MLR Model

Preston Dunton, Trevor Overton, Jasmine DeMeyer

4/24/2022

Imports and Constants

```
library("tidyverse")
source('./gibbs_util.R')

RANDOM_SEED = 440
```

Data Loading / Cleaning

```
load('./burritodata.Rda')
head(burrito)
```

```
##              Location Cost Hunger Length Circum Volume Tortilla Temp Meat
## 1   Donato's taco shop 6.49    3.0     NA     NA     NA        3  5.0  3.0
## 2 Oscar's Mexican food 5.45    3.5     NA     NA     NA        2  3.5  2.5
## 3 Oscar's Mexican food 4.85    1.5     NA     NA     NA        3  2.0  2.5
## 4 Oscar's Mexican food 5.25    2.0     NA     NA     NA        3  2.0  3.5
## 5         Pollos Maria 6.59    4.0     NA     NA     NA        4  5.0  4.0
## 6         Pollos Maria 6.99    4.0     NA     NA     NA        3  4.0  5.0
##   Fillings Meat_filling Uniformity Salsa Synergy Wrap Reviewer overall Beef
## 1      3.5          4.0        4.0   4.0     4.0    4    Scott    3.80    1
## 2      2.5          2.0        4.0   3.5     2.5    5    Scott    3.00    1
## 3      3.0          4.5        4.0   3.0     3.0    5    Emily    3.00    0
## 4      3.0          4.0        5.0   4.0     4.0    5  Ricardo    3.75    1
## 5      3.5          4.5        5.0   2.5     4.5    4    Scott    4.20    1
## 6      3.5          2.5        2.5   2.5     4.0    1    Emily    3.20    0
##   Pico Guac Cheese Fries Sour_cream Pork Chicken Shrimp Fish Rice Beans Lettuce
## 1    1    1      1     1          0    0       0      0    0    0     0       0
## 2    1    1      1     1          0    0       0      0    0    0     0       0
## 3    1    1      0     0          0    1       0      0    0    0     0       0
## 4    1    1      0     0          0    0       0      0    0    0     0       0
## 5    1    0      1     1          0    0       0      0    0    0     0       0
## 6    0    1      1     0          1    0       1      0    0    1     1       1
##   Tomato Bell_peper Carrots Cabbage Sauce Cilantro Onion Taquito Pineapple Ham
## 1      0          0       0       0     0        0     0       0         0   0
## 2      0          0       0       0     0        0     0       0         0   0
## 3      0          0       0       0     0        0     0       0         0   0
## 4      0          0       0       0     0        0     0       0         0   0
## 5      0          0       0       0     0        0     0       0         0   0
## 6      1          0       0       0     0        0     0       0         0   0
```

```
##   Chile_relleno Nopales Lobster Egg Mushroom Bacon Sushi Avocado Corn Zucchini
## 1             0       0       0   0        0     0     0       0    0        0
## 2             0       0       0   0        0     0     0       0    0        0
## 3             0       0       0   0        0     0     0       0    0        0
## 4             0       0       0   0        0     0     0       0    0        0
## 5             0       0       0   0        0     0     0       0    0        0
## 6             0       0       0   0        0     0     0       0    0        0
```

```
# Count Remove NA Cost rows
which(is.na(burrito$Cost))
```

```
## [1] 113 135
```

```
burrito = burrito[!is.na(burrito$Cost),]
nrow(burrito)
```

```
## [1] 237
```

```
burrito<-burrito%>%mutate(Vegetable=as.logical(Pineapple+Bell_peper+Tomato+
                                                 Cabbage+Mushroom+Corn+
                                                 Carrots+Zucchini))
burrito<-burrito%>%mutate(Breakfast=as.logical(Egg+Bacon+Ham))
burrito<-burrito%>%mutate(Other=as.logical(Fish+Taquito+Chile_relleno+
                                             Nopales+Sushi+Lobster))
burrito<-select(burrito, -c('Pineapple', 'Bell_peper', 'Tomato', 'Cabbage',
                            'Mushroom', 'Corn', 'Carrots', 'Zucchini',
                            'Egg', 'Ham', 'Fish', 'Taquito', 'Chile_relleno',
                            'Nopales', 'Sushi', 'Lobster', 'Bacon'))
burrito<-burrito%>%mutate_at(c('Vegetable','Other','Breakfast'),as.double)
head(burrito)
```

```
##               Location Cost Hunger Length Circum Volume Tortilla Temp Meat
## 1   Donato's taco shop 6.49    3.0     NA     NA     NA        3  5.0  3.0
## 2 Oscar's Mexican food 5.45    3.5     NA     NA     NA        2  3.5  2.5
## 3 Oscar's Mexican food 4.85    1.5     NA     NA     NA        3  2.0  2.5
## 4 Oscar's Mexican food 5.25    2.0     NA     NA     NA        3  2.0  3.5
## 5         Pollos Maria 6.59    4.0     NA     NA     NA        4  5.0  4.0
## 6         Pollos Maria 6.99    4.0     NA     NA     NA        3  4.0  5.0
##   Fillings Meat_filling Uniformity Salsa Synergy Wrap Reviewer overall Beef
## 1      3.5          4.0        4.0   4.0     4.0    4    Scott    3.80    1
## 2      2.5          2.0        4.0   3.5     2.5    5    Scott    3.00    1
## 3      3.0          4.5        4.0   3.0     3.0    5    Emily    3.00    0
## 4      3.0          4.0        5.0   4.0     4.0    5  Ricardo    3.75    1
## 5      3.5          4.5        5.0   2.5     4.5    4    Scott    4.20    1
## 6      3.5          2.5        2.5   2.5     4.0    1    Emily    3.20    0
##   Pico Guac Cheese Fries Sour_cream Pork Chicken Shrimp Rice Beans Lettuce
## 1    1    1      1     1          0    0       0      0    0     0       0
## 2    1    1      1     1          0    0       0      0    0     0       0
## 3    1    1      0     0          0    1       0      0    0     0       0
## 4    1    1      0     0          0    0       0      0    0     0       0
## 5    1    0      1     1          0    0       0      0    0     0       0
## 6    0    1      1     0          1    0       1      0    1     1       1
##   Sauce Cilantro Onion Avocado Vegetable Breakfast Other
## 1     0        0     0       0         0         0     0
## 2     0        0     0       0         0         0     0
## 3     0        0     0       0         0         0     0
## 4     0        0     0       0         0         0     0
```

```
## 5     0        0     0       0         0         0     0
## 6     0        0     0       0         1         0     0
```

```
burrito = burrito %>% mutate(Num_Proteins= Chicken + Beef + Pork + Shrimp + Other + Breakfast)

ingredient_cols = colnames(burrito)[18:36]
ingredient_cols
```

```
##  [1] "Beef"       "Pico"       "Guac"       "Cheese"     "Fries"
##  [6] "Sour_cream" "Pork"       "Chicken"    "Shrimp"     "Rice"
## [11] "Beans"      "Lettuce"    "Sauce"      "Cilantro"   "Onion"
## [16] "Avocado"    "Vegetable"  "Breakfast"  "Other"
```

```
ingredient_X = as.matrix(burrito[ingredient_cols])
dim(ingredient_X); head(ingredient_X)
```

```
## [1] 237  19
```

```
##   Beef Pico Guac Cheese Fries Sour_cream Pork Chicken Shrimp Rice Beans Lettuce
## 1    1    1    1      1     1          0    0       0      0    0     0       0
## 2    1    1    1      1     1          0    0       0      0    0     0       0
## 3    0    1    1      0     0          0    1       0      0    0     0       0
## 4    1    1    1      0     0          0    0       0      0    0     0       0
## 5    1    1    0      1     1          0    0       0      0    0     0       0
## 6    0    0    1      1     0          1    0       1      0    1     1       1
##   Sauce Cilantro Onion Avocado Vegetable Breakfast Other
## 1     0        0     0       0         0         0     0
## 2     0        0     0       0         0         0     0
## 3     0        0     0       0         0         0     0
## 4     0        0     0       0         0         0     0
## 5     0        0     0       0         0         0     0
## 6     0        0     0       0         1         0     0
```

```
cost_y = burrito$Cost
length(cost_y); head(cost_y)
```

```
## [1] 237
```

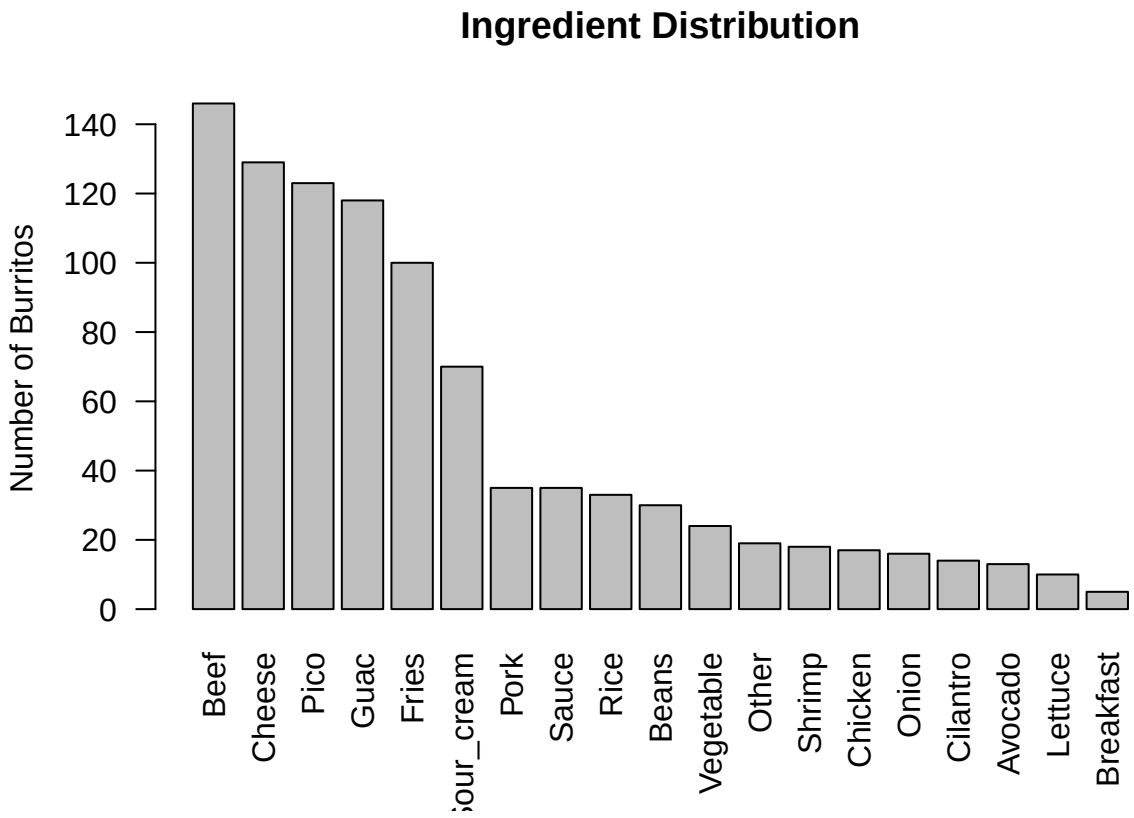
```
## [1] 6.49 5.45 4.85 5.25 6.59 6.99
```

```
num_burrito_ingredients = c()
for (ingredient in ingredient_cols) {
  num_burrito_ingredients = c(num_burrito_ingredients,
                              sum(burrito[ingredient]))
}
ingredient_counts_df = data.frame(ingredient=ingredient_cols,
                                  count=num_burrito_ingredients)

# sort by count
ingredient_counts_df = ingredient_counts_df[order(ingredient_counts_df$count, decreasing=TRUE),]

kable(ingredient_counts_df, row.names=FALSE)
```

ingredient	count
Beef	146
Cheese	129
Pico	123

ingredient	count
Guac	118
Fries	100
Sour_cream	70
Pork	35
Sauce	35
Rice	33
Beans	30
Vegetable	24
Other	19
Shrimp	18
Chicken	17
Onion	16
Cilantro	14
Avocado	13
Lettuce	10
Breakfast	5

```
barplot(ingredient_counts_df$count, ylab='Number of Burritos',
        main='Ingredient Distribution',
        names.arg=ingredient_counts_df$ingredient, las=2)
```



Definitions of Priors and Constants

```
p = ncol(ingredient_X) + 1
tau_2 = 4
prior_sigma = 1.5
a = 1 / (prior_sigma^4)
b = 1 / (prior_sigma^2)
```

Model Fit with Gibbs Sampler

```
set.seed(RANDOM_SEED)

mlr_post_dist = mlr_gibbs(ingredient_X, cost_y, mu=rep(0, p), tau_2, a, b)
mlr_post_dist = mlr_post_dist[5001:1000, ]
summarize_dist(mlr_post_dist, colnames(mlr_post_dist), round_places=2)
```

Parameter	Post. Mean	Post. Sd	95% CI Low	95% CI High
Intercept	6.41	0.20	6.02	6.80
Beef	0.16	0.30	-0.42	0.75
Pico	-0.09	0.20	-0.47	0.31
Guac	0.19	0.20	-0.20	0.57
Cheese	-0.17	0.25	-0.66	0.31
Fries	0.29	0.24	-0.19	0.75
Sour_cream	0.34	0.21	-0.06	0.75
Pork	0.16	0.33	-0.49	0.81
Chicken	0.47	0.38	-0.27	1.24
Shrimp	1.60	0.46	0.69	2.50
Rice	0.00	0.28	-0.55	0.54
Beans	-0.45	0.28	-0.99	0.11
Lettuce	0.18	0.41	-0.60	0.98
Sauce	0.17	0.31	-0.44	0.77
Cilantro	-0.17	0.82	-1.77	1.39
Onion	-0.05	0.78	-1.58	1.47
Avocado	-0.03	0.56	-1.12	1.09
Vegetable	0.21	0.28	-0.35	0.75
Breakfast	-0.32	0.54	-1.36	0.75
Other	1.30	0.31	0.69	1.91
sigma	1.15	0.05	1.05	1.26

This model won't work for us because it fits prices to be negative. Instead, why don't we use a truncated Gibbs sampler.

