

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
## 2    1    1      1      1          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_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
```

Model Fit with Gibbs Sampler

```
set.seed(RANDOM_SEED)

p = ncol(ingredient_X) + 1
tau_2 = 4
```

```
prior_sigma = 1.5
a = 1 / (prior_sigma^4)
b = 1 / (prior_sigma^2)

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.

Truncated Gibbs

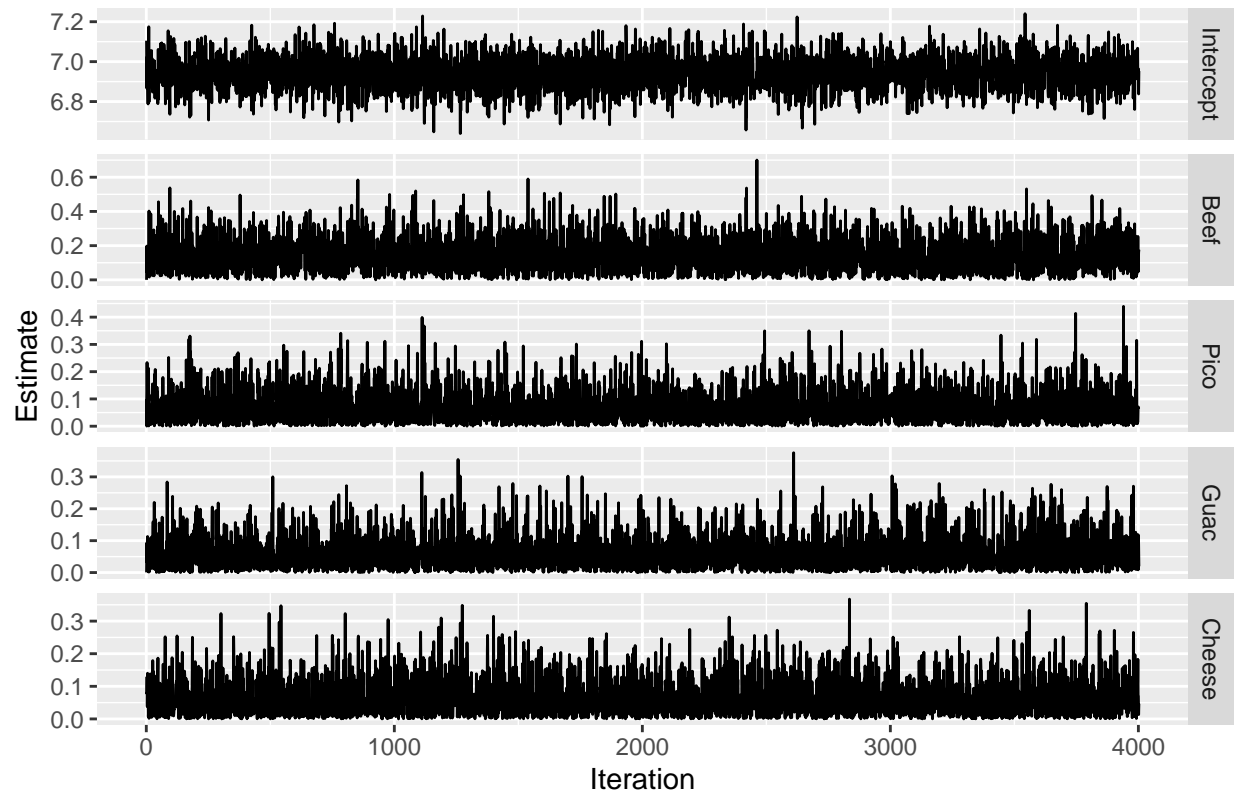
```
set.seed(RANDOM_SEED)

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, ]
```

