MLR Model

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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
## [1,]    1    1    1      1     1          0    0       0      0    0     0
## [2,]    1    1    1      1     1          0    0       0      0    0     0
## [3,]    0    1    1      0     0          0    1       0      0    0     0
## [4,]    1    1    1      0     0          0    0       0      0    0     0
## [5,]    1    1    0      1     1          0    0       0      0    0     0
## [6,]    0    0    1      1     0          1    0       1      0    1     1
##      Lettuce Sauce Cilantro Onion Avocado Vegetable Breakfast Other
## [1,]       0     0        0     0       0         0         0     0
## [2,]       0     0        0     0       0         0         0     0
## [3,]       0     0        0     0       0         0         0     0
## [4,]       0     0        0     0       0         0         0     0
## [5,]       0     0        0     0       0         0         0     0
## [6,]       1     0        0     0       0         1         0     0
```

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

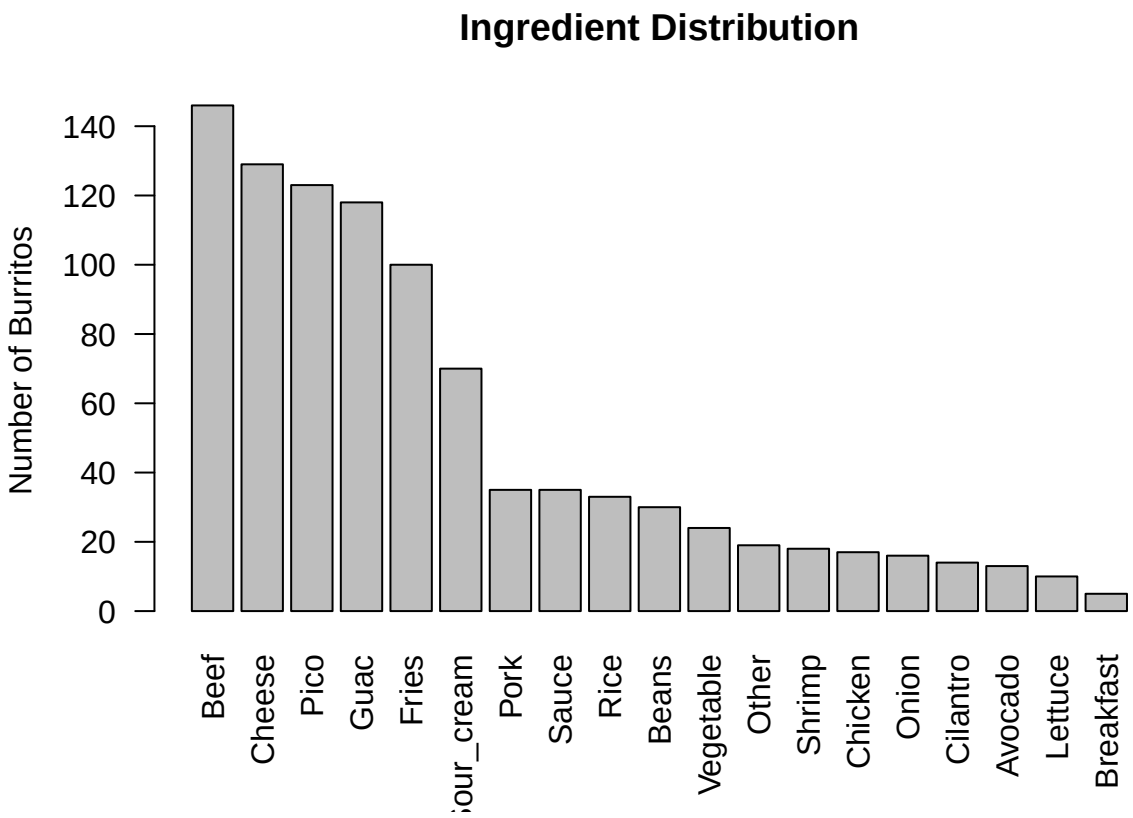
```
## [1] 237
```

```
## [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
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

Parameter	Post. Mean	Post. Sd	95% CI Low	95% CI High
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

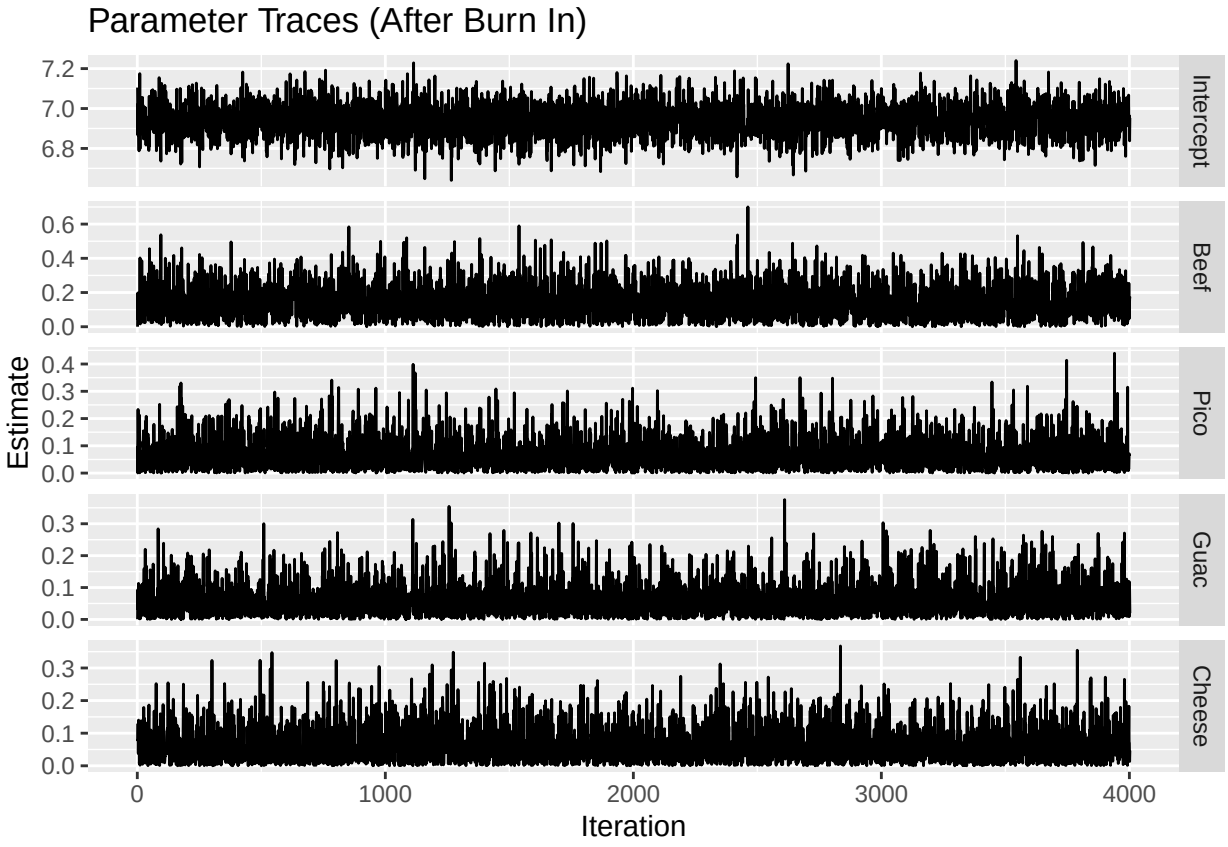
```
set.seed(RANDOM_SEED)

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
```