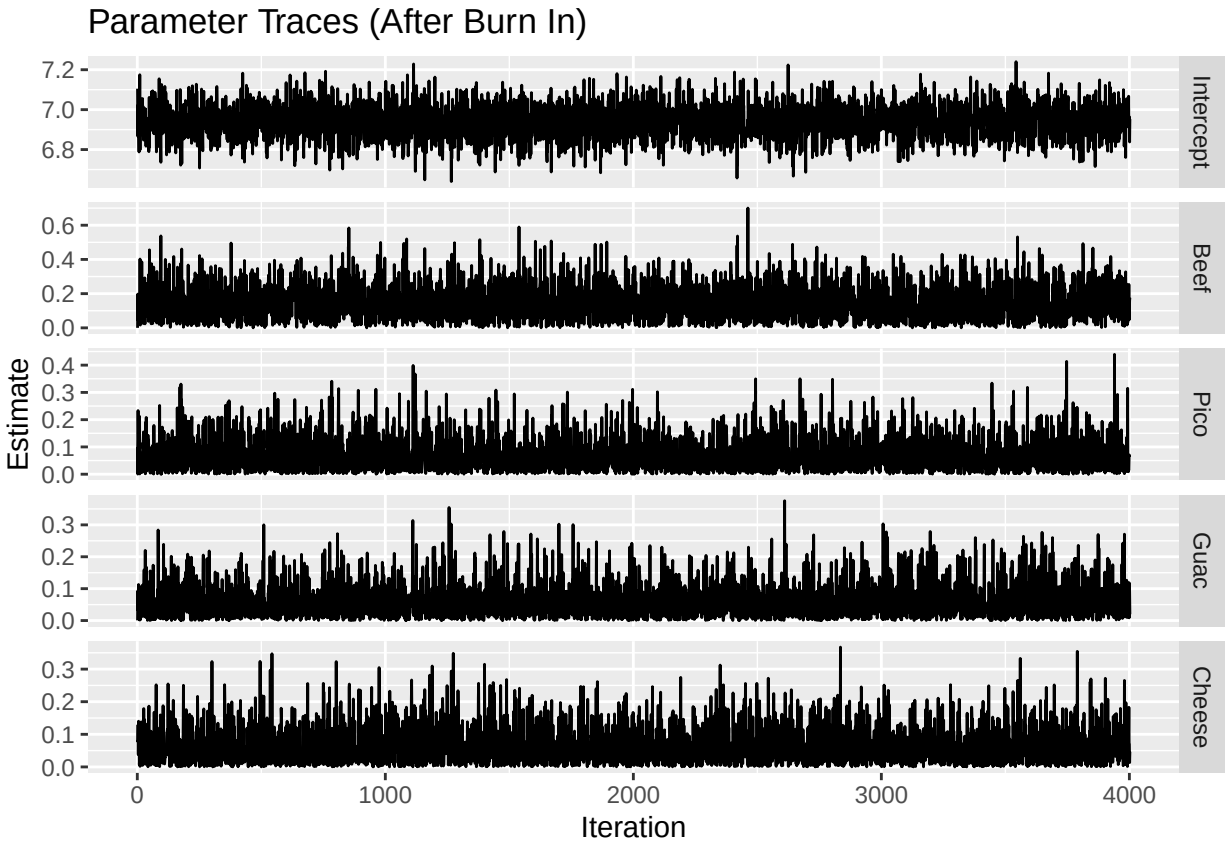
Full Truncated Gibbs Model

```
set.seed(RANDOM_SEED)

truncated_post_dist<-truncated_gibbs(ingredient_X, cost_y, mu=rep(1, p),
                                     tau_2, a, b, lb=rep(0,p), ub=rep(Inf,p))
truncated_post_dist = truncated_post_dist[5001:1000, ]
head(truncated_post_dist)
```

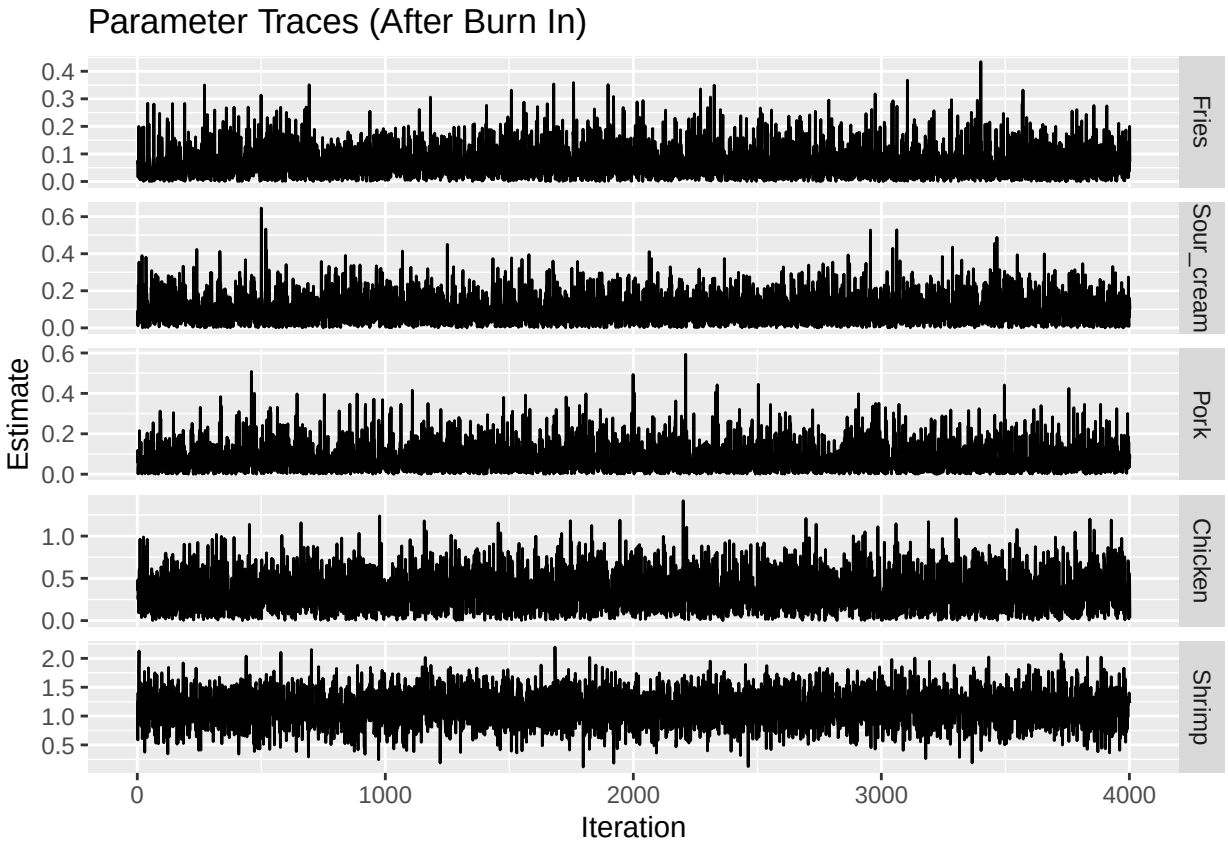
```
##      Intercept         Beef         Pico         Guac     Cheese      Fries
## [1,]  7.104997 7.068643e-05 0.0982310933 0.0006970822 0.08218745 0.06558578
## [2,]  6.866894 1.972101e-01 0.0004800598 0.0930557859 0.07809313 0.07407327
## [3,]  7.021933 4.398818e-02 0.2332324372 0.0370003128 0.12866329 0.01554467
## [4,]  6.927842 7.245190e-02 0.0864504239 0.0306965771 0.03776723 0.07755346
## [5,]  6.930743 6.139482e-02 0.1663135488 0.1129644739 0.14004429 0.04775014
## [6,]  6.864799 1.054844e-01 0.1225350844 0.0135627473 0.07167120 0.19946607
##      Sour_cream        Pork   Chicken    Shrimp        Rice        Beans
## [1,] 0.09361947 0.055025406 0.3541003 1.2493796 0.043968139 0.0740352671
## [2,] 0.01399790 0.118048810 0.4794720 0.5853450 0.088832715 0.0020084165
## [3,] 0.01115228 0.001983574 0.2521943 1.4024397 0.002192694 0.0001414085
## [4,] 0.22878749 0.034875560 0.2941830 0.8534084 0.081522181 0.0283246119
## [5,] 0.20886993 0.007513146 0.2277103 1.0475678 0.003221273 0.0664826573
## [6,] 0.08483420 0.079496544 0.0923727 1.8607733 0.072246195 0.0287425831
##        Lettuce     Sauce    Cilantro       Onion    Avocado   Vegetable
## [1,] 0.32231365 0.1337738 0.055637610 0.043461999 0.03719855 0.065980639
## [2,] 0.41904243 0.2674609 0.057706562 0.190681788 0.52204447 0.141212512
## [3,] 0.37117995 0.2441431 0.030493664 0.074956861 0.17943047 0.078305077
## [4,] 0.10781560 0.4652029 0.005265489 0.007145941 0.23394291 0.053717588
## [5,] 0.17140874 0.1877594 0.327104079 0.029627456 0.43873726 0.112226348
## [6,] 0.06732199 0.1447768 0.055650882 0.065043220 0.04725805 0.005873666
##       Breakfast     Other    sigma
## [1,] 0.158133864 0.4900959 1.258307
## [2,] 0.208874582 0.9411699 1.227090
## [3,] 0.118458869 0.5238342 1.262930
## [4,] 0.029771416 0.9737864 1.248420
## [5,] 0.188658515 0.7422988 1.258279
## [6,] 0.006046198 0.7521763 1.324477
```

Model Diagnostics

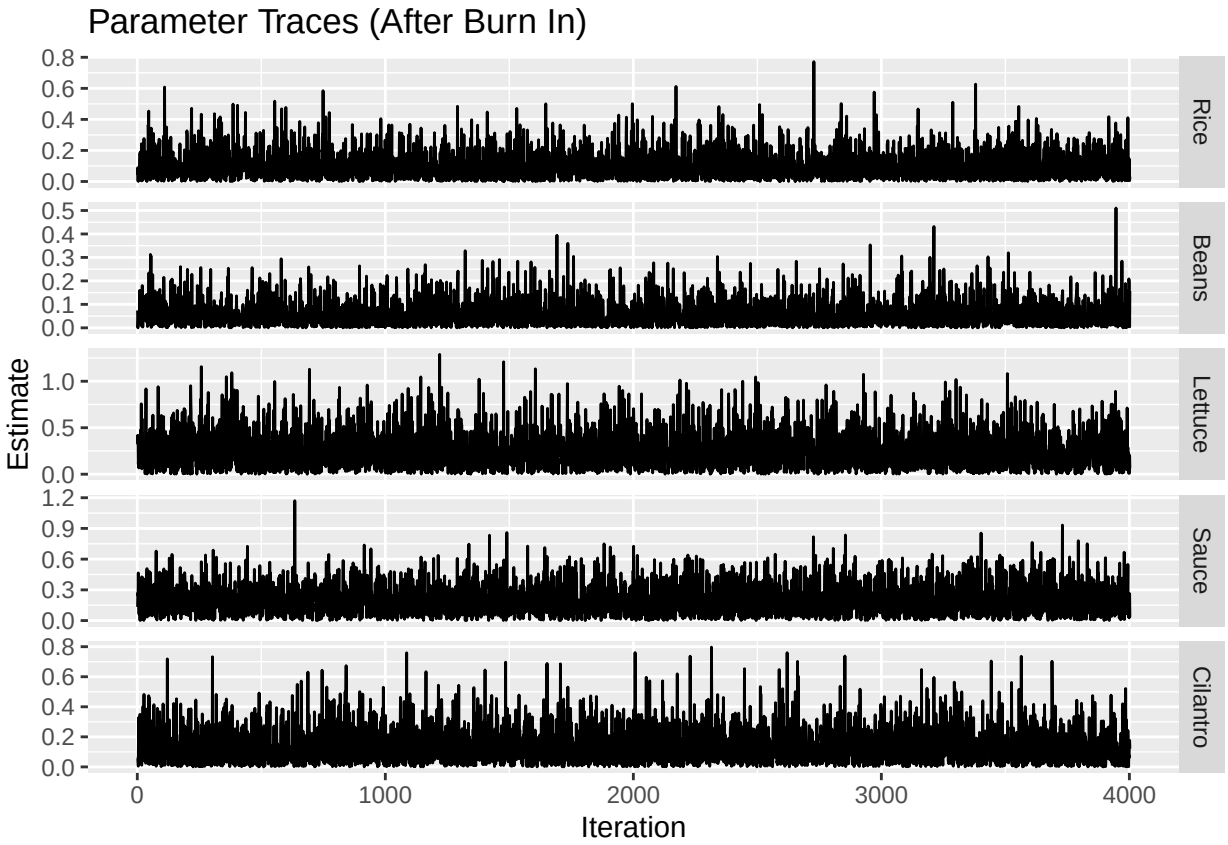
```
plot_traces(truncated_post_dist[,1:5], 'Parameter Traces (After Burn In)')
```