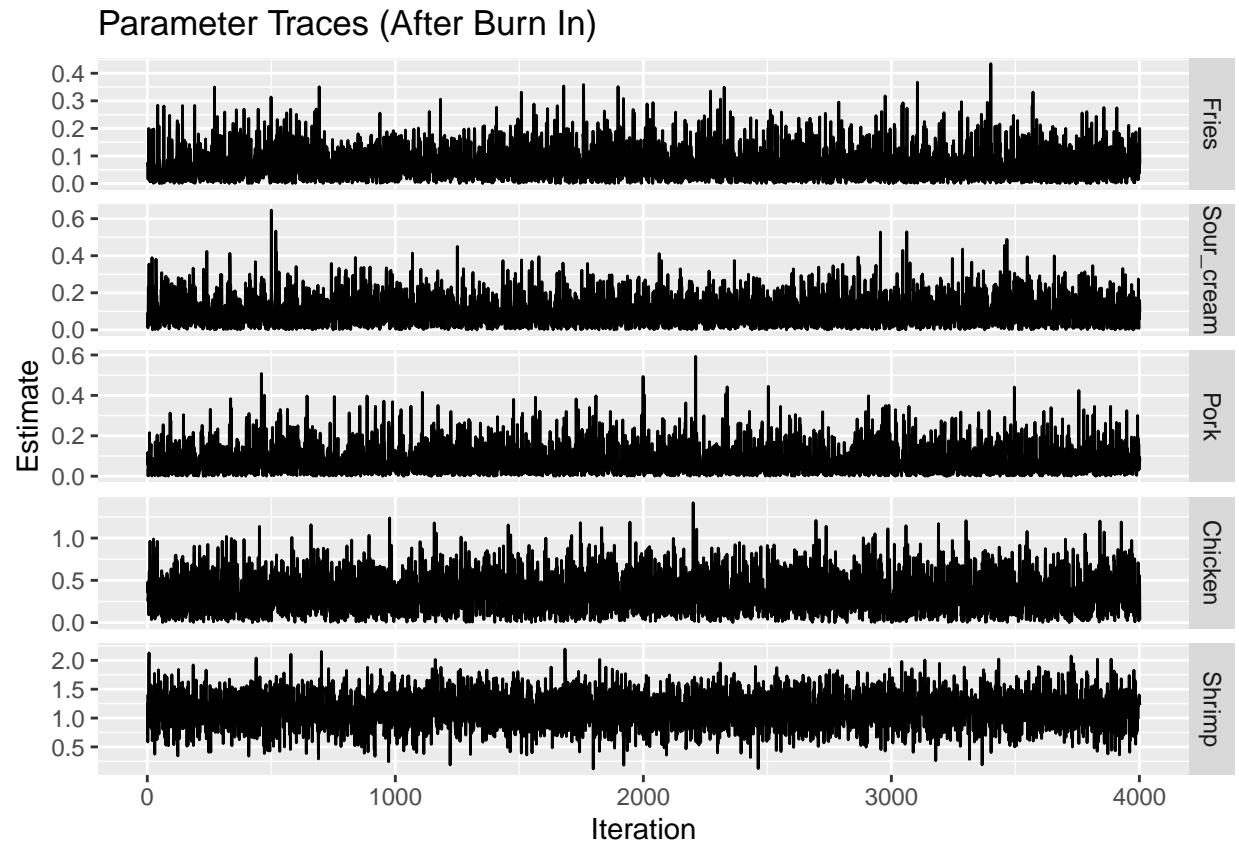
Model Diagnostics

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

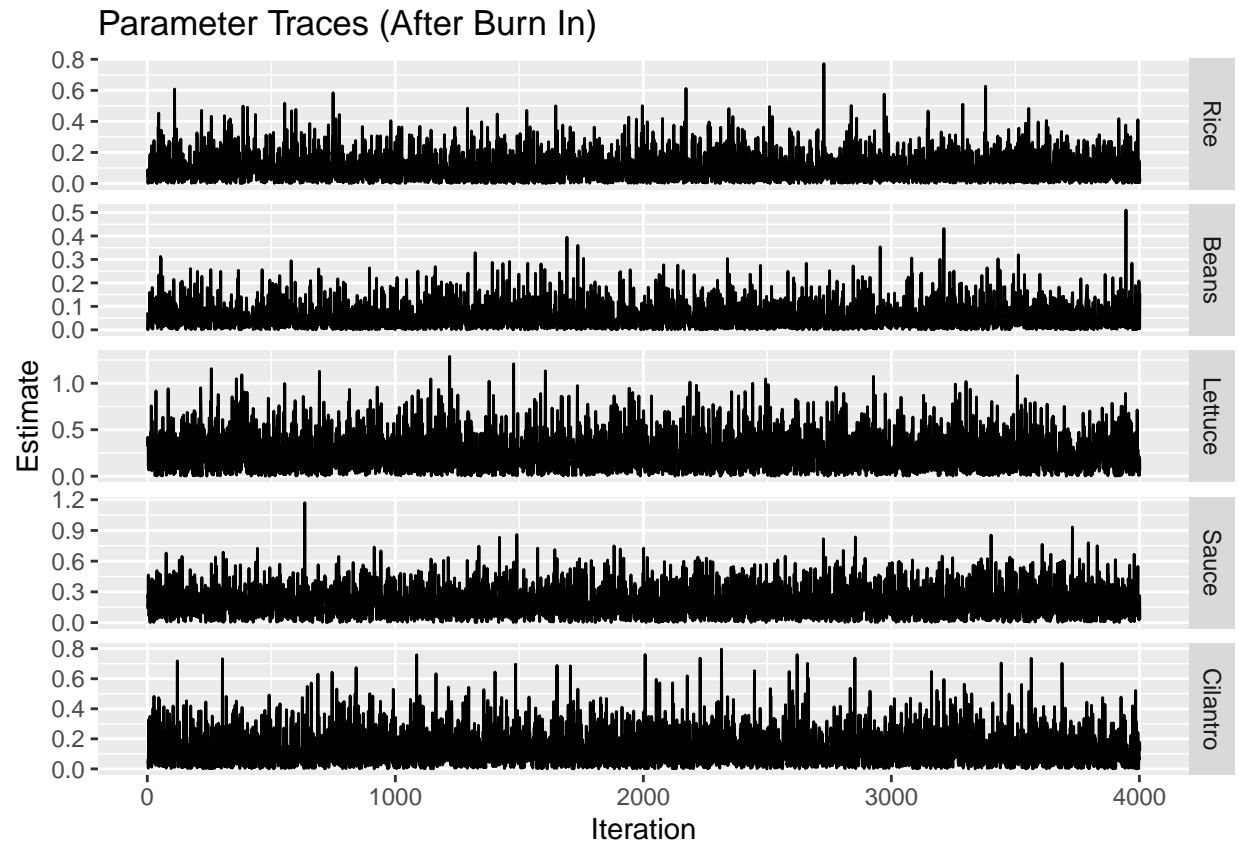