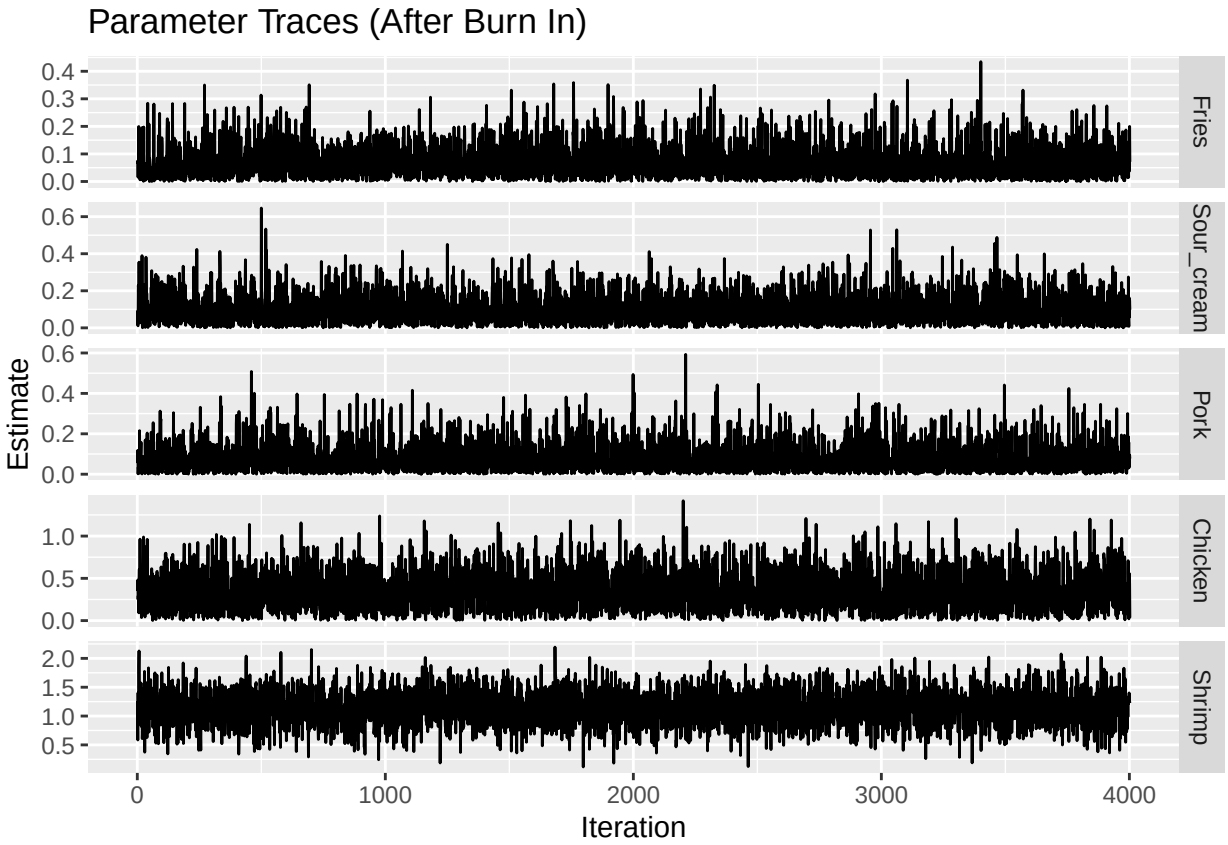
```
## [1,] 0.32231365 0.1337738 0.055637610 0.043461999 0.03719855 0.065980639
## [2,] 0.41904243 0.2674609 0.057706562 0.190681788 0.52204447 0.141212512
## [3,] 0.37117995 0.2441431 0.030493664 0.074956861 0.17943047 0.078305077
## [4,] 0.10781560 0.4652029 0.005265489 0.007145941 0.23394291 0.053717588
## [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

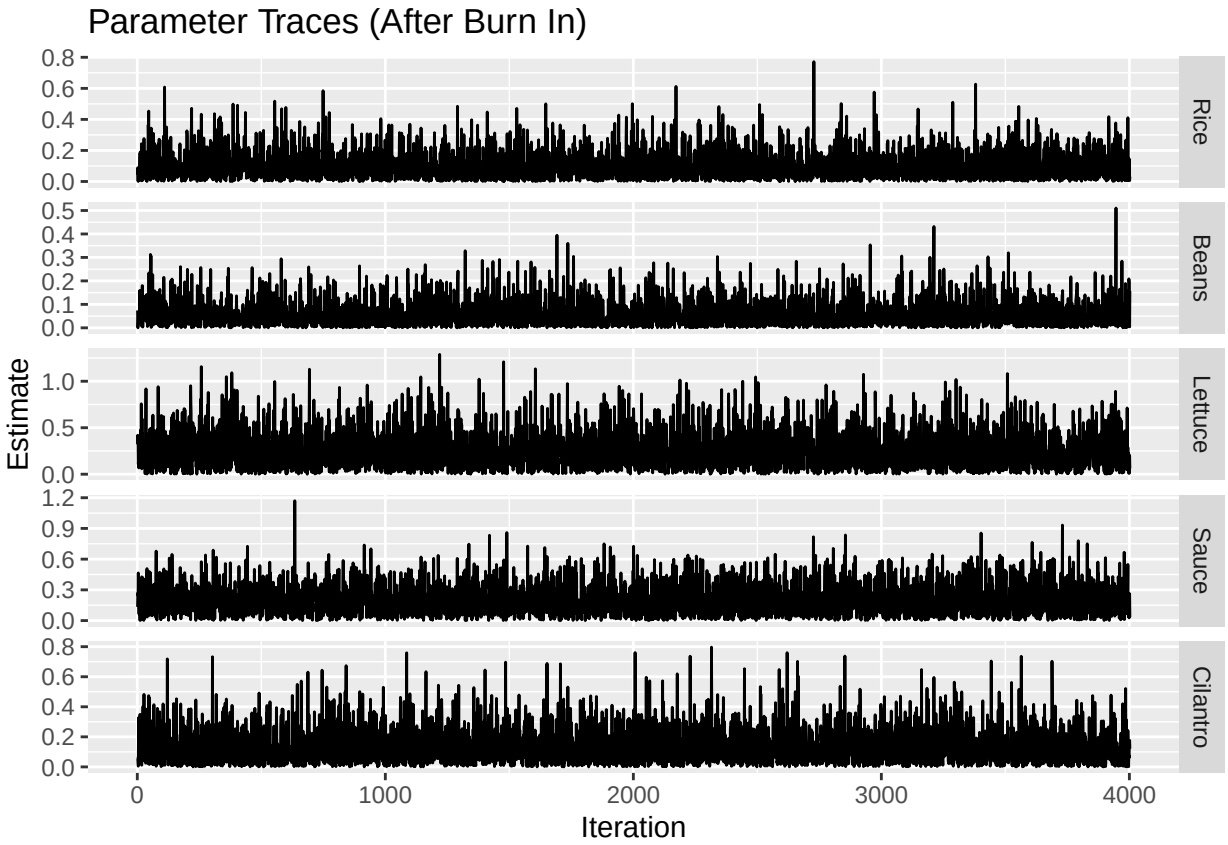
```
plot_traces(truncated_post_dist[,1:5], 'Parameter Traces (After Burn In)')
```



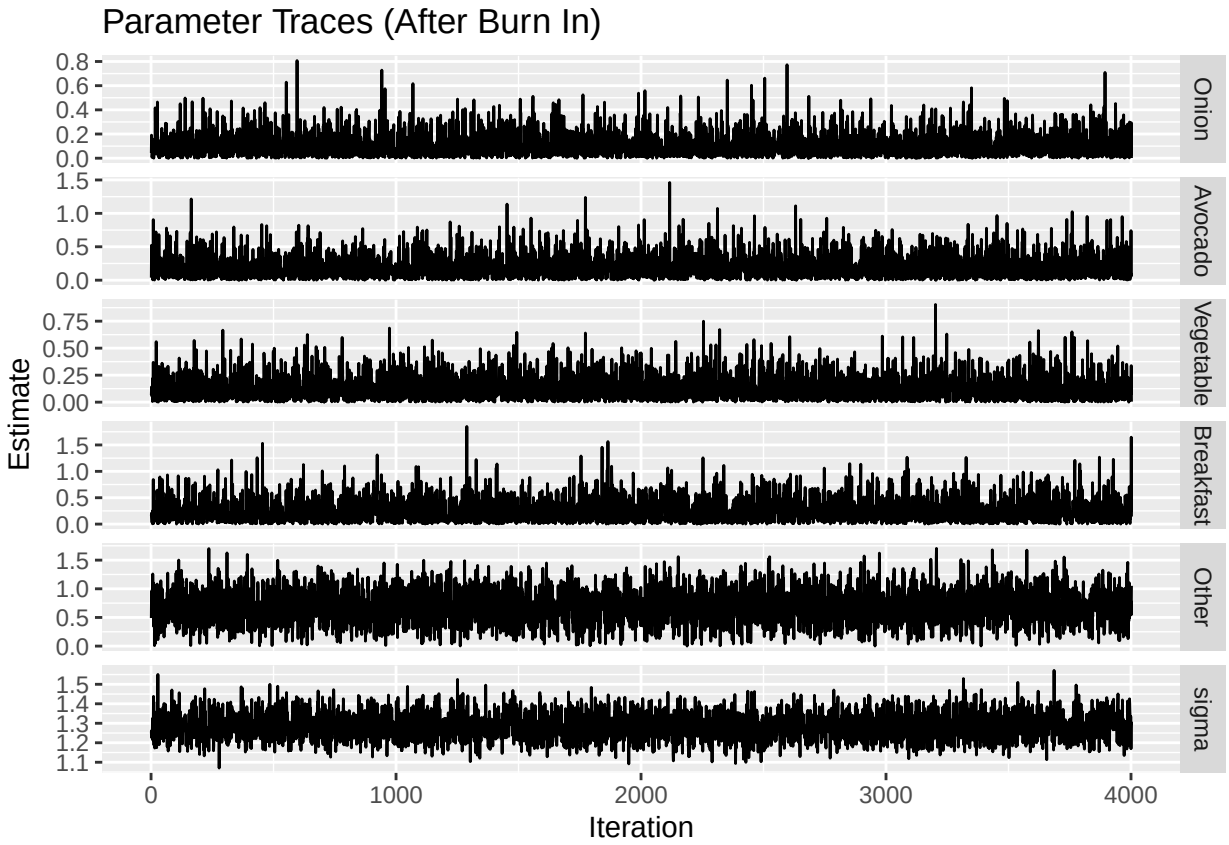