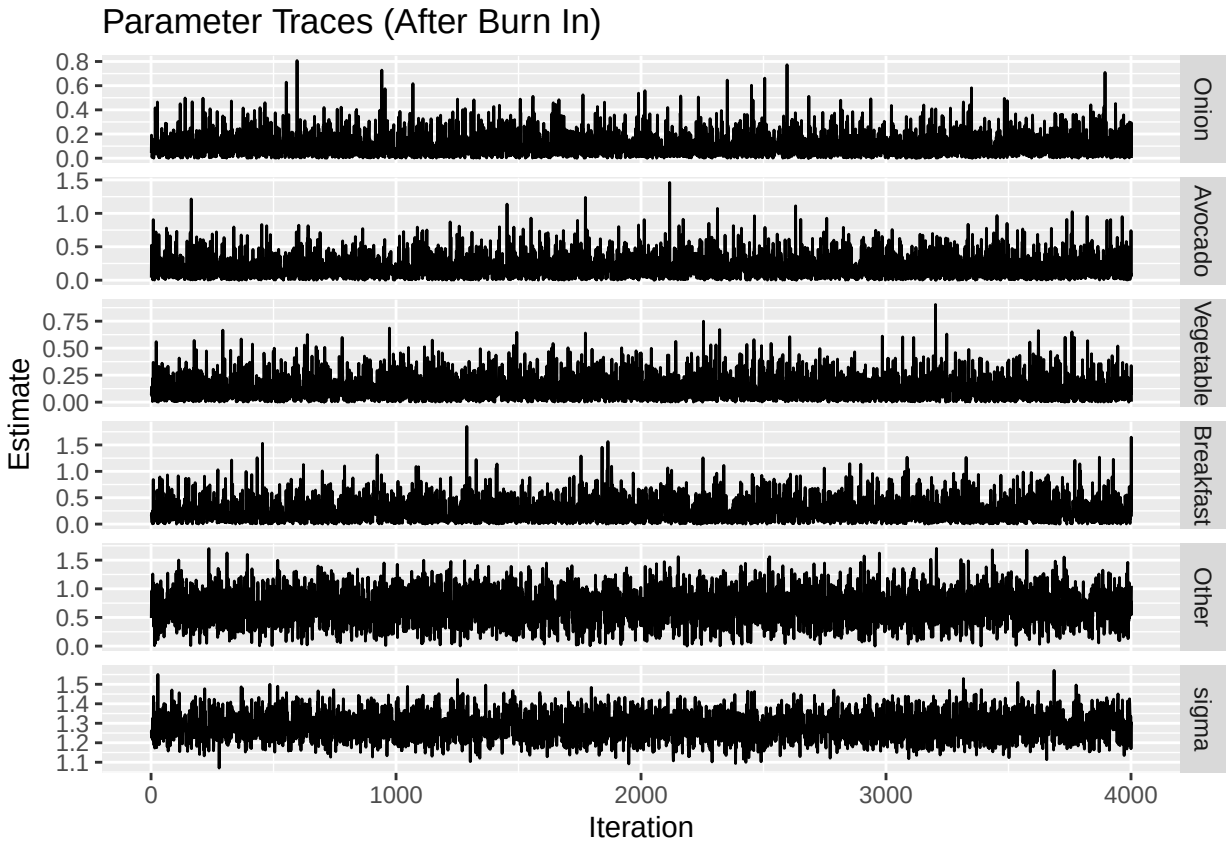

```
plot_traces(truncated_post_dist[,6:10], 'Parameter Traces (After Burn In)')
```



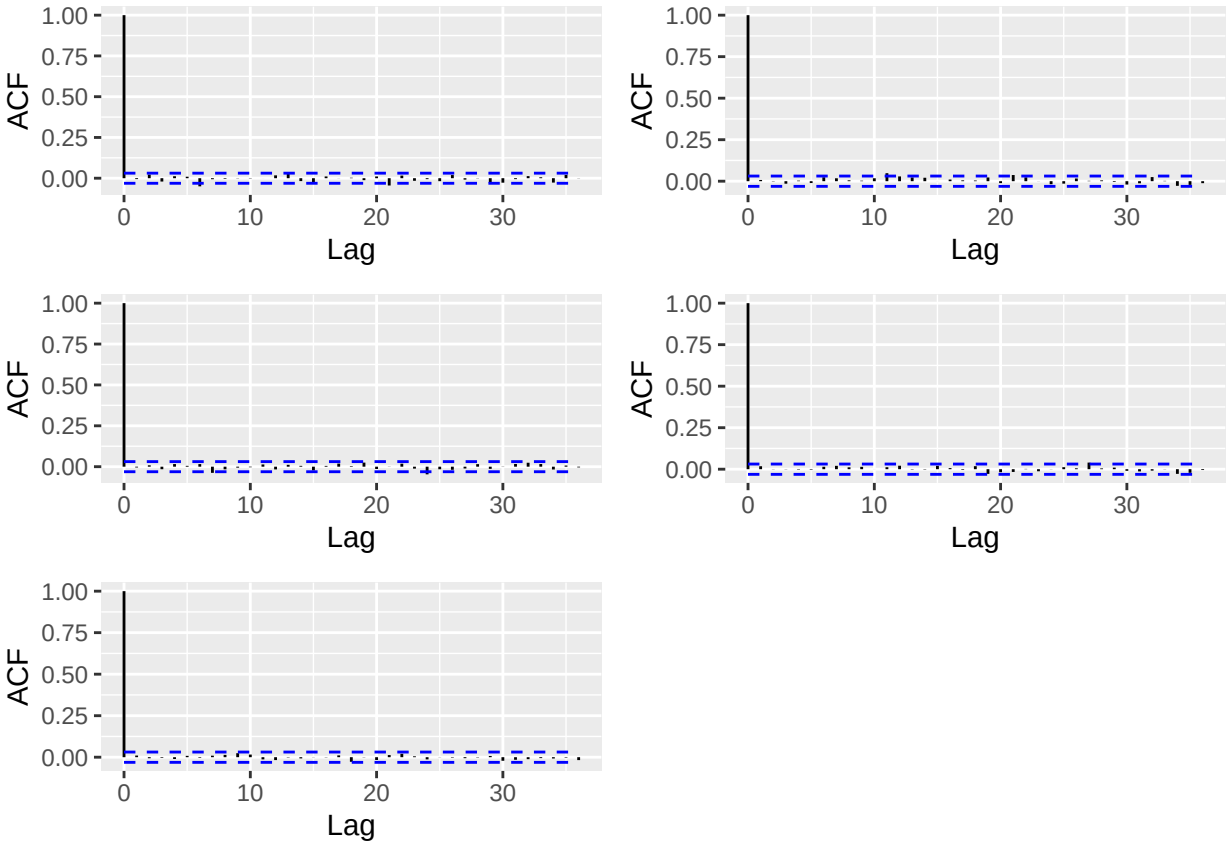

```
plot_traces(truncated_post_dist[,11:15], 'Parameter Traces (After Burn In)')
```



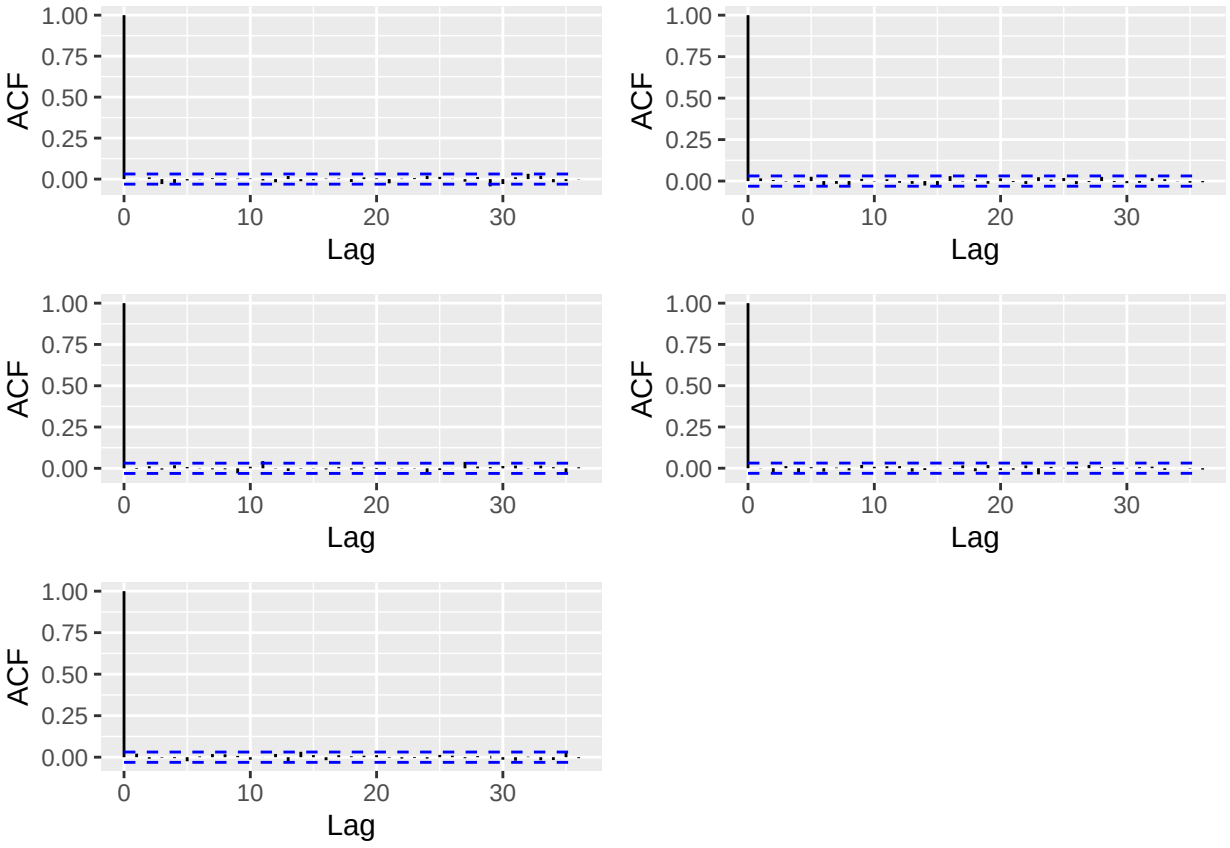

```
plot_traces(truncated_post_dist[,16:21], 'Parameter Traces (After Burn In)')
```



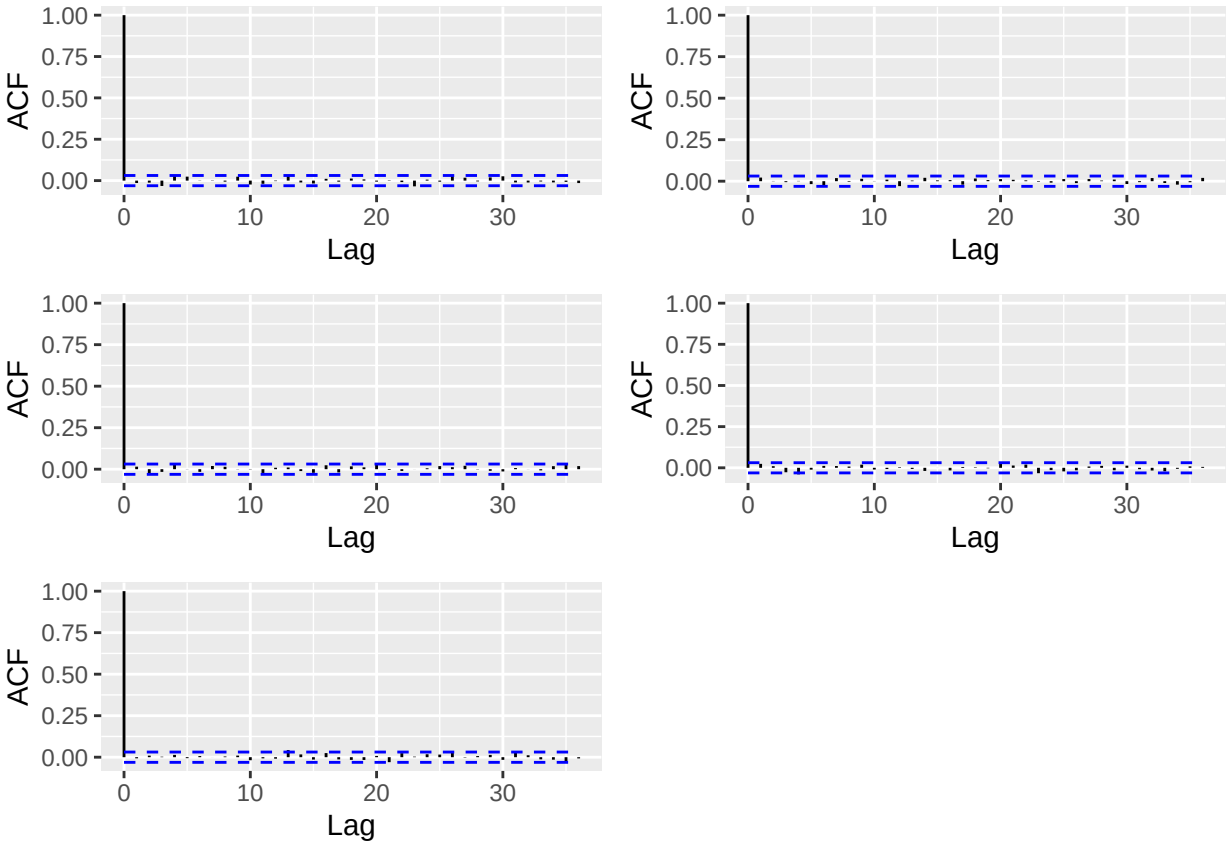

```
acf_plots(truncated_post_dist[,1:5])
```