Parameter Traces (After Burn In)



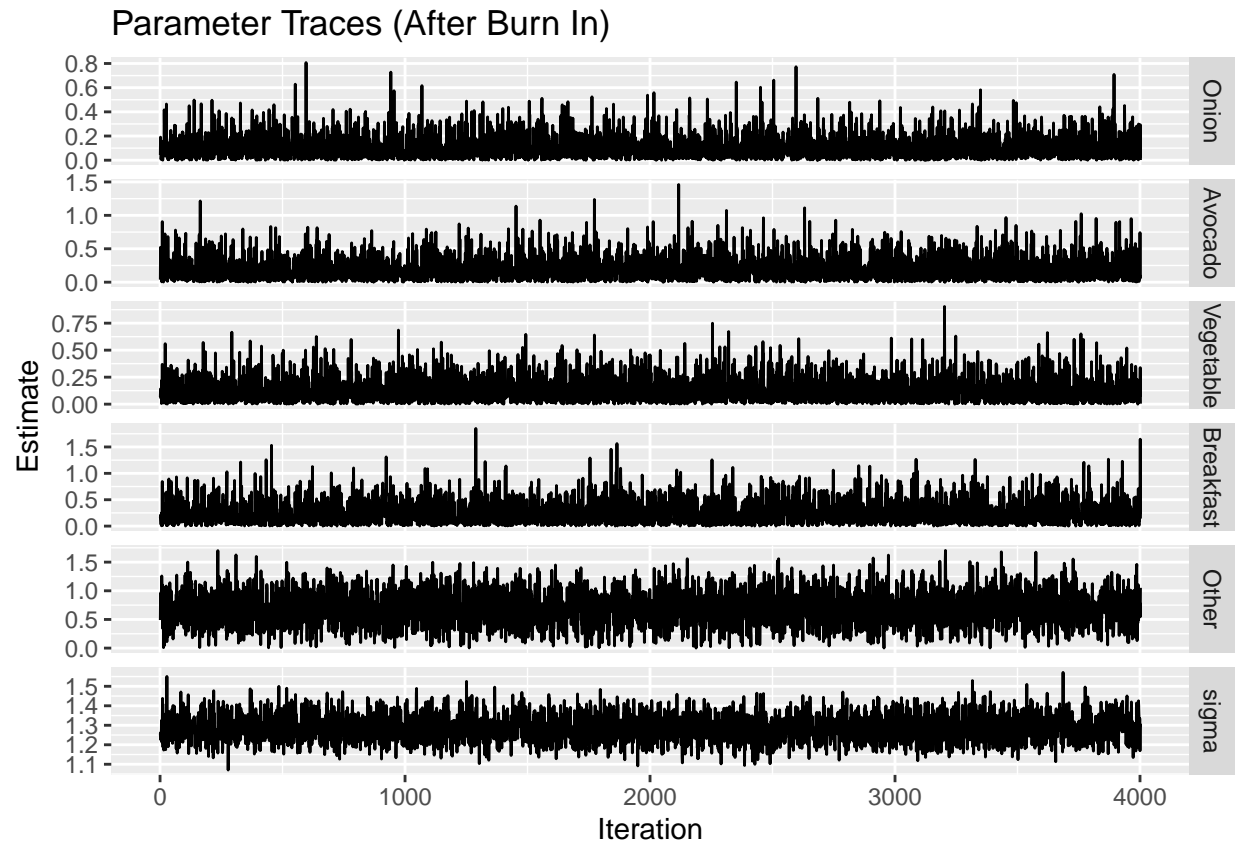
```
plot_traces(truncated_post_dist[,6:10], 'Parameter Traces (After Burn In)')
```