```
plot_traces(truncated_post_dist[,6:10], 'Parameter Traces (After Burn In)')
```



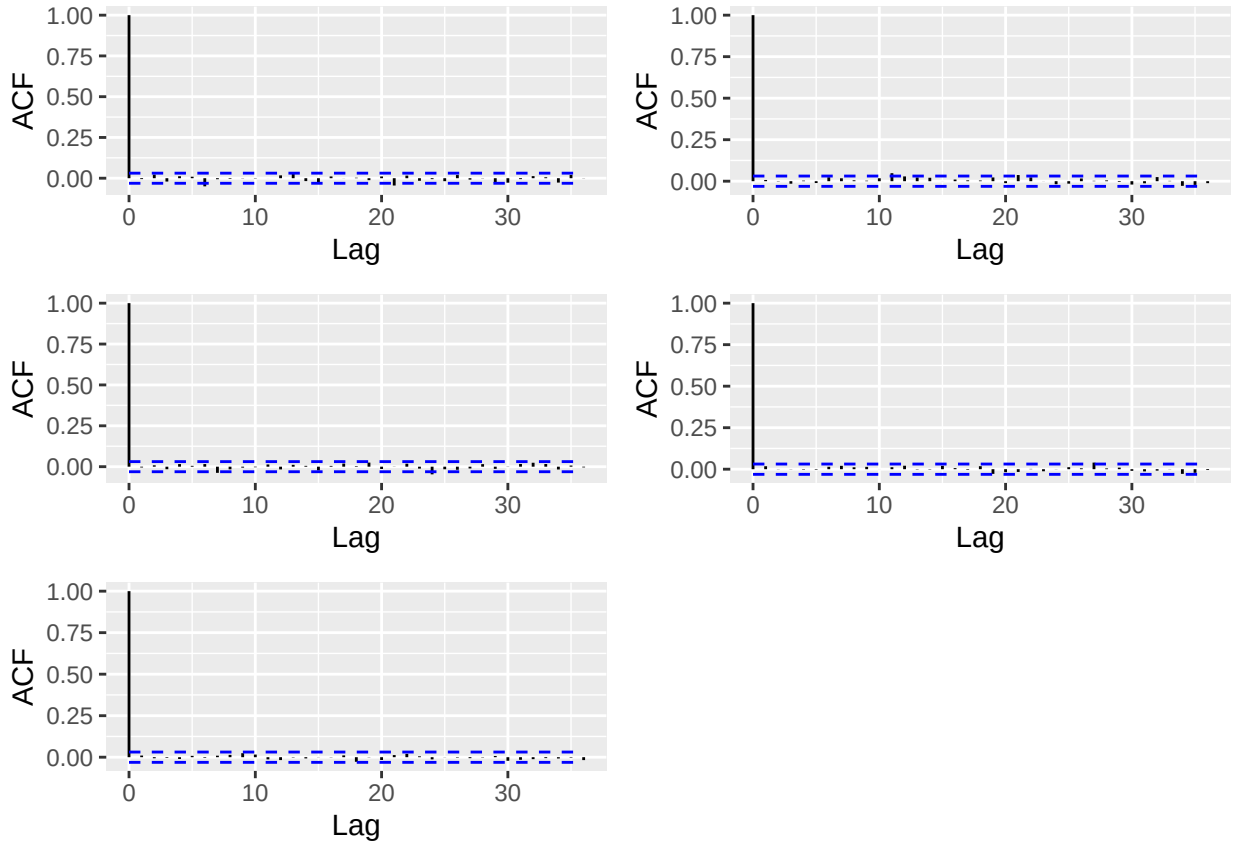