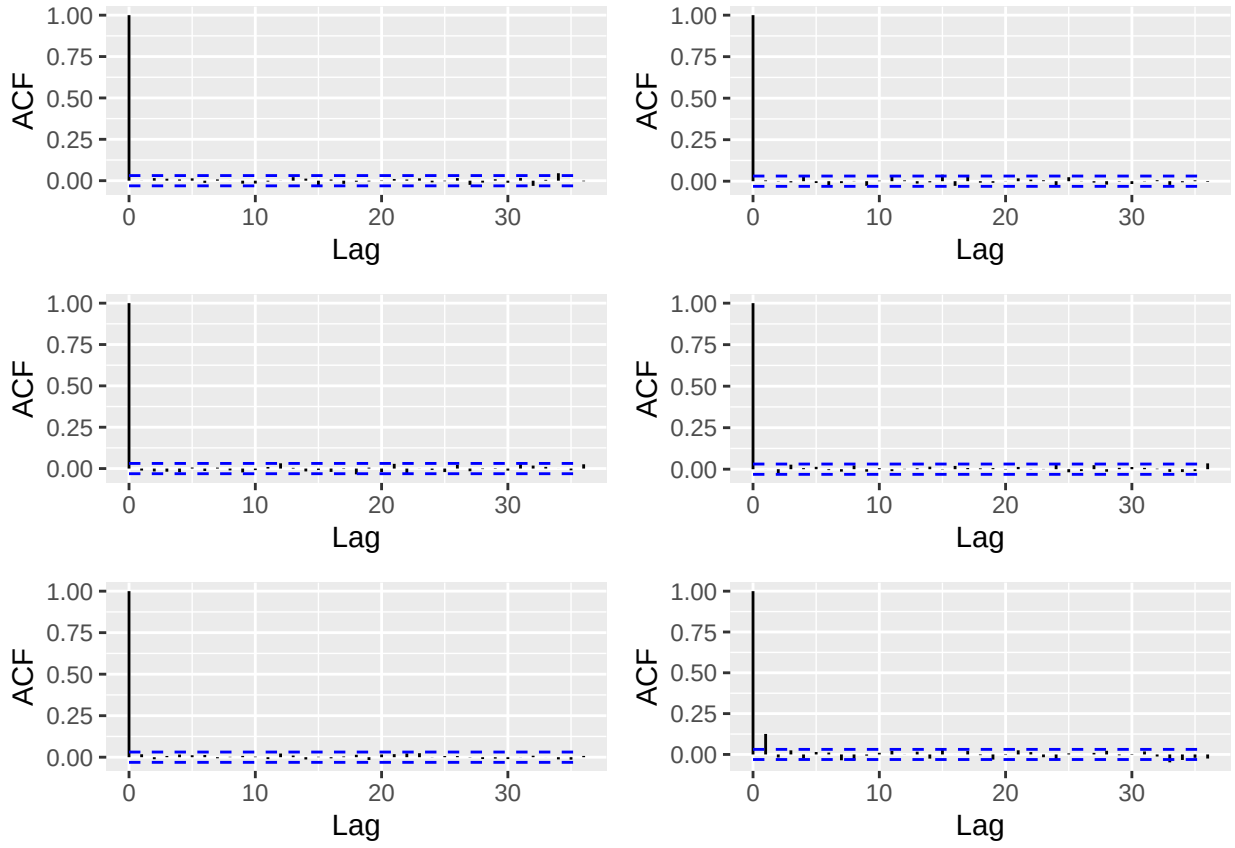

```
acf_plots(truncated_post_dist[,6:10])
```




```
acf_plots(truncated_post_dist[,11:15])
```




```
acf_plots(truncated_post_dist[,16:21])
```




```
summarize_dist(truncated_post_dist, colnames(truncated_post_dist), round_places=2)
```

Parameter	Post. Mean	Post. Sd	95% CI Low	95% CI High
Intercept	6.94	0.08	6.78	7.11
Beef	0.15	0.10	0.01	0.37
Pico	0.07	0.06	0.00	0.23
Guac	0.06	0.05	0.00	0.20
Cheese	0.06	0.06	0.00	0.21
Fries	0.07	0.06	0.00	0.22
Sour_cream	0.10	0.08	0.00	0.30
Pork	0.08	0.07	0.00	0.28
Chicken	0.35	0.23	0.02	0.87
Shrimp	1.14	0.30	0.55	1.73
Rice	0.10	0.09	0.00	0.33
Beans	0.06	0.06	0.00	0.21
Lettuce	0.25	0.20	0.01	0.77
Sauce	0.20	0.15	0.01	0.57
Cilantro	0.14	0.12	0.00	0.44
Onion	0.11	0.10	0.00	0.37
Avocado	0.20	0.18	0.01	0.65
Vegetable	0.13	0.11	0.00	0.42
Breakfast	0.25	0.22	0.01	0.83
Other	0.69	0.30	0.13	1.28
sigma	1.28	0.07	1.16	1.42

Protein Model

```
num_burritos_no_protein = sum(burrito$Num_Proteins == 0)
num_burritos_no_protein
```

```
## [1] 31
```

```
num_burritos_double_protein = sum(burrito$Num_Proteins == 2)
num_burritos_double_protein
```

```
## [1] 34
```

```
burrito_no_double_protein = burrito[burrito$Num_Proteins != 2, ]
head(burrito_no_double_protein)
```

```
##               Location Cost Hunger Length Circum Volume Tortilla Temp Meat
## 1   Donato's taco shop 6.49    3.0     NA     NA     NA        3  5.0  3.0
## 2 Oscar's Mexican food 5.45    3.5     NA     NA     NA        2  3.5  2.5
## 3 Oscar's Mexican food 4.85    1.5     NA     NA     NA        3  2.0  2.5
## 4 Oscar's Mexican food 5.25    2.0     NA     NA     NA        3  2.0  3.5
## 5         Pollos Maria 6.59    4.0     NA     NA     NA        4  5.0  4.0
## 6         Pollos Maria 6.99    4.0     NA     NA     NA        3  4.0  5.0
##   Fillings Meat_filling Uniformity Salsa Synergy Wrap Reviewer overall Beef
## 1      3.5          4.0        4.0   4.0     4.0    4    Scott    3.80    1
## 2      2.5          2.0        4.0   3.5     2.5    5    Scott    3.00    1
## 3      3.0          4.5        4.0   3.0     3.0    5    Emily    3.00    0
## 4      3.0          4.0        5.0   4.0     4.0    5  Ricardo    3.75    1
## 5      3.5          4.5        5.0   2.5     4.5    4    Scott    4.20    1
## 6      3.5          2.5        2.5   2.5     4.0    1    Emily    3.20    0
##   Pico Guac Cheese Fries Sour_cream Pork Chicken Shrimp Rice Beans Lettuce
## 1    1    1      1     1          0    0       0      0    0     0       0
## 2    1    1      1     1          0    0       0      0    0     0       0
## 3    1    1      0     0          0    1       0      0    0     0       0
## 4    1    1      0     0          0    0       0      0    0     0       0
## 5    1    0      1     1          0    0       0      0    0     0       0
## 6    0    1      1     0          1    0       1      0    1     1       1
##   Sauce Cilantro Onion Avocado Vegetable Breakfast Other Num_Proteins
## 1     0        0     0       0         0         0     0            1
## 2     0        0     0       0         0         0     0            1
## 3     0        0     0       0         0         0     0            1
## 4     0        0     0       0         0         0     0            1
## 5     0        0     0       0         0         0     0            1
## 6     0        0     0       0         1         0     0            1
```

```
burrito_no_double_protein = burrito_no_double_protein %>% mutate(Protein= as.factor(Chicken + 2*Beef + 3
head(burrito_no_double_protein)
```

```
##               Location Cost Hunger Length Circum Volume Tortilla Temp Meat
## 1   Donato's taco shop 6.49    3.0     NA     NA     NA        3  5.0  3.0
## 2 Oscar's Mexican food 5.45    3.5     NA     NA     NA        2  3.5  2.5
## 3 Oscar's Mexican food 4.85    1.5     NA     NA     NA        3  2.0  2.5
## 4 Oscar's Mexican food 5.25    2.0     NA     NA     NA        3  2.0  3.5
## 5         Pollos Maria 6.59    4.0     NA     NA     NA        4  5.0  4.0
## 6         Pollos Maria 6.99    4.0     NA     NA     NA        3  4.0  5.0
##   Fillings Meat_filling Uniformity Salsa Synergy Wrap Reviewer overall Beef
## 1      3.5          4.0        4.0   4.0     4.0    4    Scott    3.80    1
```

```
## 2      2.5          2.0        4.0   3.5     2.5    5    Scott    3.00    1
## 3      3.0          4.5        4.0   3.0     3.0    5    Emily    3.00    0
## 4      3.0          4.0        5.0   4.0     4.0    5  Ricardo    3.75    1
## 5      3.5          4.5        5.0   2.5     4.5    4    Scott    4.20    1
## 6      3.5          2.5        2.5   2.5     4.0    1    Emily    3.20    0
##   Pico Guac Cheese Fries Sour_cream Pork Chicken Shrimp Rice Beans Lettuce
## 1    1    1      1     1          0    0       0      0    0     0       0
## 2    1    1      1     1          0    0       0      0    0     0       0
## 3    1    1      0     0          0    1       0      0    0     0       0
## 4    1    1      0     0          0    0       0      0    0     0       0
## 5    1    0      1     1          0    0       0      0    0     0       0
## 6    0    1      1     0          1    0       1      0    1     1       1
##   Sauce Cilantro Onion Avocado Vegetable Breakfast Other Num_Proteins Protein
## 1     0        0     0       0         0         0     0            1       2
## 2     0        0     0       0         0         0     0            1       2
## 3     0        0     0       0         0         0     0            1       3
## 4     0        0     0       0         0         0     0            1       2
## 5     0        0     0       0         0         0     0            1       2
## 6     0        0     0       0         1         0     0            1       1
```

```
proteins = c('Chicken', 'Beef', 'Pork', 'Shrimp', 'Other', 'Breakfast')
proteins_X = as.matrix(burrito_no_double_protein[proteins])
head(proteins_X)
```

```
##   Chicken Beef Pork Shrimp Other Breakfast
## 1       0    1    0      0     0         0
## 2       0    1    0      0     0         0
## 3       0    0    1      0     0         0
## 4       0    1    0      0     0         0
## 5       0    1    0      0     0         0
## 6       1    0    0      0     0         0
```