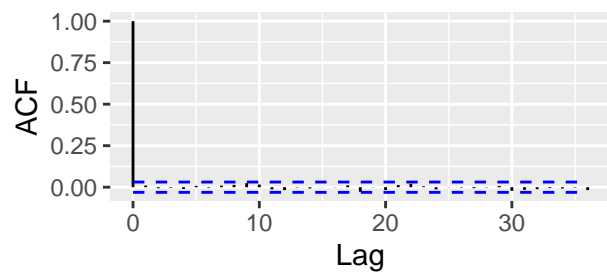
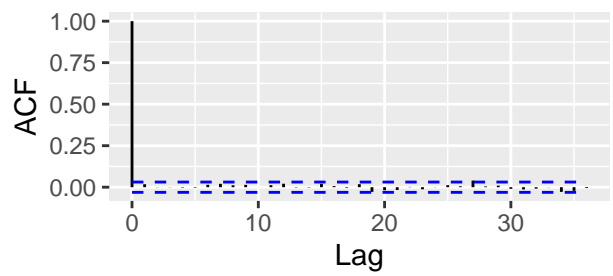
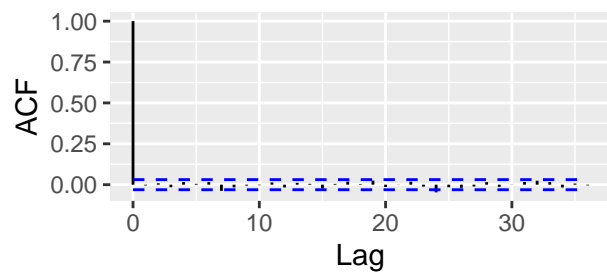
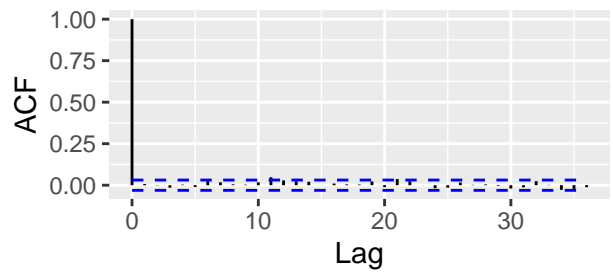
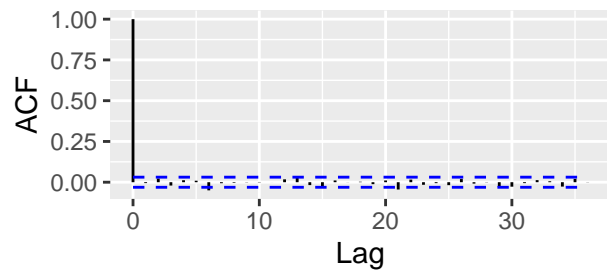
```
plot_traces(truncated_post_dist[,11:15], 'Parameter Traces (After Burn In)')
```