```
plot_traces(truncated_post_dist[,11:15], 'Parameter Traces (After Burn In)')
```



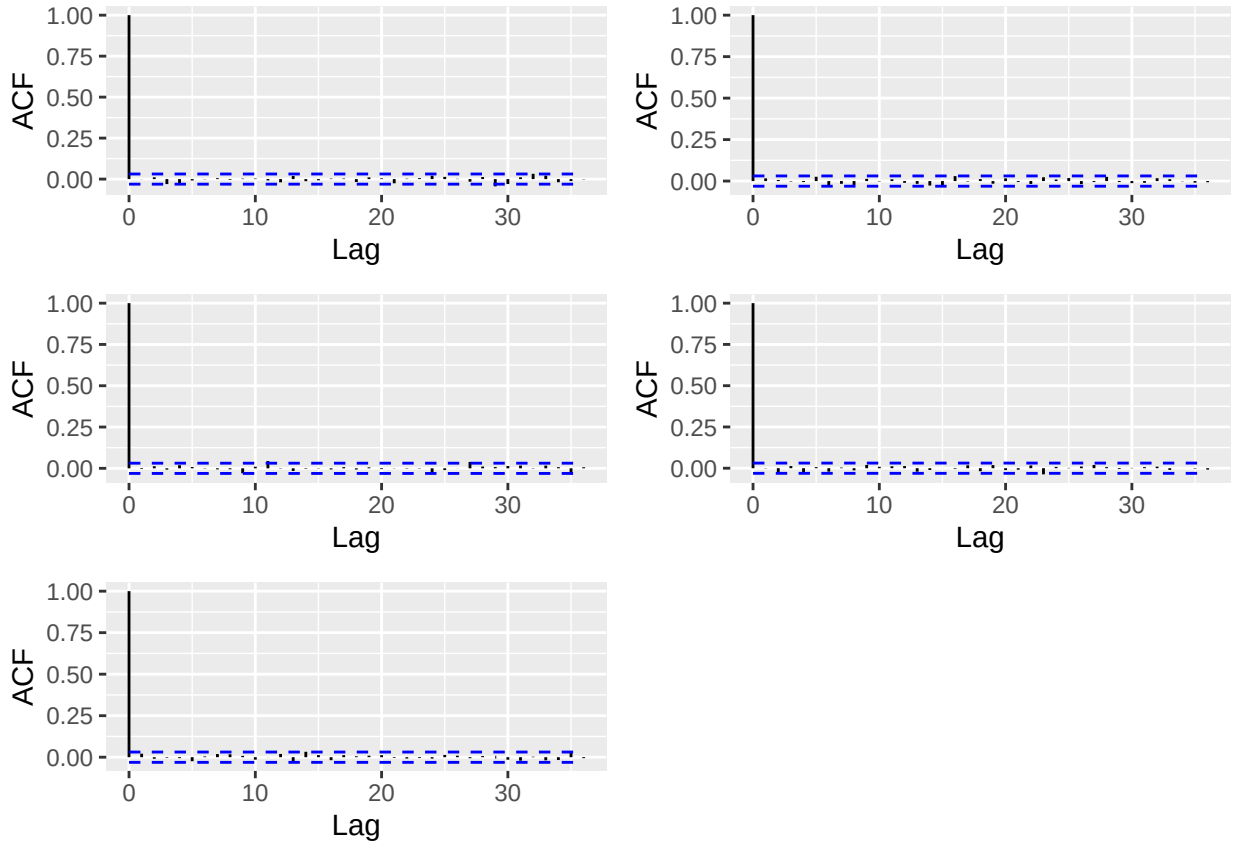

```
plot_traces(truncated_post_dist[,16:21], 'Parameter Traces (After Burn In)')
```



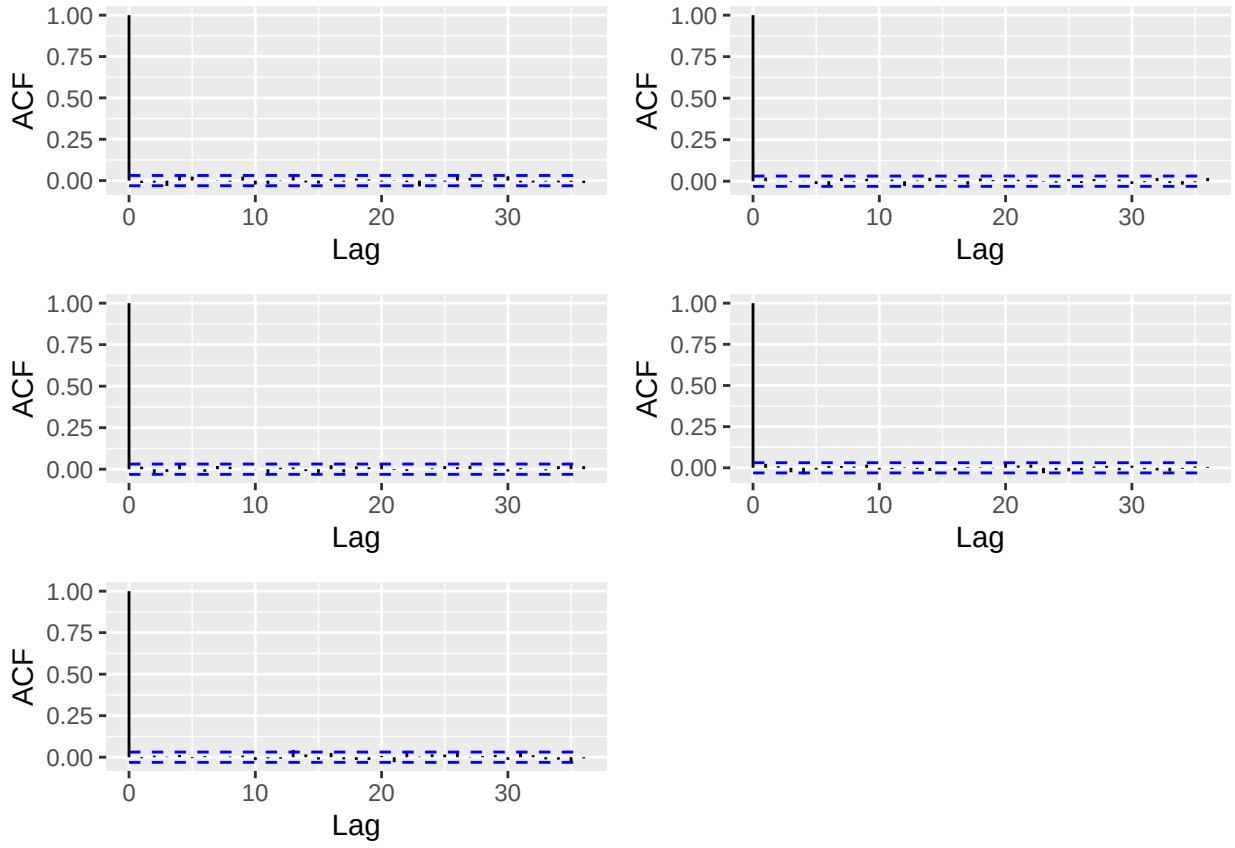

```
acf_plots(truncated_post_dist[,1:5])
```



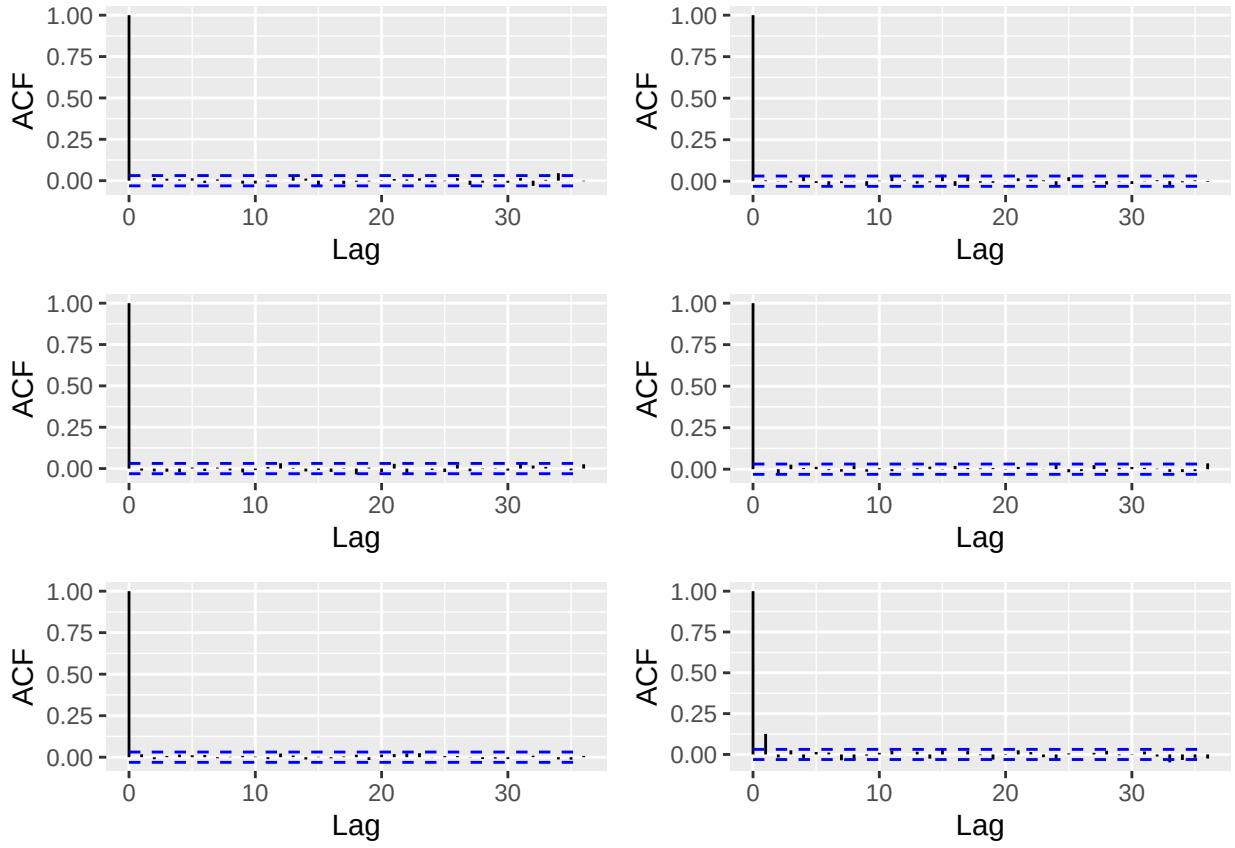

