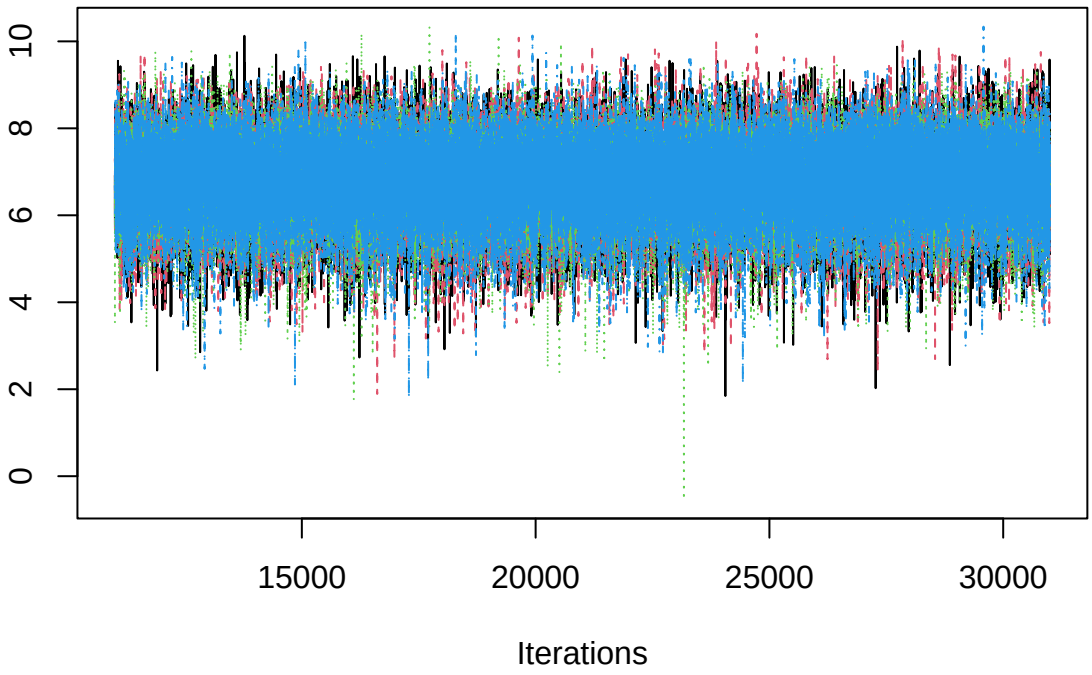
```
update(exp_jags, n.iter = 10000)
```

```
# Choose the parameters to watch
model_parameters =  c("alpha","beta","gamma","tau","phi")
# Set up samples
exp_sim=coda.samples(model=exp_jags,
                     variable.names=model_parameters,
                     n.iter=20000)
```

### Check Convergence

Misc trace plot

```
traceplot(exp_sim[, "alpha[3]"])
```




**Gelman Rubin Statistic** All are 1.

```
gelman.diag(exp_sim)
```

```
## Potential scale reduction factors:
##
##          Point est. Upper C.I.
## alpha[1]          1          1
## alpha[2]          1          1
## alpha[3]          1          1
## alpha[4]          1          1
## alpha[5]          1          1
## alpha[6]          1          1
## beta[1]           1          1
## beta[2]           1          1
## beta[3]           1          1
## beta[4]           1          1
## beta[5]           1          1
## beta[6]           1          1
## gamma[1]          1          1
## gamma[2]          1          1
## gamma[3]          1          1
## gamma[4]          1          1
## gamma[5]          1          1
## gamma[6]          1          1
## phi               1          1
## tau[1]            1          1
## tau[2]            1          1
## tau[3]            1          1
## tau[4]            1          1
## tau[5]            1          1
## tau[6]            1          1
##
```

```
## Multivariate psrf
##
## 1
```

