Exercise 2

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```
library(MASS)
library(MCMCpack)
```

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

```
## ##
## ## Markov Chain Monte Carlo Package (MCMCpack)
```

```
## ## Copyright (C) 2003-2019 Andrew D. Martin, Kevin M. Quinn, and Jong Hee Park
```

```
## ##
## ## Support provided by the U.S. National Science Foundation
```

```
## ## (Grants SES-0350646 and SES-0350613)
## ##
```

```
df <- read.csv("cheese.csv")
df <- df[order(df$store),]
store <- df$store
n_vec <- table(df$store)
group_idx <- cumsum(n_vec)
Y <- log(df$vol)
n <- length(Y)
X <- cbind(rep(1 ,n), log(df$price), df$disp, df$disp*log(df$price))
p <- ncol(X)
```

```
mu_0 <- rep(0, p)
L_0 <- diag(1, p)
n_0 <- 1
S_0 <- diag(1, p)
a_0 <- 1
b_0 <- 1
```

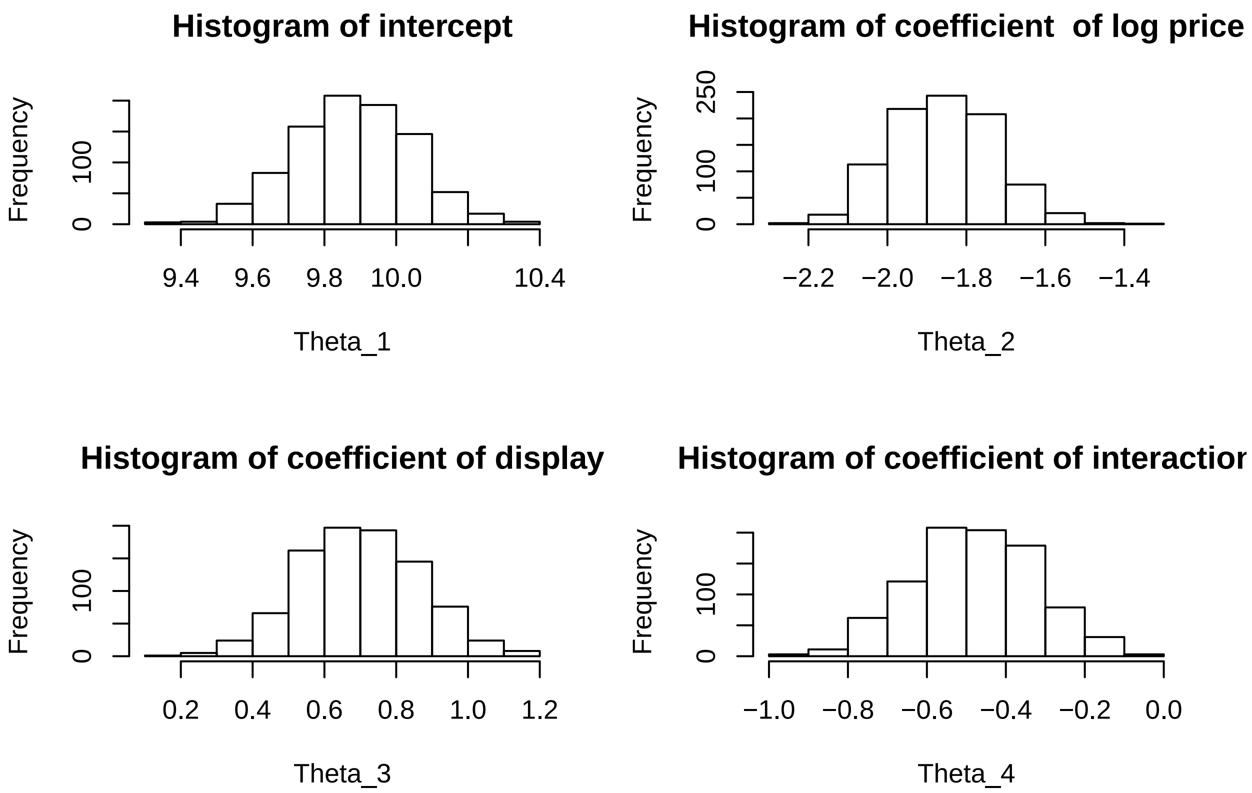
```
K <- length(unique(df$store))

theta_vec <- mvrnorm(1, mu = mu_0, Sigma = L_0)
Sigma <- diag(1,p)
cur_lambda <- rgamma(1, a_0, b_0)

beta_mat <- matrix(NA, nrow = K, ncol = p)