```
acf_plots(truncated_post_dist[,6:10])
```




```
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
```

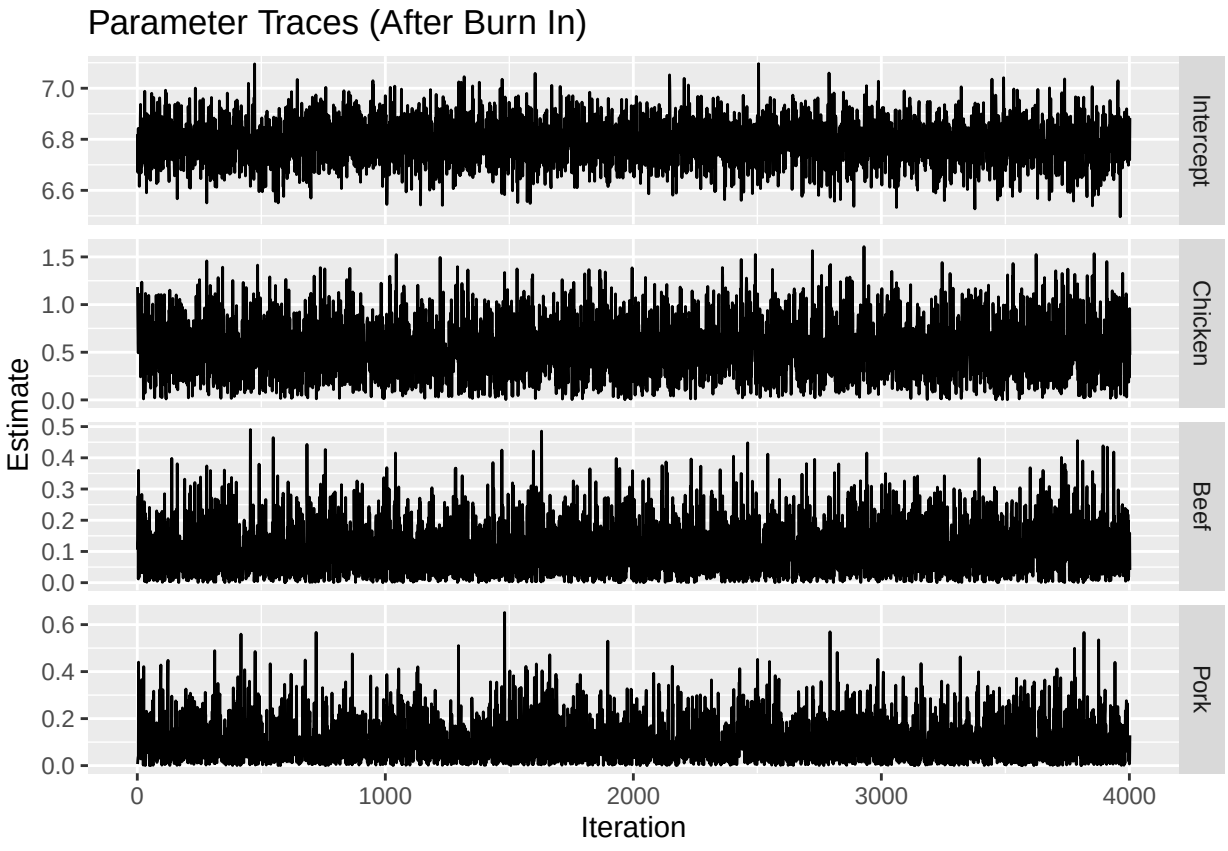
```
set.seed(RANDOM_SEED)