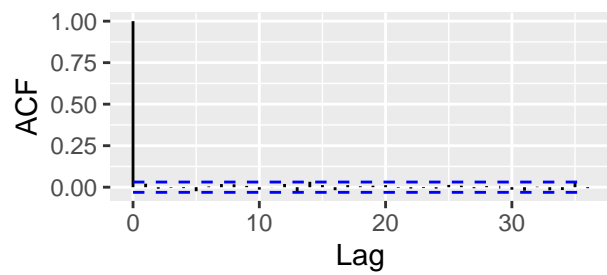
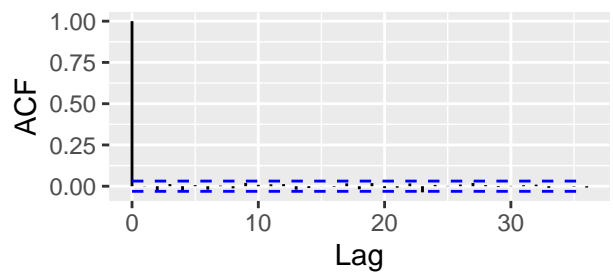
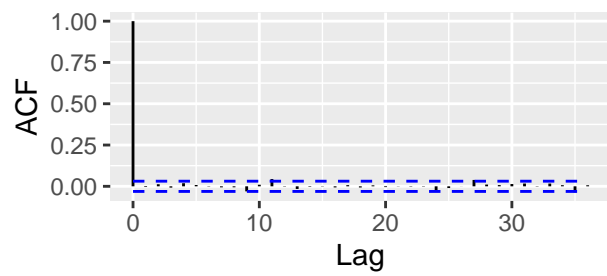
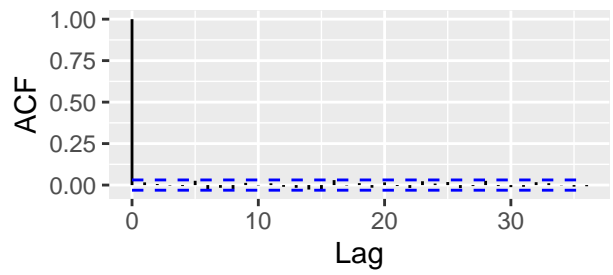
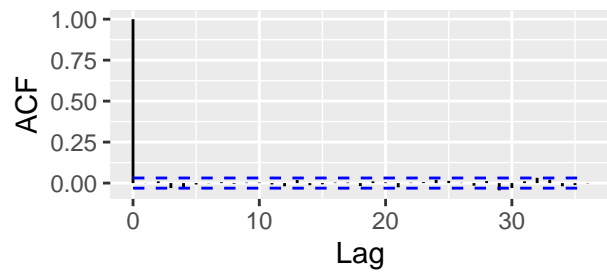
```
plot_traces(truncated_post_dist[:,16:21], 'Parameter Traces (After Burn In)')
```



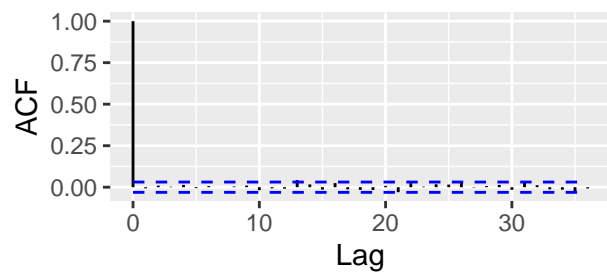
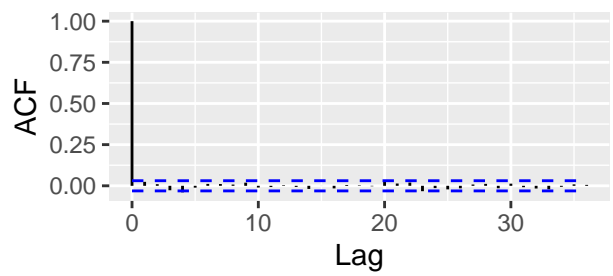
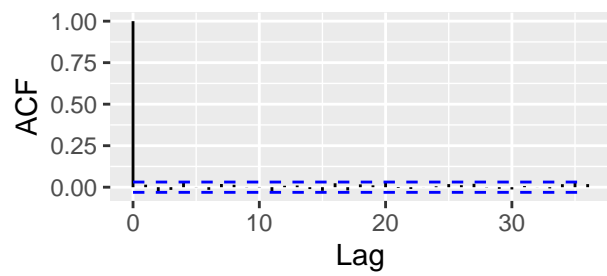
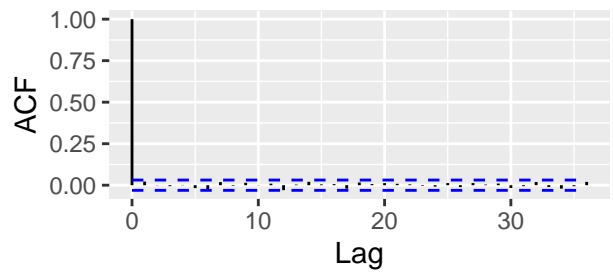
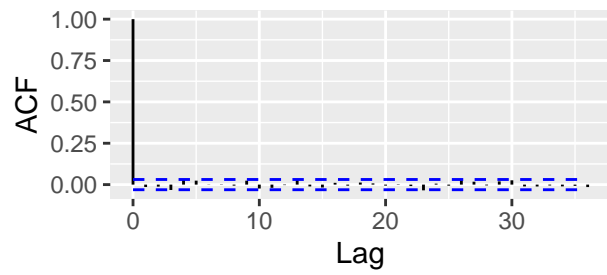
```
acf_plots(truncated_post_dist[,1:5])
```