B <- 1000
```

```
##Store results
theta_mat <- matrix(NA, ncol= p, nrow = B)
Sigma_arr <- array(NA, c(B, p, p))
beta_arr <- array(NA, c(B, K, p))
lambda_vec <- rep(NA, B)

for(iter in 1:B){
    for(i in 1:K){
        if(i == 1){
            idx_group <- 1:group_idx[i]
        }
        else{
            idx_group <- (group_idx[i-1]+1):group_idx[i]
        }
        X_i <- X[idx_group, ]
        Y_i <- Y[idx_group]
        Sig_Inv <- solve(Sigma)
        temp_sigma <- solve(cur_lambda*t(X_i)%*%X_i + Sig_Inv)
        temp_mu <- cur_lambda*t(X_i)%*%Y_i + Sig_Inv%*%theta_vec
        beta_mat[i, ] <- mvrnorm(1, mu = temp_sigma%*%temp_mu, Sigma = temp_sigma)
    }

    Sig_Inv <- solve(Sigma)
    temp_sigma <- solve(K*Sig_Inv + solve(L_0))
    temp_mu <- Sig_Inv%*%apply(beta_mat, 2, sum) + solve(L_0)%*%mu_0
    theta_vec <-mvrnorm(1, mu = temp_sigma%*%temp_mu, Sigma = temp_sigma)

    ss <- matrix(0, ncol = p, nrow = p)
    for(i in 1:K){
        d <- beta_mat[i, ] - theta_vec
        ss <- ss + d%*%t(d)
    }
    Sigma <- riwish(K + n_0, ss + S_0)

    temp <- 0
    for(i in 1:K){
        if(i == 1){
            idx_group <- 1:group_idx[i]
        }
        else{
            idx_group <- (group_idx[i-1]+1):group_idx[i]
        }
        X_i <- X[idx_group, ]
        Y_i <- Y[idx_group]
        temp <- temp + t(Y_i - X_i%*%beta_mat[i, ])%*%(Y_i - X_i%*%beta_mat[i, ])
    }
    cur_lambda <- rgamma(1, sum(n_vec)/2 + a_0, temp/2 + b_0 )