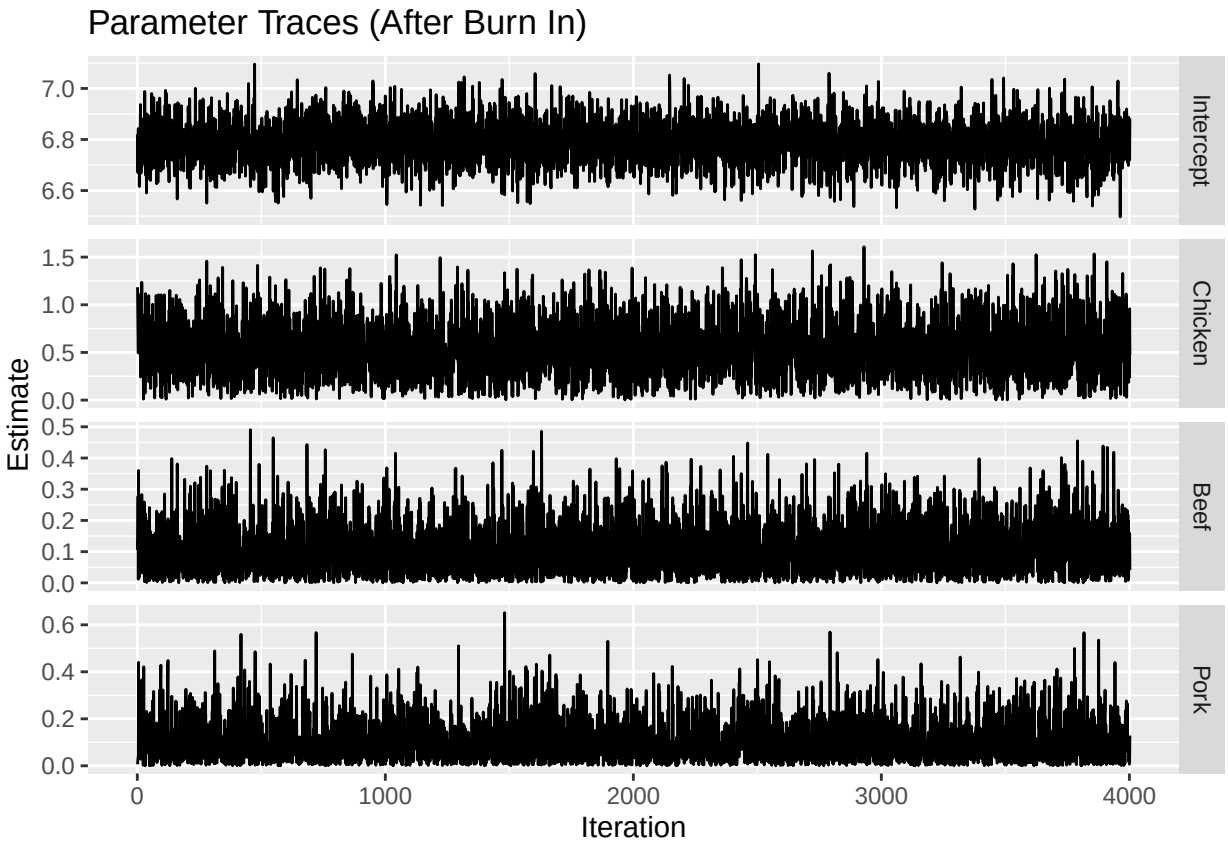
```
protein_cost_y = burrito_no_double_protein$Cost
```

```
set.seed(RANDOM_SEED)

mlr_protein_post_dist = truncated_gibbs(proteins_X, protein_cost_y, mu=rep(1, 7),
                                        tau_2, a, b, lb=rep(0,7), ub=rep(Inf,7))
mlr_protein_post_dist = mlr_protein_post_dist[5001:1000, ]
head(mlr_protein_post_dist)
```

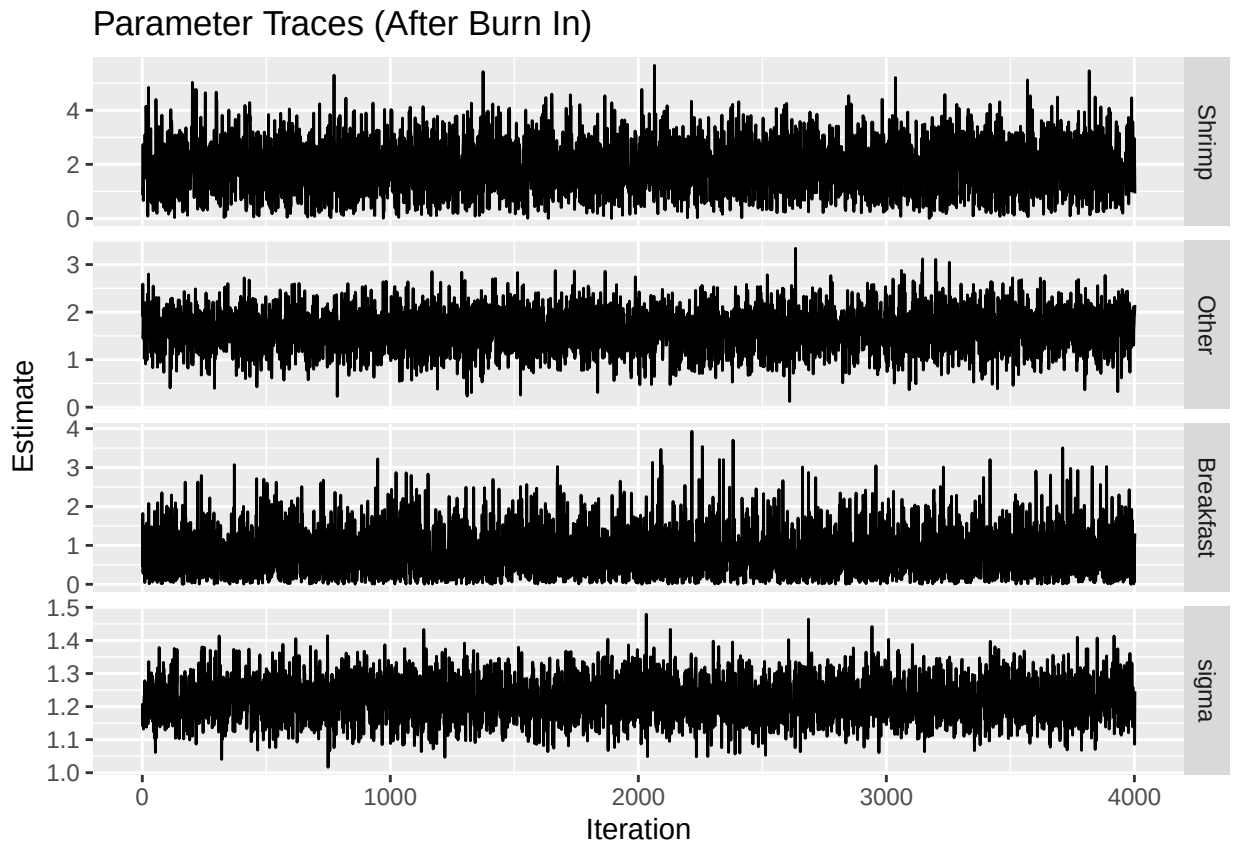
```
##      Intercept   Chicken       Beef        Pork    Shrimp    Other Breakfast
## [1,]  6.819649 1.1838688 0.10596626 0.006696897 0.8610927 1.908981 0.4454483
## [2,]  6.670769 0.8494238 0.13714299 0.023989596 1.1824861 2.589815 1.8189703
## [3,]  6.758531 0.5968113 0.27743274 0.035797087 2.7364552 1.447467 0.2880023
## [4,]  6.842586 0.4936924 0.01193676 0.040058333 0.6643153 1.550390 0.9349632
## [5,]  6.683130 0.7891352 0.35991111 0.440114948 1.4217828 2.133226 0.2820344
## [6,]  6.750401 1.1084105 0.16474648 0.184533258 1.7953945 1.456925 0.5024557
##         sigma
## [1,] 1.210100
## [2,] 1.140552
## [3,] 1.182736
## [4,] 1.205538
## [5,] 1.131851
## [6,] 1.152073
```

Model Diagnostics

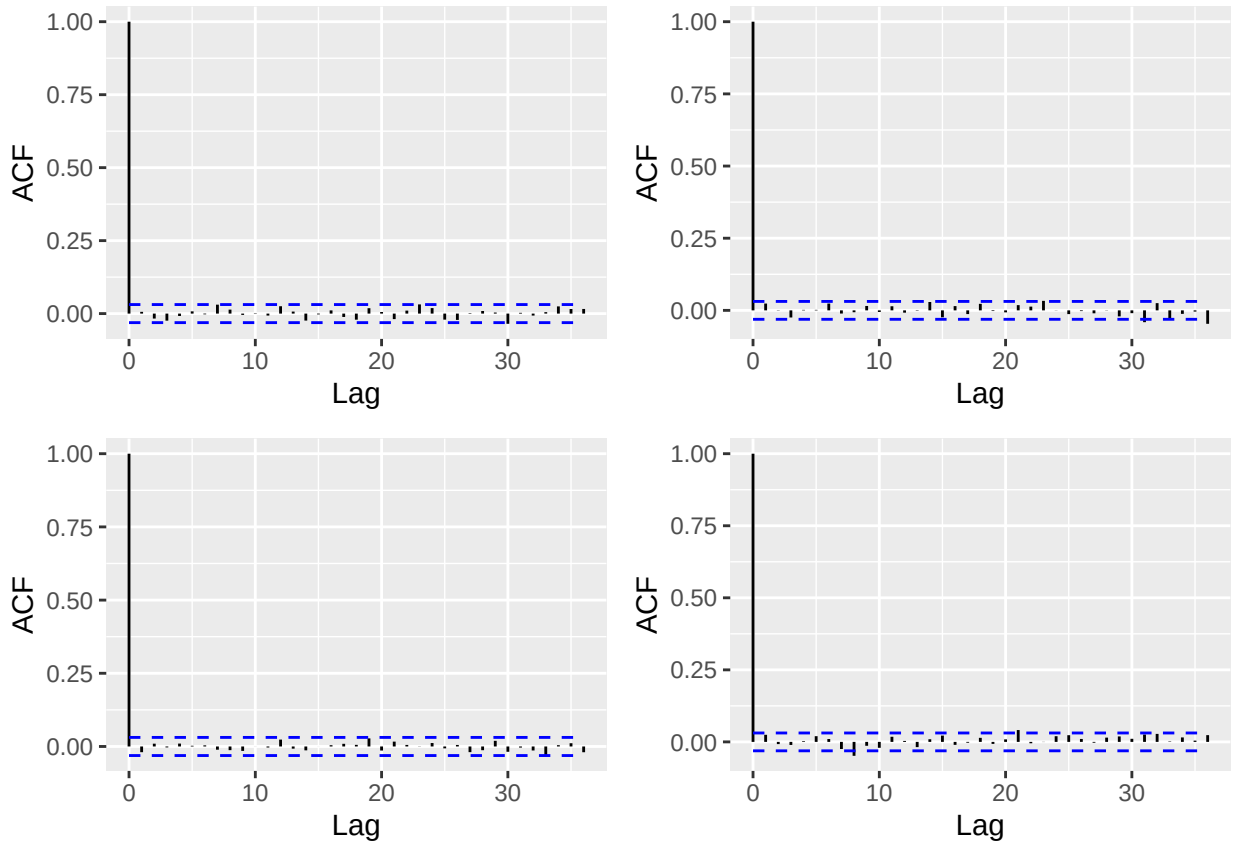
```
plot_traces(mlr_protein_post_dist[,1:4], 'Parameter Traces (After Burn In)')
```



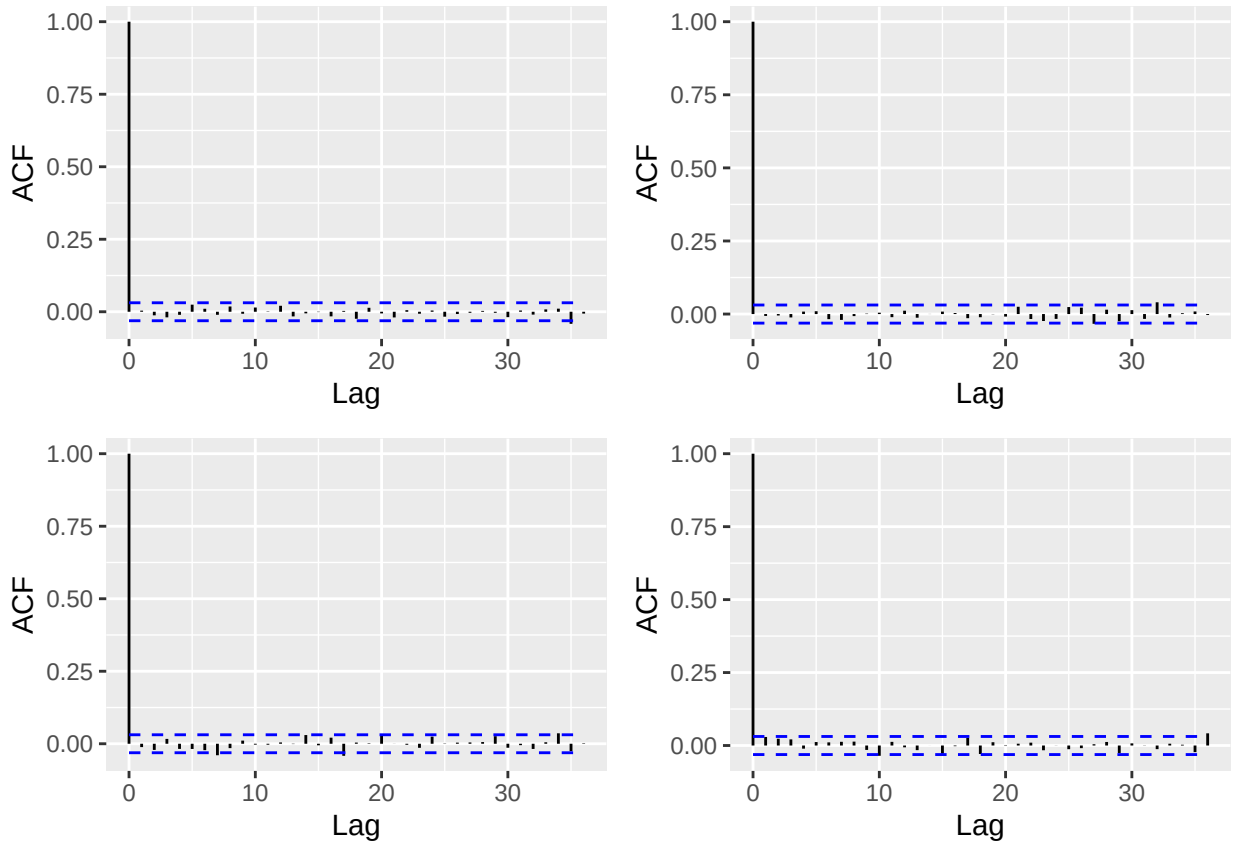

```
plot_traces(mlr_protein_post_dist[,5:8], 'Parameter Traces (After Burn In)')
```




```
acf_plots(mlr_protein_post_dist[,1:4])
```




```
acf_plots(mlr_protein_post_dist[,5:8])
```




```
summarize_dist(mlr_protein_post_dist, colnames(mlr_protein_post_dist), round_places=2)
```