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
```

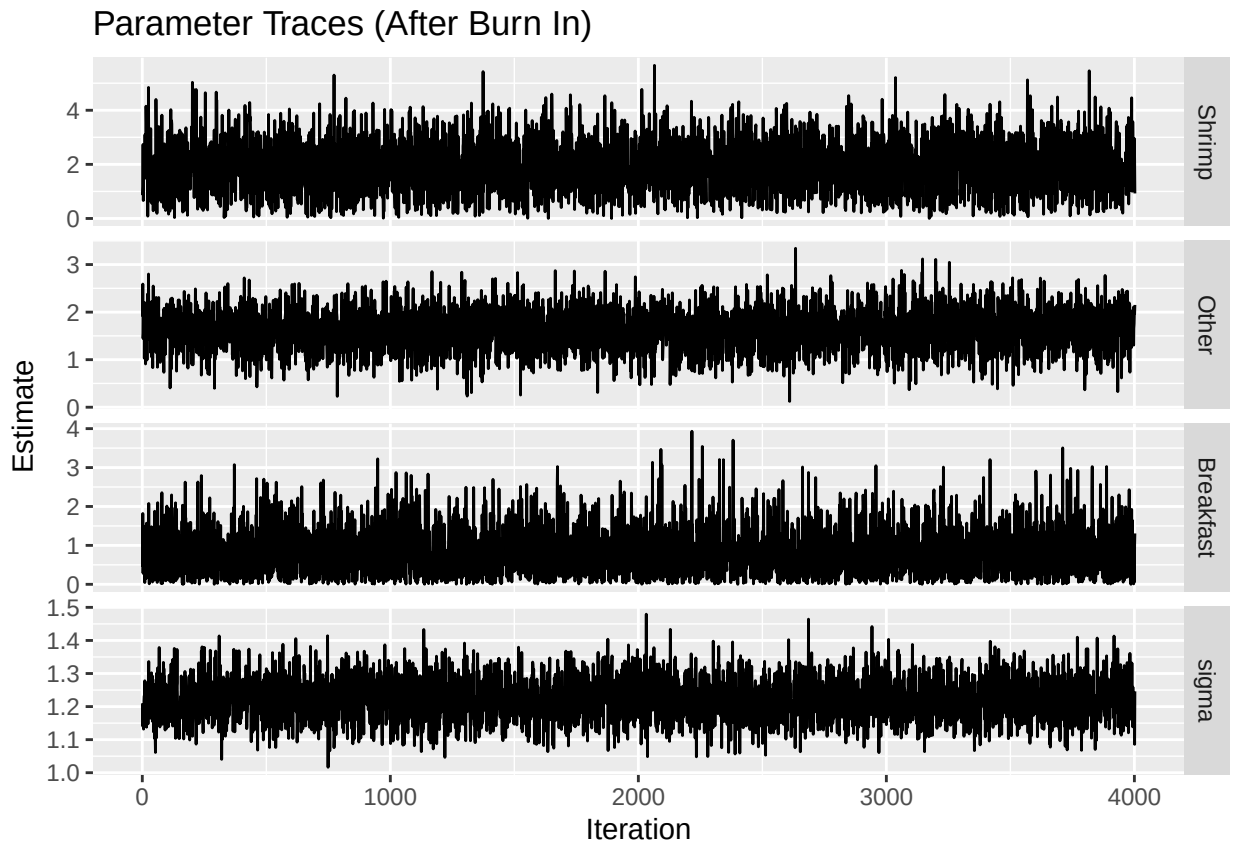
```
## [5,]  6.683130 0.7891352 0.35991111 0.440114948 1.4217828 2.133226 0.2820344
## [6,]  6.750401 1.1084105 0.16474648 0.184533258 1.7953945 1.456925 0.5024557
##         sigma
## [1,] 1.210100
## [2,] 1.140552
## [3,] 1.182736
## [4,] 1.205538
## [5,] 1.131851
## [6,] 1.152073
```

Model Diagnostics

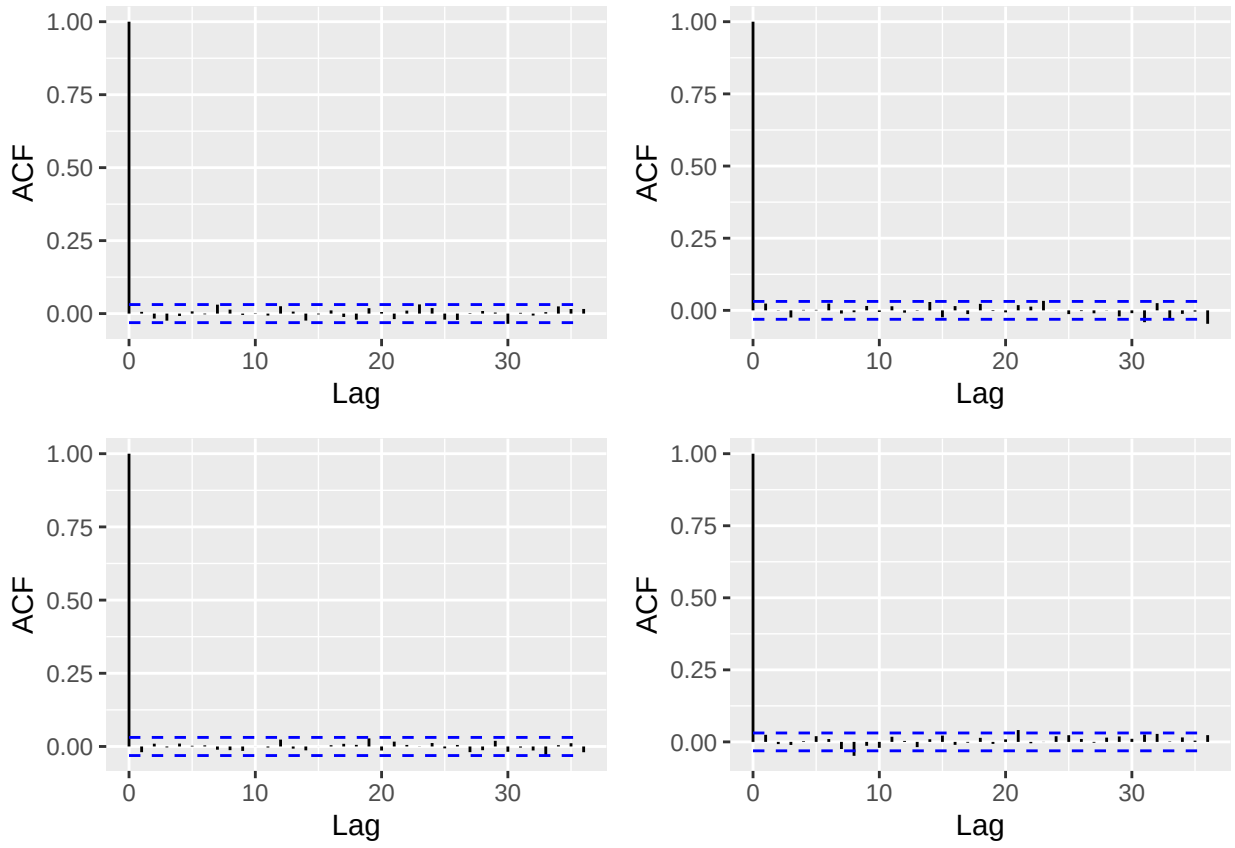
```
plot_traces(mlr_protein_post_dist[,1:4], 'Parameter Traces (After Burn In)')
```



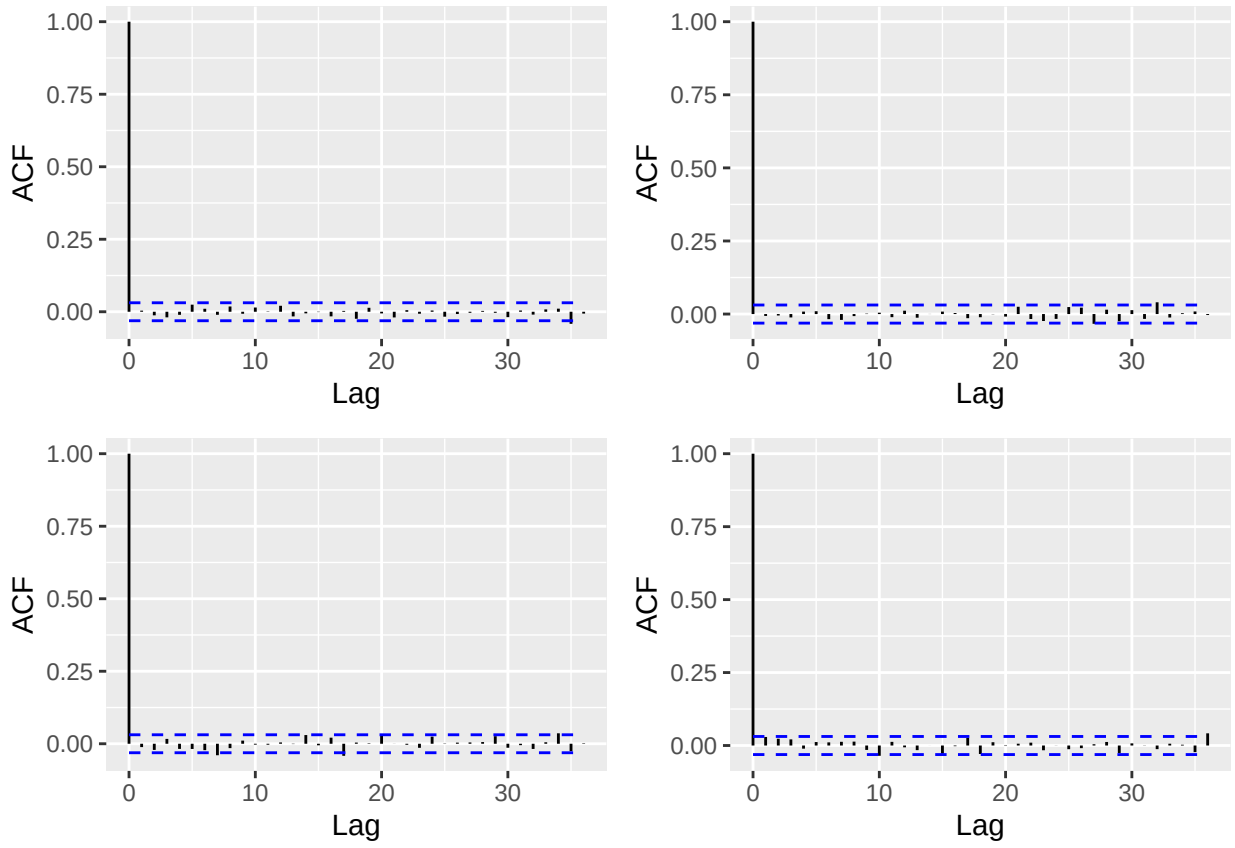