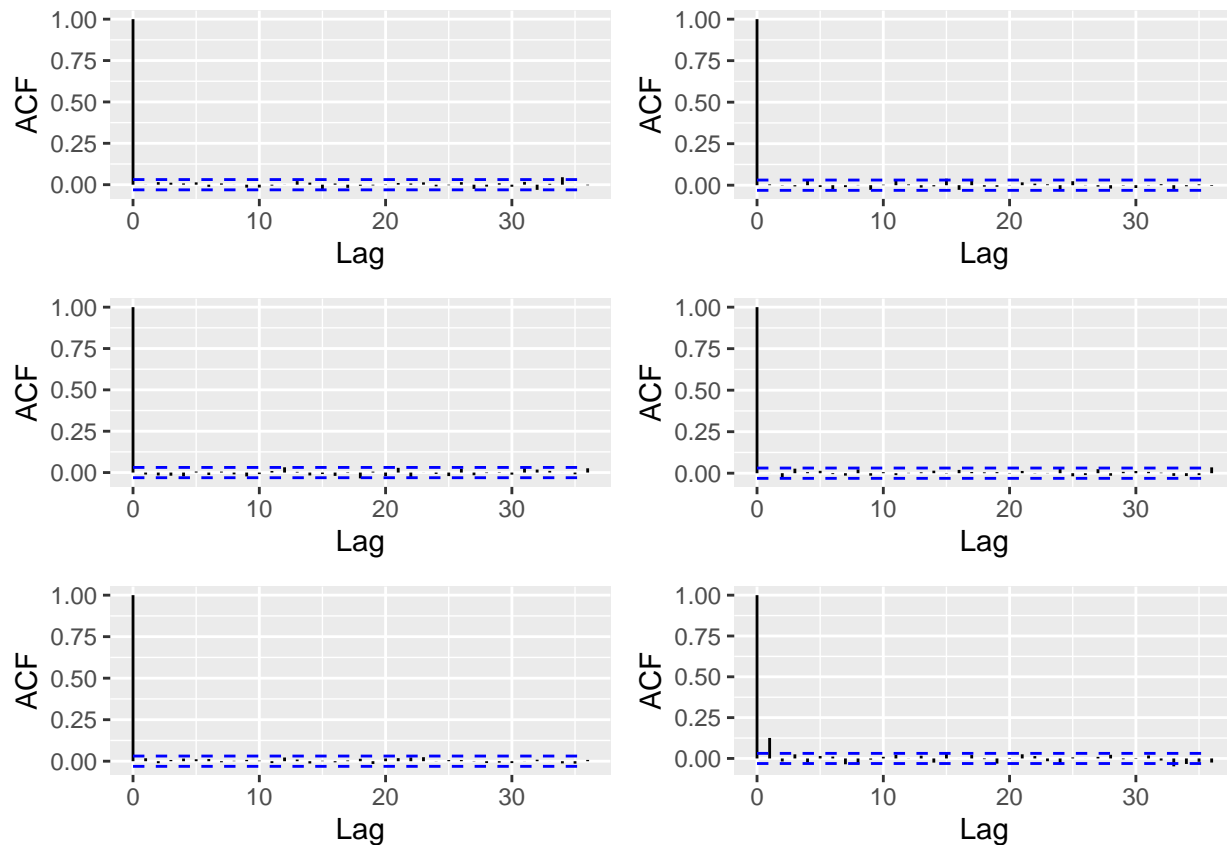
```
acf_plots(truncated_post_dist[,6:10])
```



```
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 Models

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