Parameter	Post. Mean	Post. Sd	95% CI Low	95% CI High
Intercept	6.79	0.08	6.62	6.96
Chicken	0.54	0.30	0.05	1.17
Beef	0.11	0.08	0.00	0.31
Pork	0.10	0.09	0.00	0.33
Shrimp	1.92	0.95	0.26	3.85
Other	1.62	0.43	0.77	2.47
Breakfast	0.80	0.61	0.03	2.26
sigma	1.22	0.06	1.10	1.35

Mixed Model

```
set.seed(RANDOM_SEED)

#source('./gibbs_util.R')

a1 <- 0.1975
a2 <- 0.44
b1 <- 0.5
b2 <- 0.5

mixed_post = mixed_effects_gibbs(proteins_X, protein_cost_y,
```

```
                                group=burrito_no_double_protein$Location,
                                mu=rep(1, p), tau_2, a1, b1, a2, b2)

mixed_post <- mixed_post[5001:10000,]

parameters_post <- mixed_post[, 1:9]
head(parameters_post)
```

```
##      Intercept   Chicken      Beef        Pork   Shrimp    Other Breakfast
## [1,]  6.318297 1.1956751 0.8583097 0.465787668 3.649521 1.864608 1.2427320
## [2,]  6.785699 0.6432455 0.4352482 0.001789646 3.486410 1.361738 1.9904427
## [3,]  6.502311 1.1990899 0.8259787 0.455804948 4.383330 1.780543 1.3048681
## [4,]  6.292565 1.3122584 0.7823506 0.654325356 4.035935 2.116692 0.5478760
## [5,]  6.343964 0.8781632 0.7703904 0.377848374 4.135862 1.678559 0.4355292
## [6,]  6.412244 1.0824813 0.7847619 0.325552969 3.720730 1.884741 2.5690202
##          Sigma    Kappa
## [1,] 0.7354635 1.706270
## [2,] 0.7230517 2.090589
## [3,] 0.7719328 1.672536
## [4,] 0.8095384 1.820020
## [5,] 0.7763290 1.776340
## [6,] 0.7616101 1.531952
```

```
restaurants_post <- mixed_post[, 10 : ncol(mixed_post)]
head(restaurants_post)
```

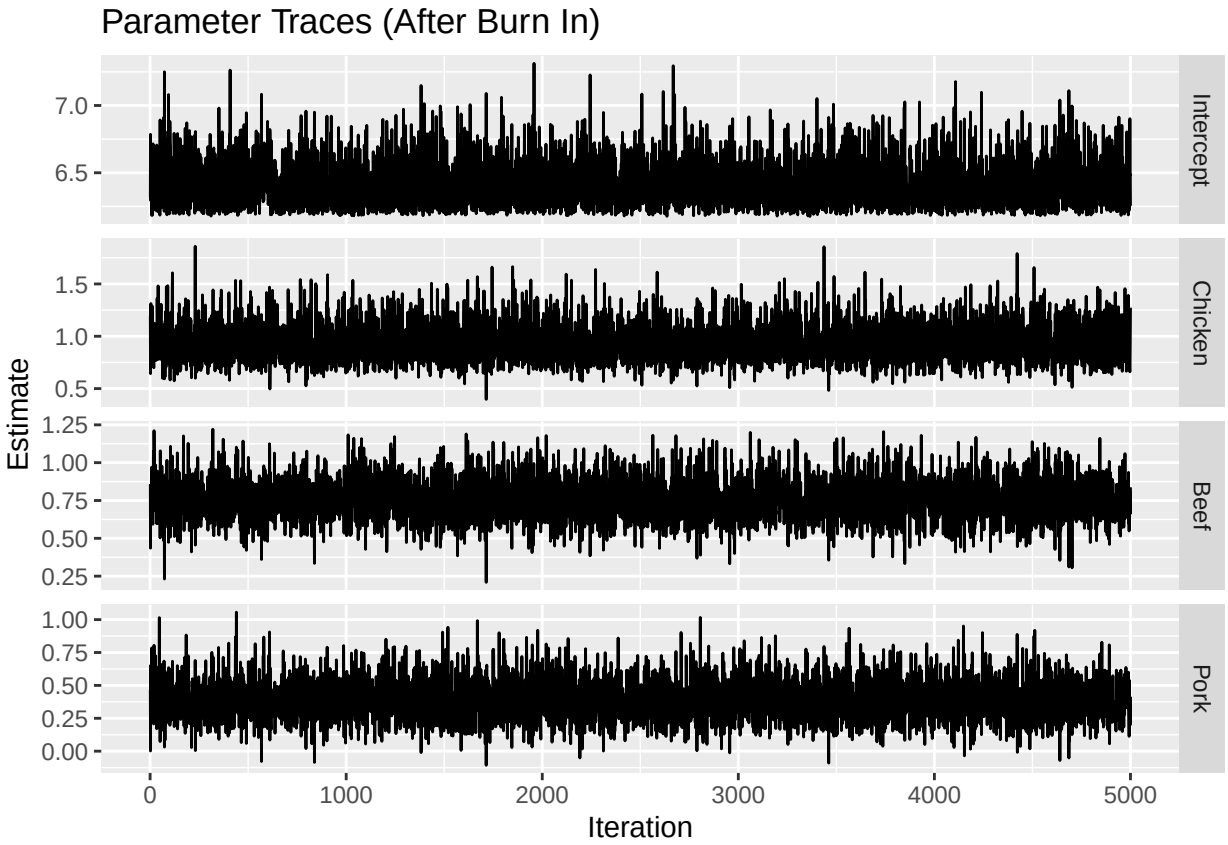
```
##      Albertacos Alberto's 623 N Escondido Blvd, Escondido, CA 92025
## [1,]  -1.294878                                          -0.946183
## [2,]  -1.471309                                          -1.503448
## [3,]  -1.564683                                          -1.581335
## [4,]  -1.207131                                          -0.727953
## [5,]  -1.088328                                          -1.237756
## [6,]  -1.429576                                          -1.125475
##      Burros and Fries California Burritos Cancun Mexican & Seafood
## [1,]      -0.05088248          -0.8093603               0.60327582
## [2,]      -0.19435525          -0.8169659               0.48355786
## [3,]       0.07216820          -0.9818817               0.07821094
## [4,]       0.36877572          -0.6568520               0.15407213
## [5,]      -0.08486604          -0.7502067               0.80528050
## [6,]       0.17587336          -0.5588729               0.16951461
##      Carmen's Mexican Food Chili Peppers  Chipotle Colima's Donato's taco shop
## [1,]           -0.41835850      2.894299 1.5946533 2.713750         -0.1662236
## [2,]           -0.17485540      2.278770 0.5727394 1.259205          0.6487787
## [3,]           -0.08747645      2.768045 0.3786638 1.682350         -0.1402406
## [4,]            0.38199229      3.243627 0.8653671 2.421052          0.7513770
## [5,]           -0.32083952      2.792593 1.1228441 2.147509          0.0880807
## [6,]           -0.22263225      3.353890 1.3754128 1.627991         -0.1003044
##       El Cuervo El dorado Mexican food  El Indio El Nopalito
## [1,] -0.1022928            -0.05855229 1.1629757  -1.7289579
## [2,] -0.2760272             0.18520796 0.7214594  -1.6536494
## [3,]  0.3161986            -0.33286015 1.9922708  -1.5377998
## [4,]  0.2329484             0.21302323 0.9050623  -1.2804169
## [5,]  0.4547335             0.27186064 1.0400829  -0.3291552
## [6,] -0.2907667             0.04561366 1.3804703  -1.3742912
```

```
##      El Pueblo Mexican Food El Torrito Foods   El Zarape   Goody's
## [1,]            -1.80296489       -1.6968791  0.22383200 0.4475074
## [2,]            -1.65540078       -1.4194555 -0.12976370 0.3195765
## [3,]            -1.43014189       -2.2198749 -0.01968862 0.7238796
## [4,]            -1.31791247       -0.8887553  0.02243985 0.5034053
## [5,]             0.04155661       -1.5712463  0.50891165 0.8776743
## [6,]            -0.84056387       -0.7472908  0.40003103 0.4664599
##      Graciela's Taco Shop   Humbertos Jorge's Mexicatessen Juanita's Taco Shop
## [1,]           -0.6570355 -0.15159101           -0.9099552          -1.1719344
## [2,]           -0.9237984 -0.65322145           -0.8273691          -0.8600914
## [3,]           -0.6016143 -0.43377165           -0.8684241          -1.5326649
## [4,]           -0.4927461  0.42508938           -0.7324726          -1.0195295
## [5,]           -0.7777174  0.35629688           -0.6129117          -0.9114541
## [6,]           -0.6185911  0.05041773           -0.4963153          -1.3828318
##      JV's Mexican Food Karina's Taco Shop King Burrito Kotija Jr.
## [1,]        -0.7899114         0.40343045   -1.4238121 -0.9055808
## [2,]         0.4602622        -0.19000720   -1.3270182 -1.0246613
## [3,]        -0.2834878        -0.01342611   -0.7669147 -1.0148015
## [4,]        -0.6659295         0.76800520   -1.4966856 -0.5054490
## [5,]        -0.1607542         0.57438005   -1.2238525 -0.6014120
## [6,]        -0.7406558         0.86699505   -1.4003503 -1.4391960
##      La Perla Cocina Lola's 7 Up Market & Deli Lolita's taco shop
## [1,]        1.266256               -0.27514062         -0.6163098
## [2,]        1.217207               -0.17866304         -0.4167449
## [3,]        1.024503               -0.67713545         -0.3866730
## [4,]        1.017292               -0.18426251         -0.6254270
## [5,]        1.367531               -0.06725716         -0.2781349
## [6,]        1.098599               -0.48795820         -0.4639057
##      Lolita's Taco shop Lolita's Taco Shop  Los Cabos Los Primos Mexican Food
## [1,]         -0.8981888          0.3091423 -0.7103243               0.6627998
## [2,]         -1.6155859          0.5754697 -0.7198198               0.7868396
## [3,]         -1.6449028          0.1068411 -0.9225256               0.6487137
## [4,]         -0.8531708          0.4634644 -0.3572955               0.6412637
## [5,]         -1.3982442          0.2488036 -0.8714079               0.8175198
## [6,]         -0.9758601          0.1553812 -0.7035657               0.7273839
##      Los tacos Los Tacos Lucha Libre North Park Mi Asador Mexican & Seafood
## [1,] 1.2389627  1.995903           -0.002523984                -0.001726894
## [2,] 1.4130244  1.397586           -0.021669370                 0.150513351
## [3,] 0.9064397  1.468115           -0.151036075                -0.467015988
## [4,] 1.9081717  2.165820            0.003620622                -0.131757960
## [5,] 1.1091919  2.003982            0.192833675                 0.074018642
## [6,] 1.1048496  2.150496            0.114802947                -0.034714500
##      Mikes Taco Club MXN on Washington Netos Mexican Food Nico's Taco Shop
## [1,]        2.297764         -2.677964         -0.3147966       0.42748309
## [2,]        1.417591         -2.867263         -0.3123497       0.54742455
## [3,]        1.393398         -2.857588         -1.4546213       0.01095697
## [4,]        1.764164         -1.297592         -0.5574236       0.07580914
## [5,]        1.725836         -2.475556         -1.1322084       0.54811758
## [6,]        1.446497         -1.782423         -0.6856610       0.58564592
##      Oscar's Mexican food Papa Chito's Mexican Food Pedro's Tacos Pokirrito
## [1,]           -1.676498               -0.7895400     0.6900647  3.676915
## [2,]           -1.684857               -0.6457236     0.2798805  3.909784
## [3,]           -1.561617               -0.7899103     0.7330436  4.481773
## [4,]           -1.592935               -0.3750558     0.4751104  3.619638
```