```
plot_traces(mlr_protein_post_dist[,5:8], 'Parameter Traces (After Burn In)')
```




```
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

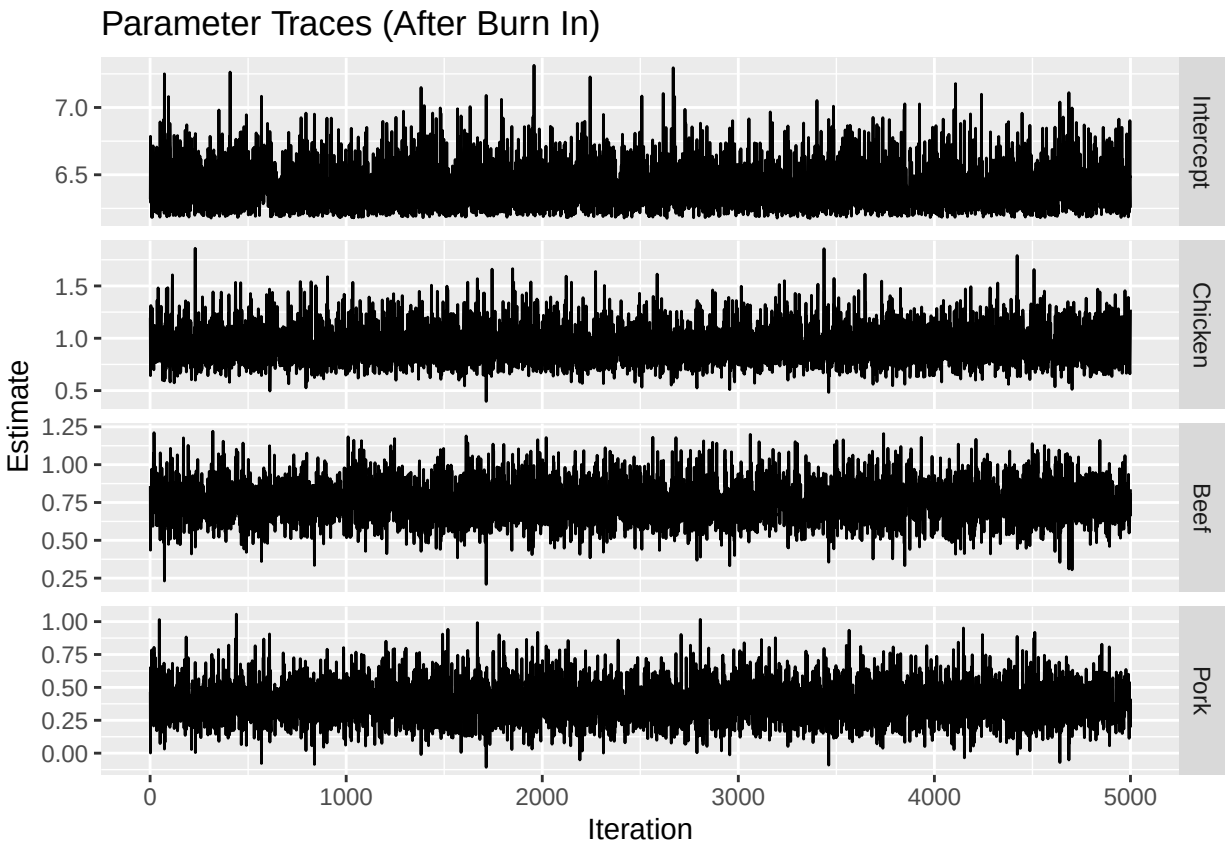
```
set.seed(RANDOM_SEED)

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,]
head(mixed_post)
```

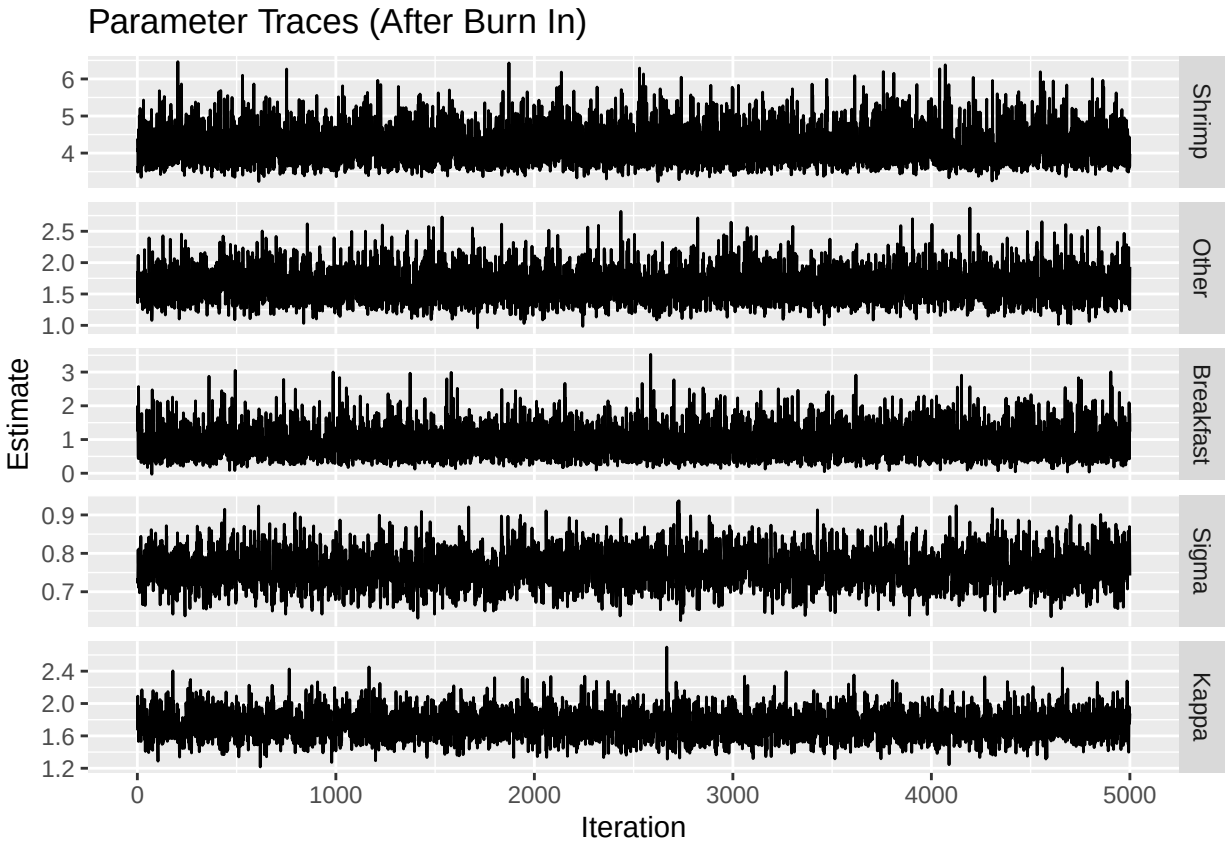
```
##      Intercept   Chicken      Beef        Pork   Shrimp    Other Breakfast
## [1,]  6.318297 1.1956751 0.8583097 0.465787668 3.649521 1.864608 1.2427320
## [2,]  6.785699 0.6432455 0.4352482 0.001789646 3.486410 1.361738 1.9904427
## [3,]  6.502311 1.1990899 0.8259787 0.455804948 4.383330 1.780543 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
```