### Check values

```
jags_sum <- summary(exp_sim)
df.stats = cbind(as.data.frame(jags_sum$statistics), as.data.frame(jags_sum$quantiles)) %>%
  rownames_to_column(var = "index") %>%
  mutate(
    new_col = case_when(
      str_detect(index, "[1]")  ~ regions[1],
      str_detect(index, "[2]")  ~ regions[2],
      str_detect(index, "[3]")  ~ regions[3],
      str_detect(index, "[4]")  ~ regions[4],
      str_detect(index, "[5]")  ~ regions[5],
      str_detect(index, "[6]")  ~ regions[6]
    )
  )

df.stats
```

```
##       index        Mean          SD     Naive SE Time-series SE        2.5%
## 1  alpha[1]  7.49499527 1.03251278 3.650484e-03   4.564507e-03  5.33765931
## 2  alpha[2]  3.97521767 0.63770121 2.254614e-03   2.711444e-03  2.64294754
## 3  alpha[3]  6.75626112 0.90454791 3.198060e-03   3.908473e-03  4.86255855
## 4  alpha[4] 12.08774298 1.58513515 5.604299e-03   7.489065e-03  8.75387057
## 5  alpha[5]  6.03504943 1.02895293 3.637898e-03   4.672295e-03  3.86585927
## 6  alpha[6]  9.01129344 1.09781535 3.881363e-03   5.148515e-03  6.69017741
## 7   beta[1] -0.48978937 1.15717432 4.091229e-03   4.579356e-03 -2.83268527
## 8   beta[2]  0.36539386 0.71794414 2.538316e-03   2.919335e-03 -1.08691982
## 9   beta[3] -0.25094438 1.01319041 3.582169e-03   3.862975e-03 -2.28208668
## 10  beta[4] -2.16626153 1.75189874 6.193897e-03   6.969979e-03 -5.72319183
## 11  beta[5]  0.17815666 1.14195113 4.037407e-03   4.446833e-03 -2.13181026
## 12  beta[6] -1.58879867 1.22384970 4.326962e-03   4.887467e-03 -4.04054676
## 13 gamma[1]  1.64323563 1.25461686 4.435740e-03   4.400205e-03 -0.84350300
## 14 gamma[2]  0.65198049 0.77814178 2.751147e-03   2.731008e-03 -0.87785666
## 15 gamma[3]  0.27234386 1.10611114 3.910693e-03   3.912722e-03 -1.89094858
## 16 gamma[4]  1.26086056 1.88032762 6.647962e-03   6.616276e-03 -2.43918199
## 17 gamma[5]  0.42448703 1.22934080 4.346376e-03   4.335454e-03 -2.00671567
## 18 gamma[6]  0.29670187 1.31606340 4.652987e-03   4.672685e-03 -2.27811157
## 19      phi  0.82418786 0.02964734 1.048192e-04   2.442264e-04  0.76775317
## 20   tau[1]  0.20164790 0.02345499 8.292590e-05   8.451713e-05  0.15822226
## 21   tau[2]  0.52262410 0.06151683 2.174948e-04   2.360809e-04  0.40979355
## 22   tau[3]  0.25800997 0.03028572 1.070762e-04   1.120723e-04  0.20210014
## 23   tau[4]  0.08861107 0.01031925 3.648405e-05   3.721441e-05  0.06945942
## 24   tau[5]  0.20824003 0.02444994 8.644360e-05   9.197275e-05  0.16329349
## 25   tau[6]  0.18130443 0.02118253 7.489155e-05   7.672077e-05  0.14230795
##            25%         50%         75%      97.5%                   new_col
## 1   6.84923517  7.53653500  8.18455942  9.4226858   HSE Dublin and Midlands
## 2   3.57963808  3.99957549  4.40340755  5.1634371 HSE Dublin and North East
## 3   6.18733076  6.79014892  7.36004072  8.4443731 HSE Dublin and South East
## 4  11.09936697 12.15970518 13.15138823 14.9884932              HSE Mid West
## 5   5.39561470  6.08438709  6.72787584  7.9262135            HSE South West
```

```
## 6   8.32771049  9.05656369  9.75535242 11.0295914   HSE West and North West
## 7  -1.24279170 -0.47408712  0.29001403  1.7401961   HSE Dublin and Midlands
## 8  -0.10075209  0.37688880  0.84849452  1.7435787 HSE Dublin and North East
## 9  -0.91823255 -0.24143297  0.43188932  1.7098292 HSE Dublin and South East
## 10 -3.31001544 -2.13185859 -0.98894895  1.1995958             HSE Mid West
## 11 -0.57219214  0.19406741  0.95047735  2.3809793           HSE South West
## 12 -2.38706796 -1.57160125 -0.76440049  0.7670723   HSE West and North West
## 13  0.81575257  1.64174360  2.47611079  4.1208335   HSE Dublin and Midlands
## 14  0.13722767  0.65128685  1.16334941  2.1895609 HSE Dublin and North East
## 15 -0.46741587  0.27092083  1.00398206  2.4712161 HSE Dublin and South East
## 16  0.02128771  1.25591965  2.50022925  4.9593911             HSE Mid West
## 17 -0.38410200  0.42821687  1.23021453  2.8504372           HSE South West
## 18 -0.57296565  0.29080549  1.16097802  2.8874702   HSE West and North West
## 19  0.80383452  0.82369304  0.84383561  0.8838802                     <NA>
## 20  0.18542768  0.20070194  0.21704131  0.2499257   HSE Dublin and Midlands
## 21  0.48021014  0.52002206  0.56231323  0.6503064 HSE Dublin and North East
## 22  0.23703550  0.25683399  0.27763295  0.3205899 HSE Dublin and South East
## 23  0.08141345  0.08825086  0.09530352  0.1099651             HSE Mid West
## 24  0.19123319  0.20717393  0.22408927  0.2589228           HSE South West
## 25  0.16656598  0.18043233  0.19496794  0.2253524   HSE West and North West
```