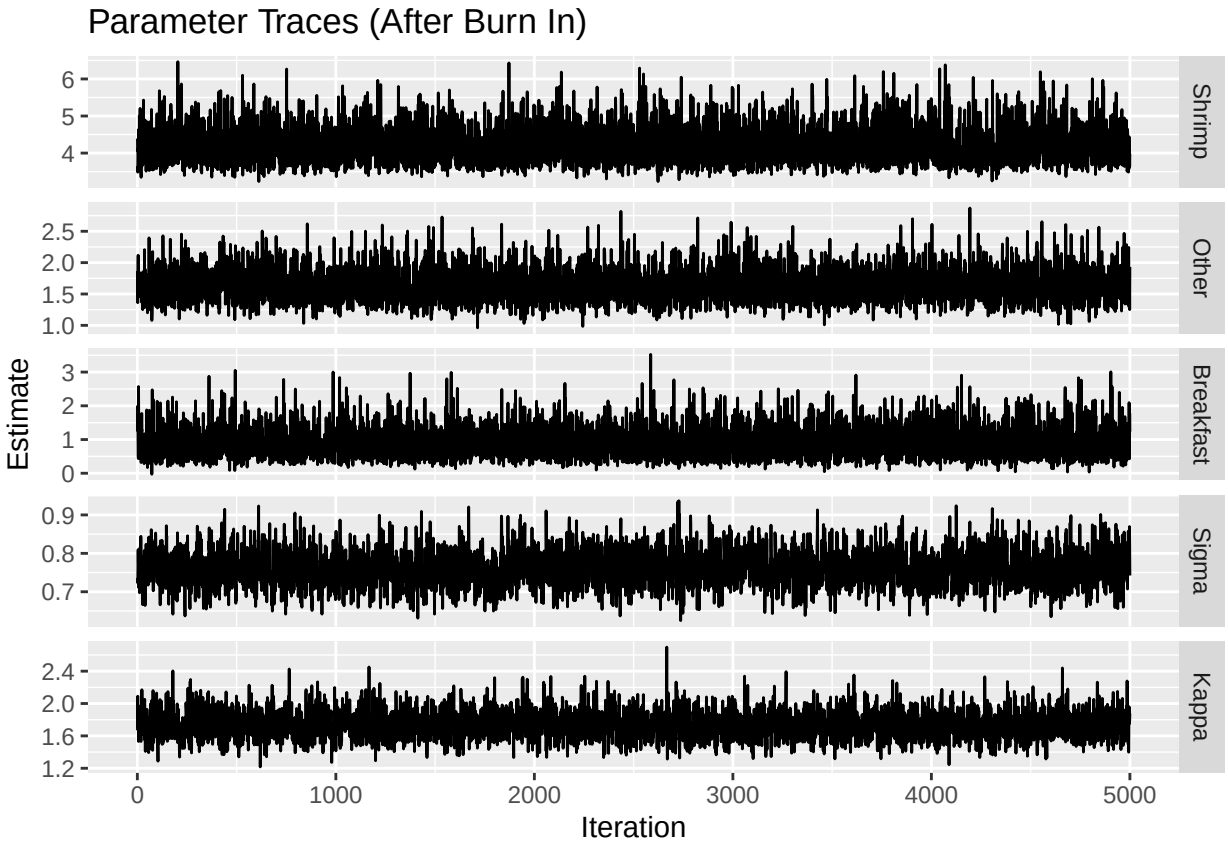
```
## [5,]           -1.264486               -0.2859147     0.5840027  3.700212
## [6,]           -1.647595               -0.6660129     1.1783707  3.398982
##      Pollos Maria Porkyland Qdoba Mexican Grill, Seatac Airport
## [1,]   -0.3462930  2.628643                           2.554869
## [2,]   -0.3863538  2.592215                           3.296434
## [3,]   -0.2507499  2.376064                           2.973432
## [4,]   -0.3818281  1.656338                           3.108850
## [5,]    0.6519052  1.854537                           2.547220
## [6,]   -0.2998028  2.074563                           3.561194
##      Raul's Mexican food Rigoberto's Taco Shop Rigoberto's Taco Shop La Jolla
## [1,]          -1.7976440          -0.20704896                     -0.5354003
## [2,]          -1.2032687          -0.66382629                     -0.6657494
## [3,]          -1.7656856          -0.58765811                     -0.6878403
## [4,]          -1.1898510          -0.35455147                     -0.2696144
## [5,]          -1.3213966          -0.01187299                     -0.5127361
## [6,]          -0.8244127          -0.72344130                     -0.5444572
##      Roberto's Taco Shop Clairemont Roberto's Very Mexican Food Rubios UCSD
## [1,]                     -0.7866134                  -1.0728803  0.87996808
## [2,]                     -0.7362840                  -0.8359087  0.90604854
## [3,]                     -0.7854089                  -0.5170017  1.00707337
## [4,]                     -0.5088365                  -1.0888297  0.13798181
## [5,]                     -0.1506776                  -0.2893459  0.88069059
## [6,]                     -0.7136384                  -0.6984260 -0.09492651
##      Rudy's Taco Shop  Saguaro's Senor Grubby's Senor Panchos
## [1,]       -0.4305485 -0.6541957       2.260695     0.3698746
## [2,]        0.2133865 -1.0407722       1.999277    -0.2257826
## [3,]        0.2519958 -1.0458712       1.886820     0.1451358
## [4,]       -0.5518825  0.1613678       1.864182     0.4670182
## [5,]       -0.2202928 -0.6906034       1.958617     1.0010468
## [6,]       -0.2809381 -0.3492330       2.145937     0.2068187
##      Sotos Mexican Food Taco stand Taco Stand Taco Surf PB Tacos La Bala
## [1,]         -0.4901377  0.7877105  0.5549426  -0.22794869    -1.0599622
## [2,]         -0.1527514  0.6722174  0.4847922   0.08380138    -1.4838301
## [3,]         -0.2346804  0.5520483  0.4520309  -0.15148064    -1.0633959
## [4,]          0.3474755  1.0194924  0.7828666  -0.11078271    -0.5809912
## [5,]         -0.1798530  0.7802876  0.9570654   0.35746194    -0.8424426
## [6,]         -0.4492813  0.6769174  0.7191453  -0.08084983    -0.6002250
##      Tacos por favor Tony's Fresh Mexican Food Vallarta express
## [1,]       0.9503790               -0.2362479        0.5427079
## [2,]       0.2588739               -0.4908258        0.1819940
## [3,]       0.3588208               -0.7782530        0.4356065
## [4,]       0.4764812               -0.6333156        0.4775430
## [5,]       1.0125495               -0.3970430        0.5790398
## [6,]       0.4273579               -0.5420410        0.1962896
```

Model Diagnostics

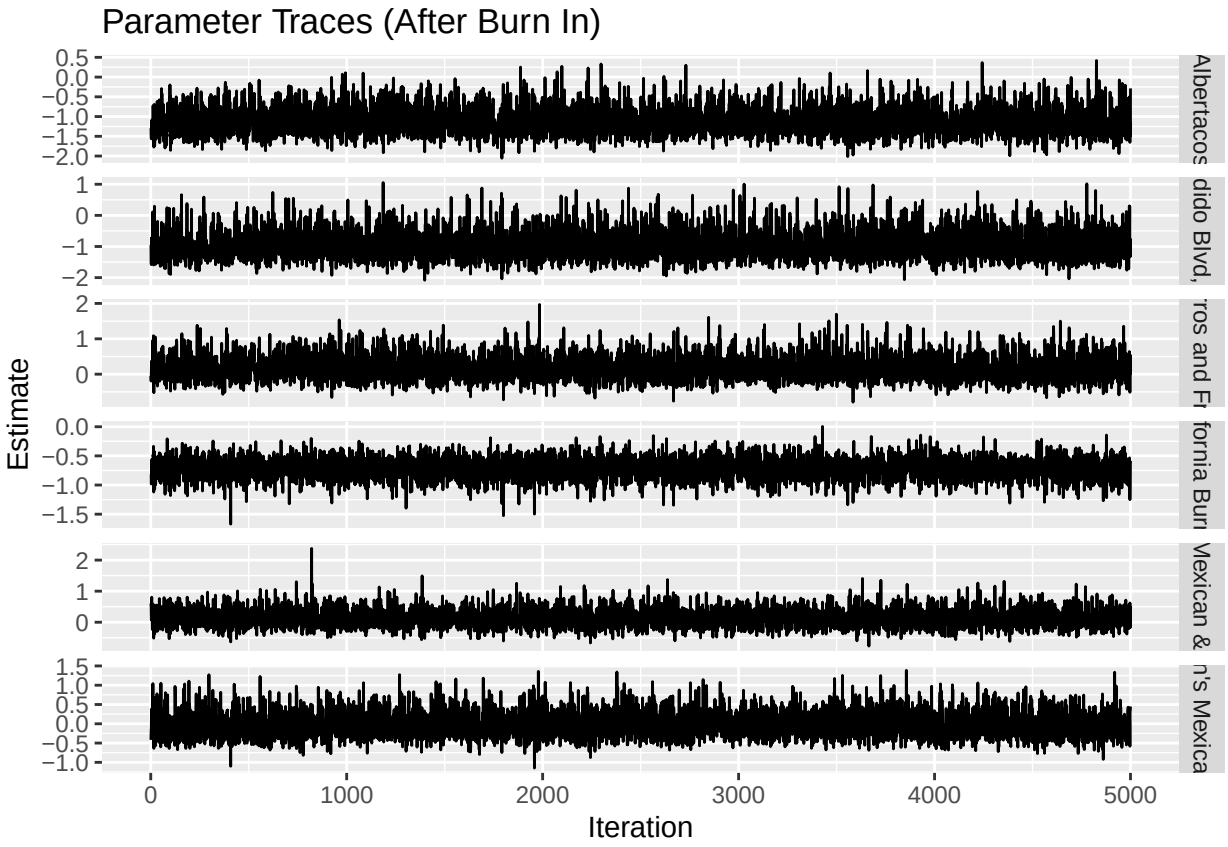
```
plot_traces(mixed_post[,1:4], 'Parameter Traces (After Burn In)')
```



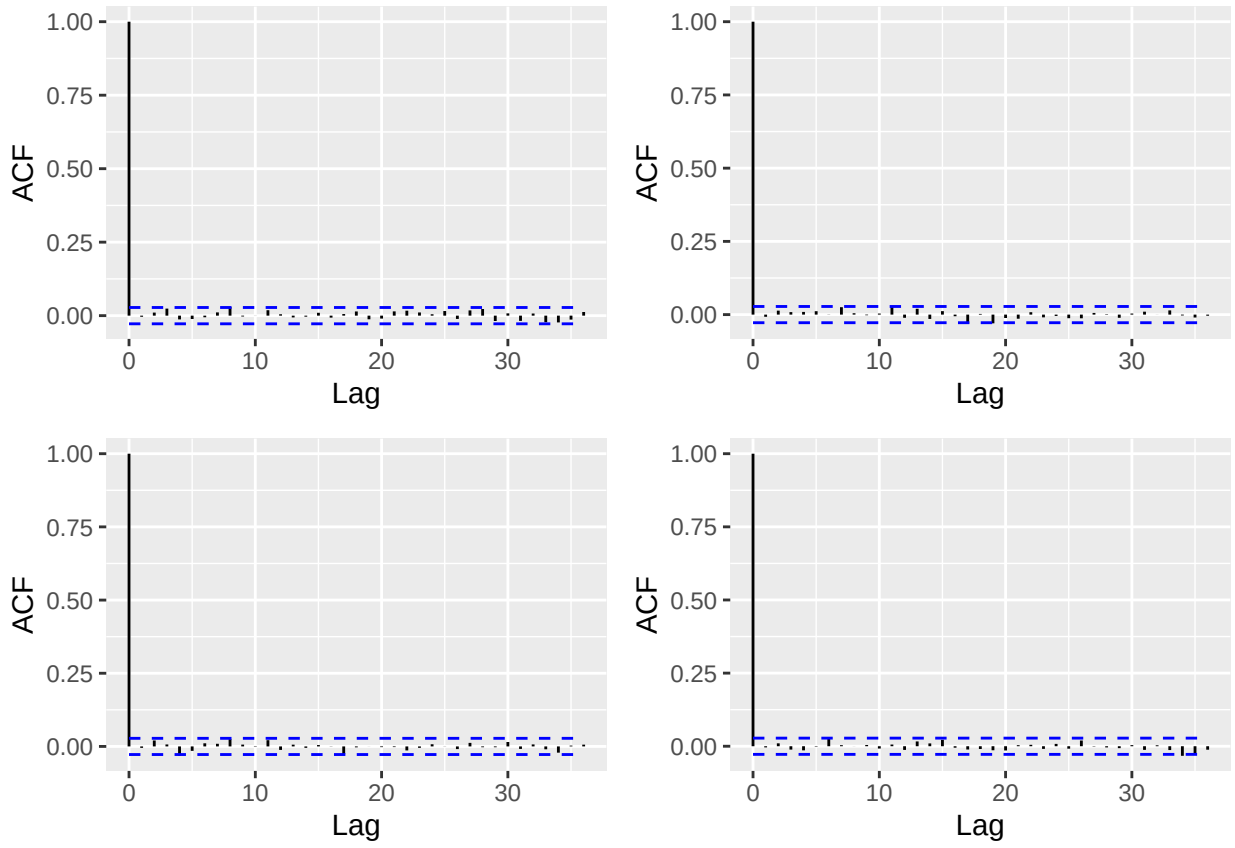

```
plot_traces(mixed_post[,5:9], 'Parameter Traces (After Burn In)')
```