    theta_mat[iter, ] <- theta_vec
    Sigma_arr[iter, ,] <- Sigma
    beta_arr[iter, , ] <- beta_mat
    lambda_vec[iter] <- cur_lambda
}
```

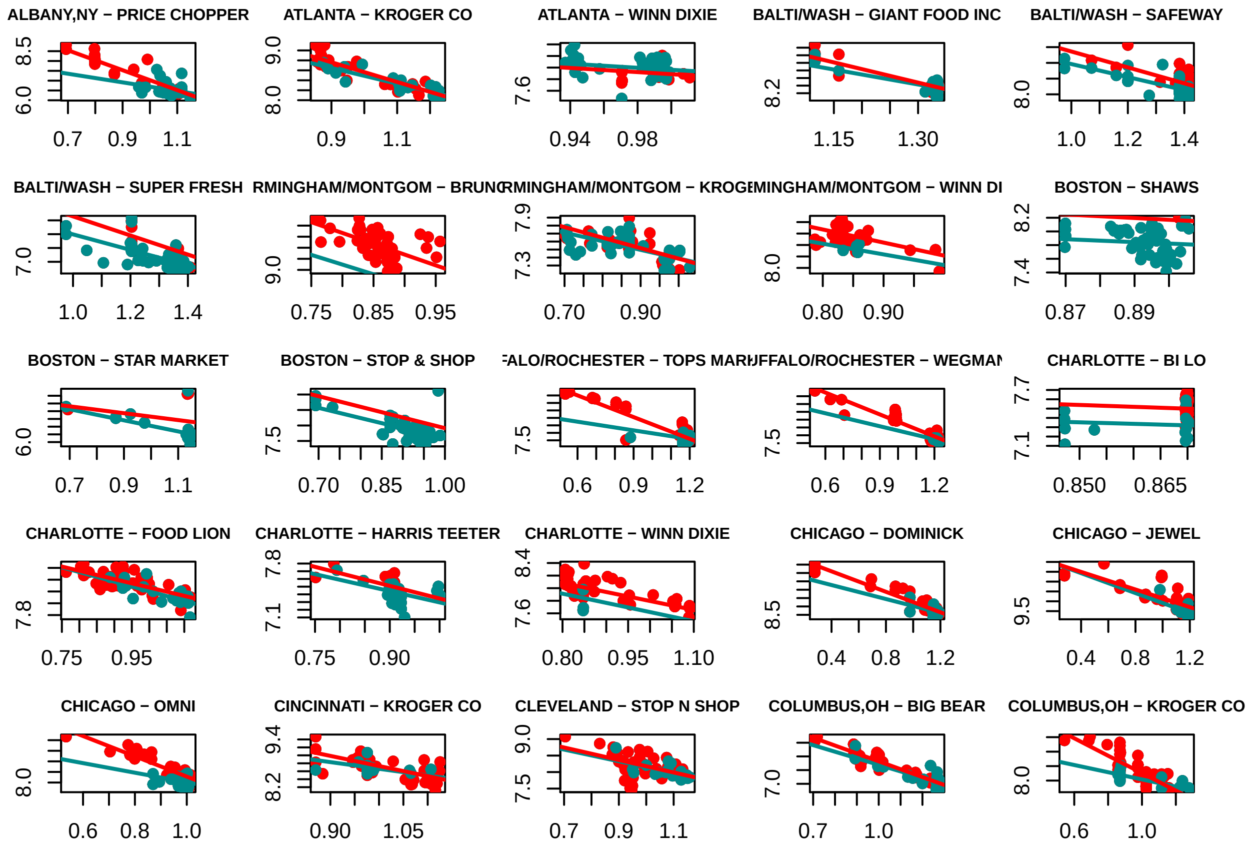
Fixed effect