Model Diagnostics

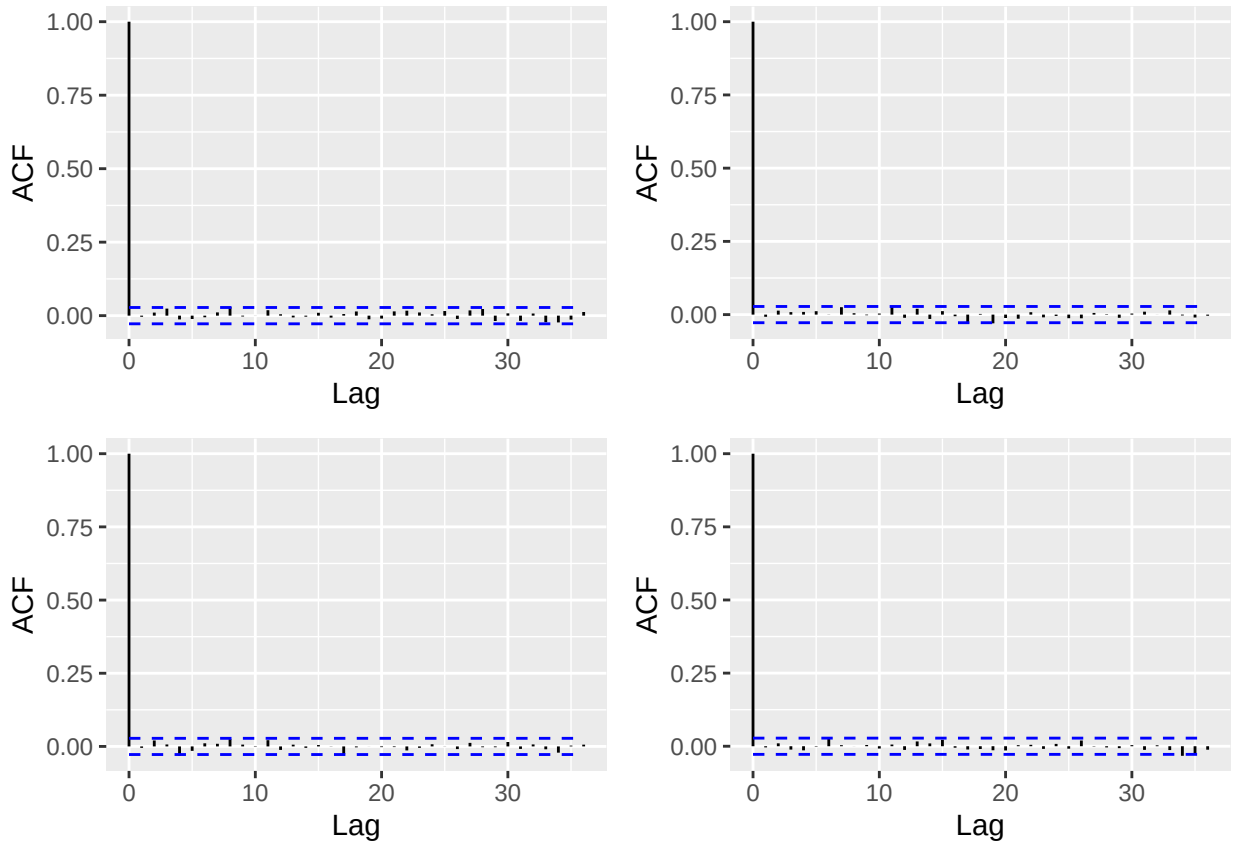
```
plot_traces(mixed_post[,1:4], 'Parameter Traces (After Burn In)')
```



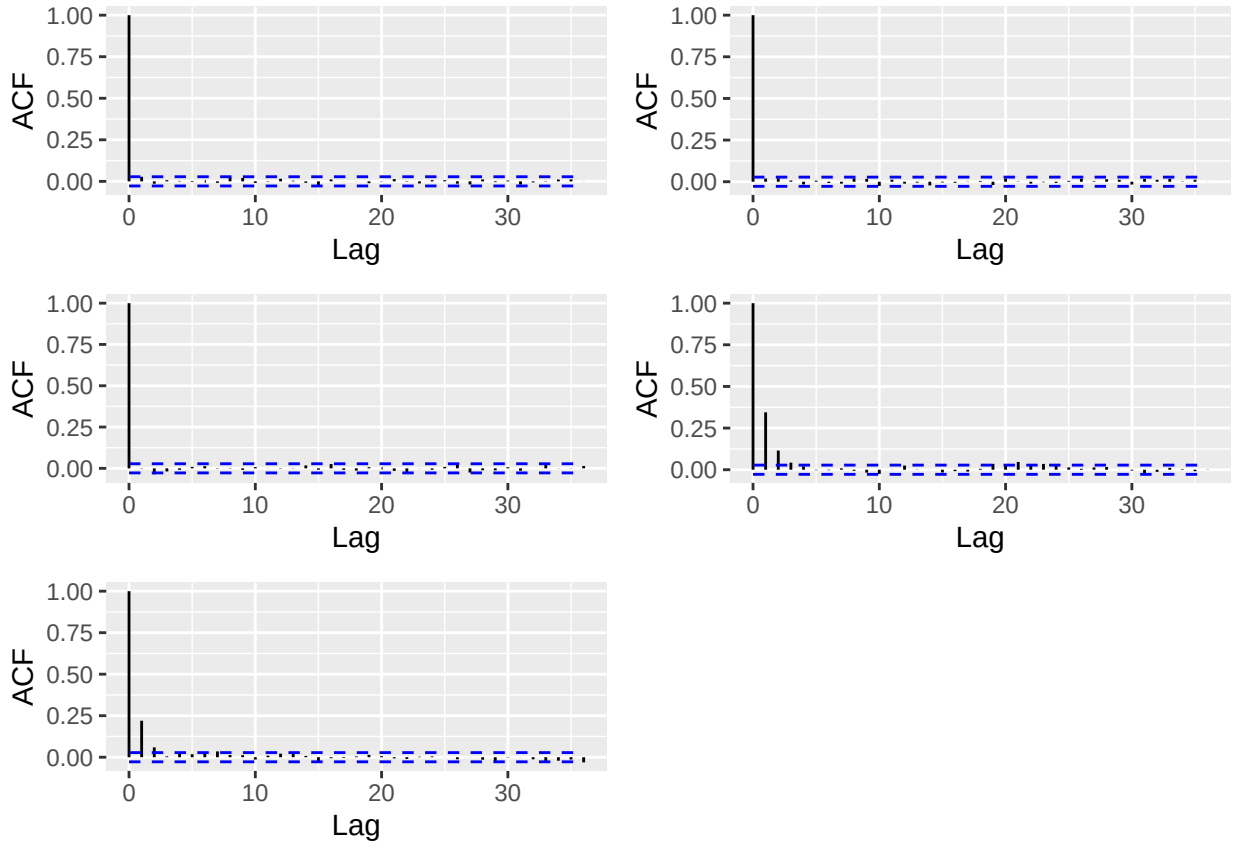

```
plot_traces(mixed_post[,5:9], 'Parameter Traces (After Burn In)')
```




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




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



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(mixed_post, colnames(mixed_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

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],
                 y=protein_cost_y)

mlr_dic
```

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

```
truncated_dic
```

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

```
reduced_dic
```

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

```
mixed_dic
```

```
## [1] 172.1392
```

Model Interpretations

The reduced model has the smallest DIC of 77 compared to -152 in the MLR, -129 in the truncated MLR, and 172 in the mixed model. According to DIC, this means that the reduced model best explains the variance in our data.