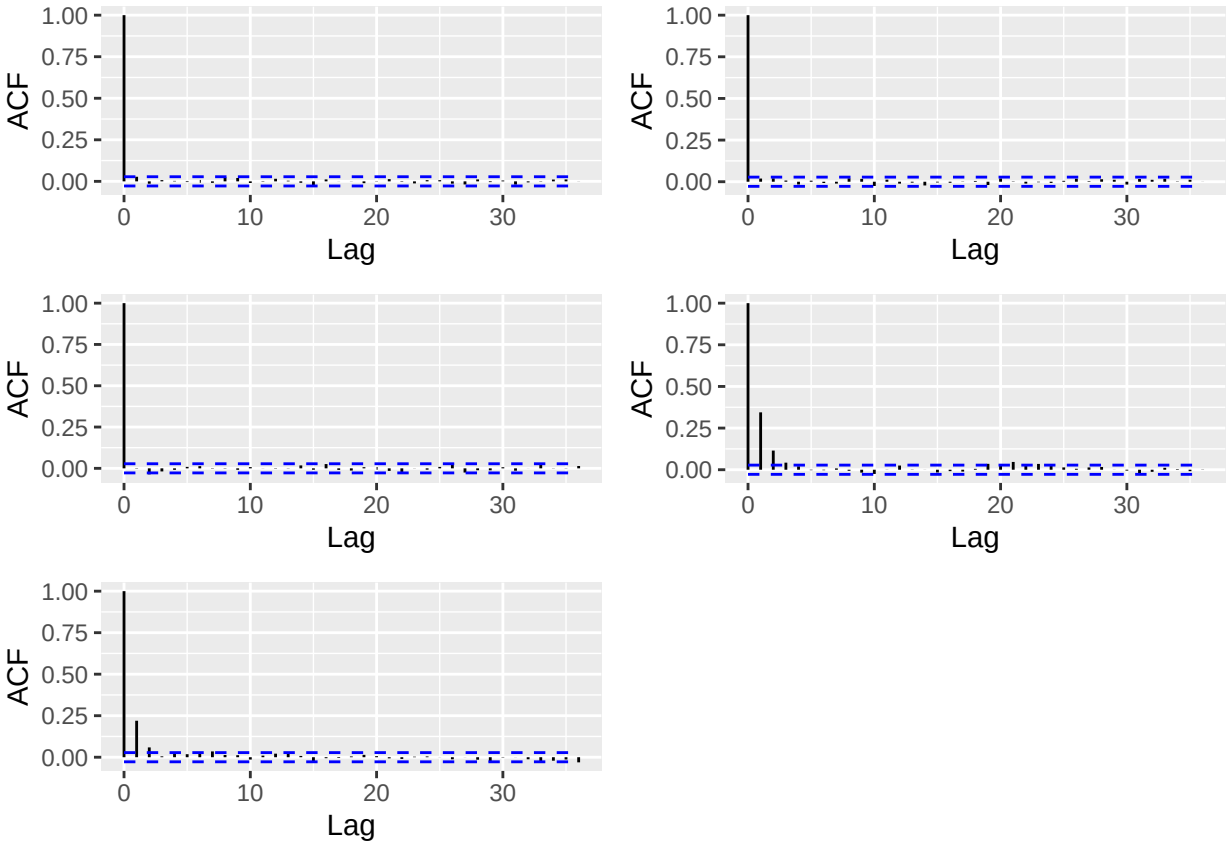

```
plot_traces(mixed_post[,10:15], 'Parameter Traces (After Burn In)')
```



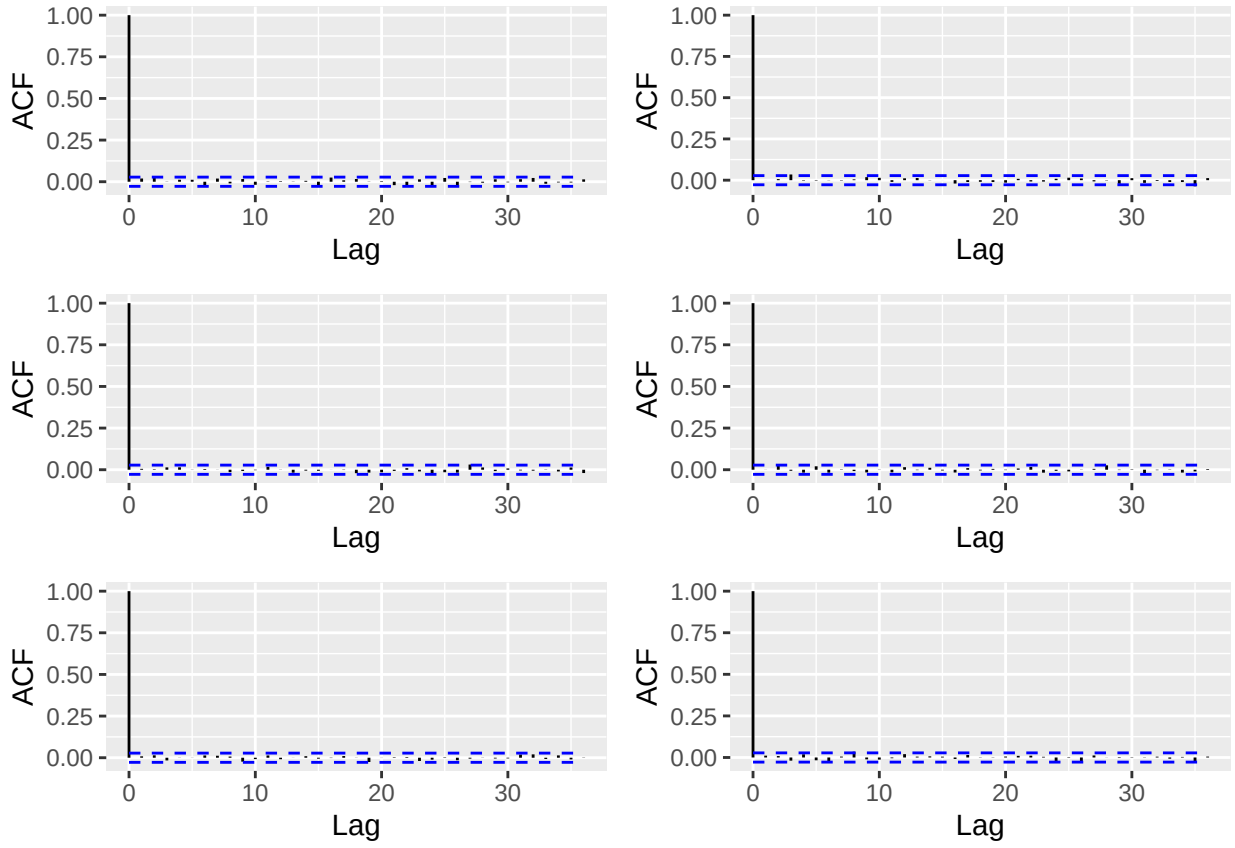

```
acf_plots(mixed_post[,1:4])
```




```
acf_plots(mixed_post[,5:9])
```




```
acf_plots(mixed_post[,10:15])
```



The ACF plots for σ and κ both have some auto correlation. This is not desirable, but was expected after seeing some autocorrelation in these parameters on Homework 8. It is ignored in this project.

```
summarize_dist(parameters_post, colnames(parameters_post), round_places = 2)
```

Parameter	Post. Mean	Post. Sd	95% CI Low	95% CI High
Intercept	6.41	0.17	6.19	6.82
Chicken	0.93	0.18	0.66	1.35
Beef	0.75	0.13	0.51	1.04
Pork	0.39	0.15	0.12	0.72
Shrimp	4.20	0.51	3.50	5.40
Other	1.63	0.26	1.21	2.21
Breakfast	0.90	0.47	0.26	2.03
Sigma	0.76	0.05	0.68	0.86
Kappa	1.73	0.17	1.43	2.09

```
summarize_dist(restaurants_post, colnames(restaurants_post), round_places = 2)
```

Parameter	Post. Mean	Post. Sd	95% CI Low	95% CI High
Albertacos	-1.13	0.34	-1.67	-0.33
Alberto's 623 N Escondido Blvd, Escondido, CA 92025	-0.97	0.46	-1.66	0.12
Burros and Fries	0.16	0.34	-0.38	0.95
California Burritos	-0.72	0.18	-1.07	-0.37
Cancun Mexican & Seafood	0.12	0.29	-0.37	0.78
Carmen's Mexican Food	-0.03	0.34	-0.57	0.74

Parameter	Post. Mean	Post. Sd	95% CI Low	95% CI High
Chili Peppers	3.07	0.45	2.38	4.08
Chipotle	0.84	0.34	0.31	1.63
Colima's	2.09	0.45	1.41	3.15
Donato's taco shop	-0.02	0.44	-0.65	1.03
El Cuervo	-0.08	0.34	-0.60	0.70
El dorado Mexican food	0.20	0.34	-0.34	0.96
El Indio	1.11	0.43	0.46	2.11
El Nopalito	-1.34	0.34	-1.88	-0.57
El Pueblo Mexican Food	-1.27	0.45	-1.95	-0.23
El Torrito Foods	-1.64	0.34	-2.19	-0.89
El Zarape	0.30	0.27	-0.15	0.89
Goody's	0.63	0.26	0.17	1.23
Graciela's Taco Shop	-0.50	0.33	-1.03	0.25
Humbertos	0.21	0.45	-0.47	1.26
Jorge's Mexicatessen	-0.90	0.34	-1.46	-0.13
Juanita's Taco Shop	-1.07	0.33	-1.60	-0.29
JV's Mexican Food	-0.22	0.44	-0.86	0.83
Karina's Taco Shop	0.40	0.43	-0.23	1.41
King Burrito	-1.27	0.34	-1.81	-0.51
Kotija Jr.	-0.74	0.47	-1.52	0.34
La Perla Cocina	1.27	0.29	0.78	1.90
Lola's 7 Up Market & Deli	-0.20	0.35	-0.75	0.59
Lolita's taco shop	-0.25	0.34	-0.79	0.50
Lolita's Taco shop	-1.38	0.34	-2.00	-0.64
Lolita's Taco Shop	0.43	0.26	-0.03	1.01
Los Cabos	-0.63	0.34	-1.17	0.19
Los Primos Mexican Food	0.80	0.20	0.42	1.21
Los tacos	1.46	0.44	0.83	2.50
Los Tacos	1.77	0.35	1.21	2.57
Lucha Libre North Park	0.19	0.19	-0.21	0.55
Mi Asador Mexican & Seafood	-0.07	0.34	-0.61	0.68
Mikes Taco Club	1.70	0.34	1.17	2.49
MXN on Washington	-2.31	0.46	-3.03	-1.26
Netos Mexican Food	-0.89	0.34	-1.45	-0.13
Nico's Taco Shop	0.51	0.34	-0.03	1.30
Oscar's Mexican food	-1.41	0.29	-1.89	-0.75
Papa Chito's Mexican Food	-0.43	0.34	-0.96	0.34
Pedro's Tacos	0.62	0.43	-0.03	1.64
Pokirrito	3.97	0.40	3.24	4.82
Pollos Maria	-0.02	0.34	-0.56	0.77
Porkyland	1.88	0.44	1.24	2.92
Qdoba Mexican Grill, Seatac Airport	2.81	0.44	2.15	3.86
Raul's Mexican food	-1.40	0.34	-1.94	-0.62
Rigoberto's Taco Shop	-0.39	0.20	-0.78	0.00
Rigoberto's Taco Shop La Jolla	-0.29	0.34	-0.82	0.47
Roberto's Taco Shop Clairemont	-0.68	0.26	-1.14	-0.09
Roberto's Very Mexican Food	-0.62	0.34	-1.17	0.13
Rubios UCSD	0.52	0.48	-0.26	1.62
Rudy's Taco Shop	-0.03	0.34	-0.57	0.72
Saguaro's	-0.42	0.44	-1.09	0.58
Senor Grubby's	2.24	0.34	1.72	3.02
Senor Panchos	0.26	0.35	-0.33	1.05

Parameter	Post. Mean	Post. Sd	95% CI Low	95% CI High
Sotos Mexican Food	-0.16	0.33	-0.68	0.60
Taco stand	0.83	0.19	0.46	1.22
Taco Stand	0.59	0.20	0.21	1.01
Taco Surf PB	-0.04	0.29	-0.51	0.61
Tacos La Bala	-0.88	0.36	-1.47	-0.06
Tacos por favor	0.47	0.29	0.00	1.15
Tony's Fresh Mexican Food	-0.36	0.27	-0.82	0.24
Vallarta express	0.38	0.23	-0.07	0.87

Model Comparisons

```
mlr_dic <- dic(x=ingredient_X,
               beta=mlr_post_dist[,-ncol(mlr_post_dist)],
               sig2=mlr_post_dist[,ncol(mlr_post_dist)],
               y=cost_y)

truncated_dic <- dic(x=ingredient_X,
                     beta=truncated_post_dist[,-ncol(truncated_post_dist)],
                     sig2=truncated_post_dist[,ncol(truncated_post_dist)],
                     y=cost_y)

reduced_dic <- dic(x=proteins_X,
                   beta=mlr_protein_post_dist[,-ncol(mlr_protein_post_dist)],
                   sig2=mlr_protein_post_dist[,ncol(mlr_protein_post_dist)],
                   y=protein_cost_y)

mixed_dic <- dic(x=proteins_X,
                 beta=mixed_post[,1:7],
                 sig2=mixed_post[,8],
                 gamma=mixed_post[,10],
                 y=protein_cost_y)

mlr_dic
```

```
## [1] -152.5537
```

```
truncated_dic
```

```
## [1] -129.853
```

```
reduced_dic
```

```
## [1] 77.76702
```

```
mixed_dic
```

```
## [1] 120.756
```

Model Interpretations

The reduced model has the smallest DIC of 77 compared to -152 in the MLR, -129 in the truncated MLR, and 121 in the mixed model. According to DIC, this means that the reduced model best explains the variance in our data.