```
##           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    0    1
## 2    0          0    0    0          0          0    0    0    1
## 3    0          0    0    0          0          0    0    0    1
## 4    0          0    0    0          0          0    0    0    1
## 5    0          0    0    0          0          0    0    0    1
## 6    0          0    0    0          1          0    0    0    1
```

```
burrito_no_double = burrito_no_double %>% mutate(Protein= as.factor(Chicken + 2*Beef + 3*Pork + 4*Shrimp))
head(burrito_no_double)
```

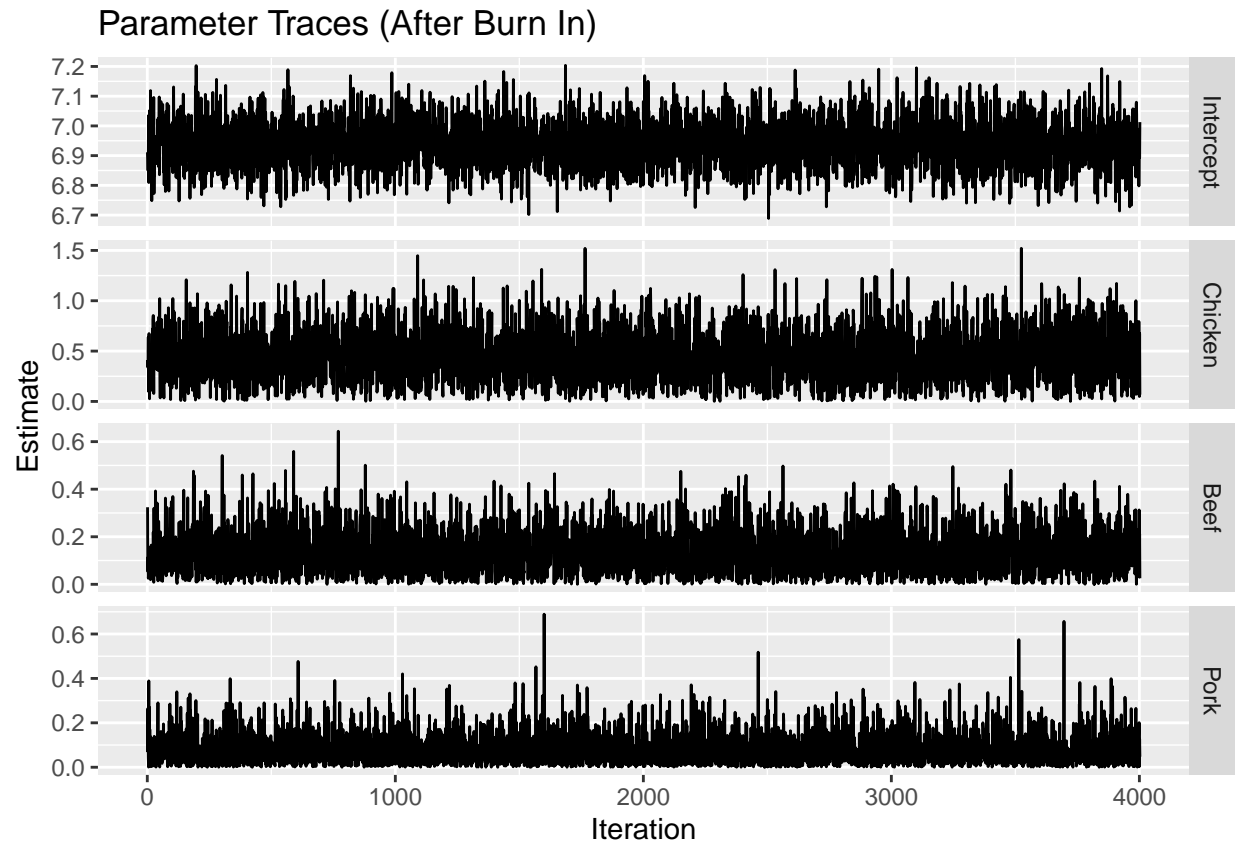
```
##           Location Cost Hunger Length Circum Volume Tortilla Temp Meat
## 1 Donato's taco shop 6.49   3.0    NA     NA      NA       3  5.0  3.0
## 2 Oscar's Mexican food 5.45   3.5    NA     NA      NA       2  3.5  2.5
```