```
par(mfrow = c(2,2))
burn_idx <- 0.1*B
hist(theta_mat[burn_idx:B,1], main = "Histogram of intercept", xlab = "Theta_1")
hist(theta_mat[burn_idx:B,2], main = "Histogram of coefficient  of log price", xlab = "Theta_2")
```

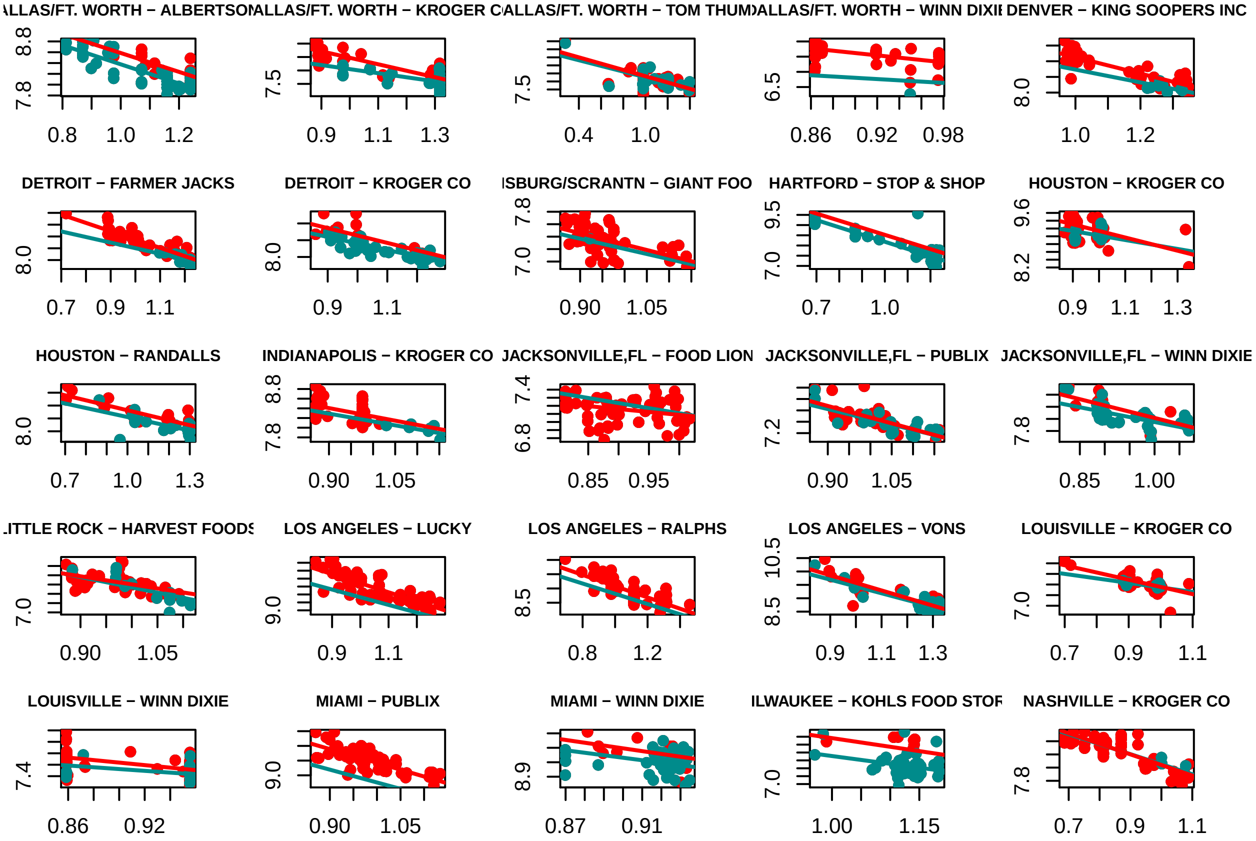
```r
hist(theta_mat[burn_idx:B,3], main = "Histogram of coefficient of display", xlab = "Theta_3")
hist(theta_mat[burn_idx:B,4], main = "Histogram of coefficient of interaction", xlab = "Theta_4")
```



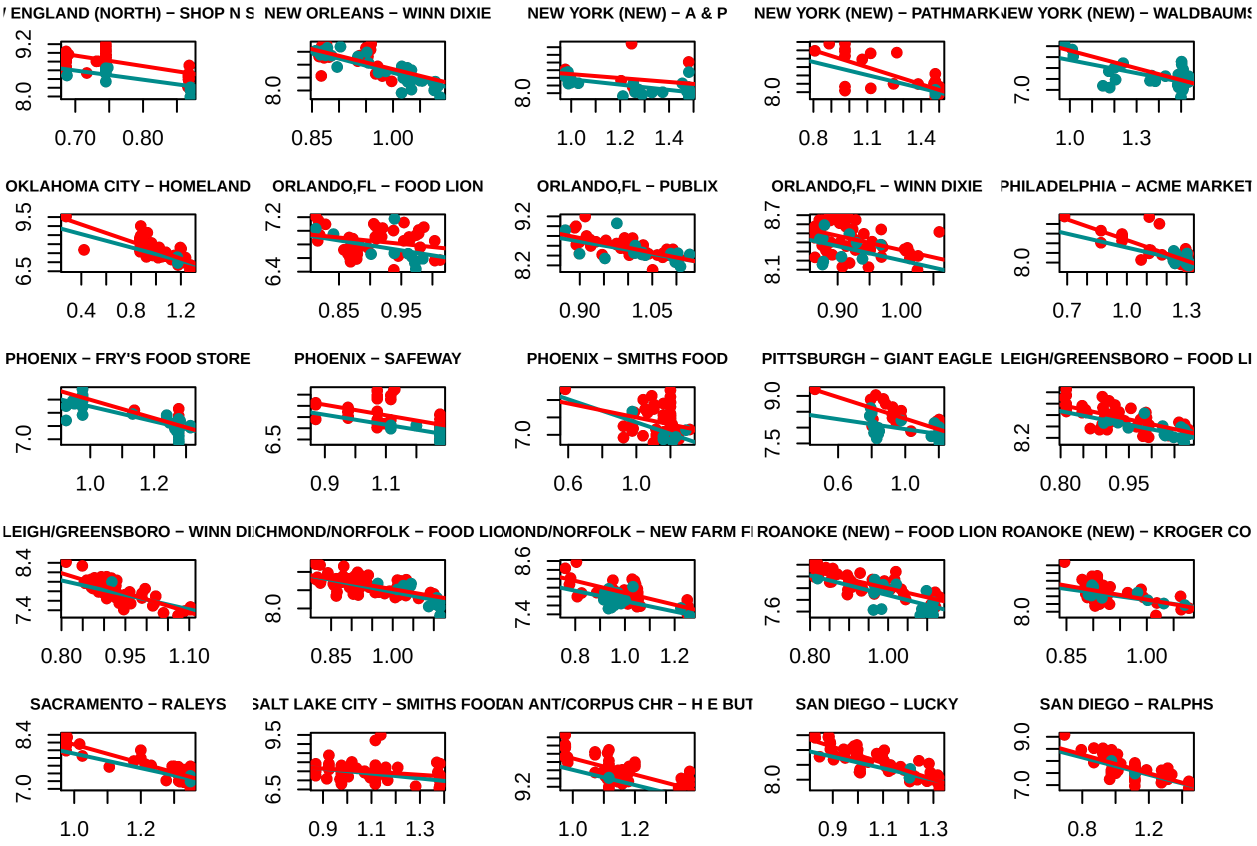
```r
par(mfrow = c(5,5))
par(mai = c(0.3,0.3,0.3,0.3))
for(i in 1:25){
    if(i == 1){
        idx_group <- 1:group_idx[i]
        store_name <- store[1]
    }
    else{
        idx_group <- (group_idx[i-1]+1):group_idx[i]
        store_name <- store[group_idx[i]]
    }
    X_i <- X[idx_group, ]
    Y_i <- Y[idx_group]