```
## 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
```

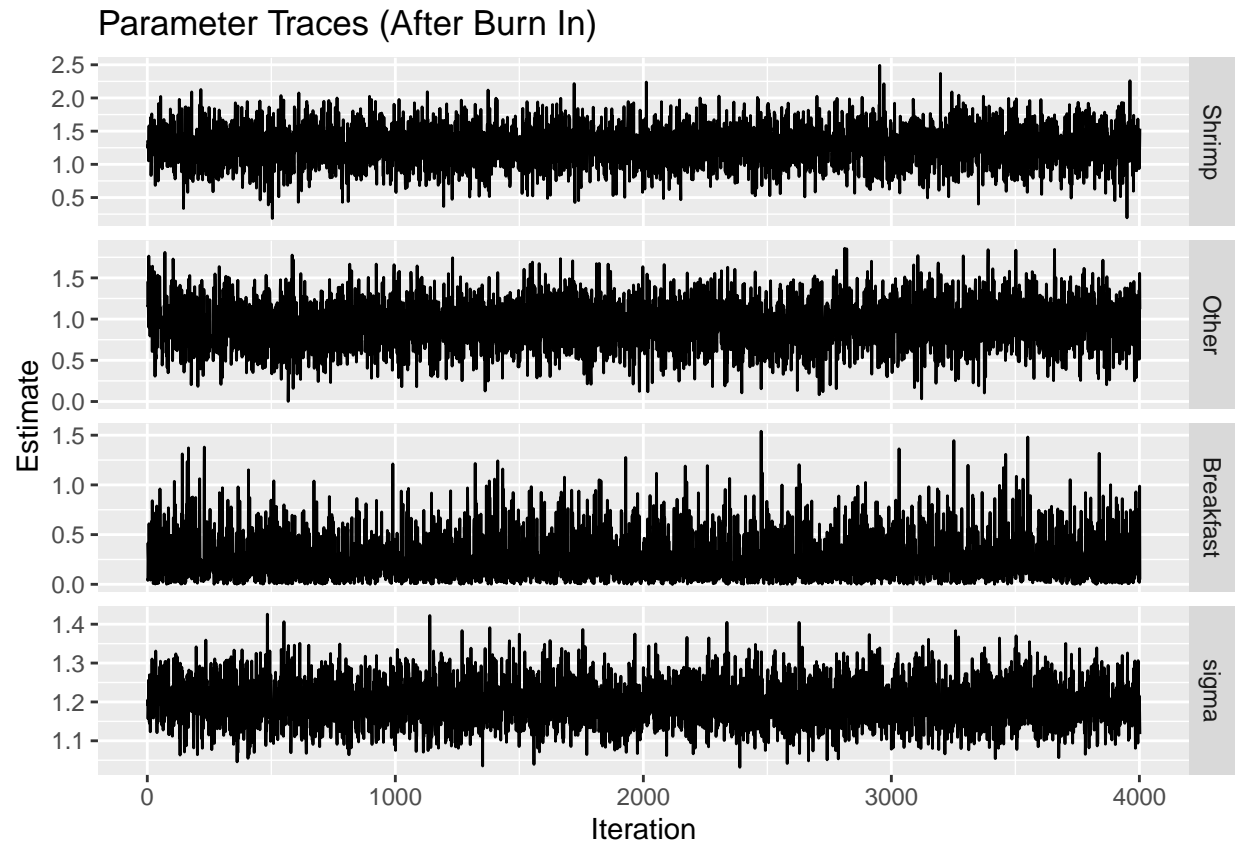
```
proteins = c('Chicken', 'Beef', 'Pork', 'Shrimp', 'Other', 'Breakfast')
X_proteins = as.matrix(burrito[proteins])
head(X_proteins)
```

```
## 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
```

```
mlr_protein_post_dist = truncated_gibbs(X_proteins, 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, ]
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)')
```



```
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	6.94	0.08	6.79	7.10
Chicken	0.45	0.25	0.04	0.99
Beef	0.13	0.09	0.01	0.35
Pork	0.08	0.07	0.00	0.27
Shrimp	1.28	0.29	0.70	1.86
Other	0.94	0.29	0.38	1.49
Breakfast	0.26	0.23	0.01	0.87
sigma	1.20	0.06	1.09	1.32

Model Interpretations