    X_1 <- X_i[X_i[,3] == 1, ]
    X_0 <- X_i[X_i[,3] == 0, ]
    temp_beta <- apply(beta_arr[,i,],2,mean)
    plot(X_i[,2],Y_i, main = store_name, cex.main = 0.8, xlab = "logP", ylab = "logQ")
    red_idx <- X_i[,3] == 1
    blue_idx <- X_i[,3] == 0
    points(X_i[red_idx,2],Y_i[red_idx], col="red", pch = 19, xlab = "logP", ylab = "logQ")
    points(X_i[blue_idx,2],Y_i[blue_idx], col="cyan4", pch = 19)
    abline(a = temp_beta[1], b = temp_beta[2], col = "cyan4", lwd = 2)
    abline(a = temp_beta[1] + temp_beta[3], b = temp_beta[2] + temp_beta[4], col = "red", lwd = 2)
}
```



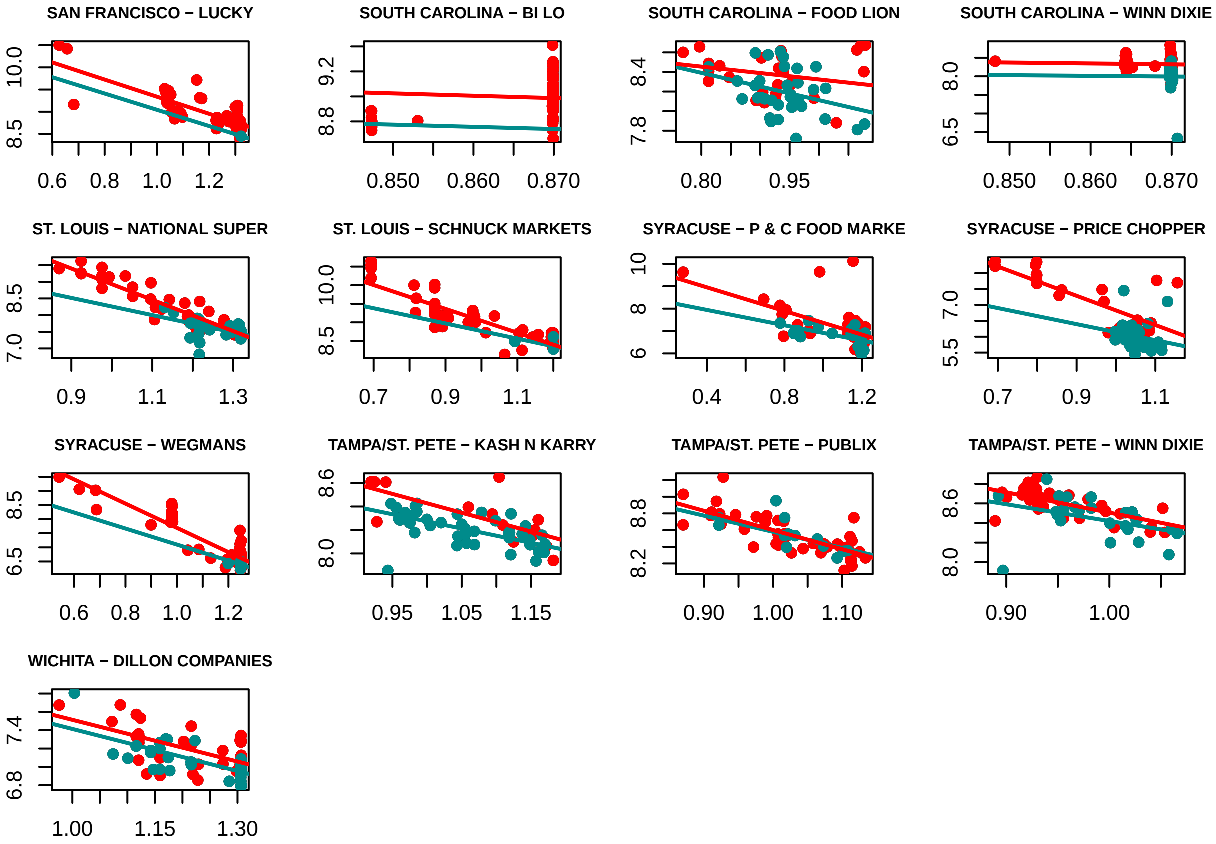
```r
par(mfrow = c(5,5))
par(mai = c(0.3,0.3,0.3,0.3))
for(i in 26:50){
    if(i == 1){
        idx_group <- 1:group_idx[i]
        store_name <- store[1]
    }
    else{
        idx_group <- (group_idx[i-1]+1):group_idx[i]
        store_name <- store[group_idx[i]]
    }
    X_i <- X[idx_group, ]
    Y_i <- Y[idx_group]
    X_1 <- X_i[X_i[,3] == 1, ]
    X_0 <- X_i[X_i[,3] == 0, ]
    temp_beta <- apply(beta_arr[,i,],2,mean)
    plot(X_i[,2],Y_i, main = store_name, cex.main = 0.8, xlab = "logP", ylab = "logQ")
    red_idx <- X_i[,3] == 1
    blue_idx <- X_i[,3] == 0
    points(X_i[red_idx,2],Y_i[red_idx], col="red", pch = 19)
    points(X_i[blue_idx,2],Y_i[blue_idx], col="cyan4", pch = 19)
    abline(a = temp_beta[1], b = temp_beta[2], col = "cyan4", lwd = 2)
    abline(a = temp_beta[1] + temp_beta[3], b = temp_beta[2] + temp_beta[4], col = "red", lwd = 2)
}
```



```r
par(mfrow = c(5,5))
par(mai = c(0.3,0.3,0.3,0.3))
for(i in 51:75){
    if(i == 1){
        idx_group <- 1:group_idx[i]
        store_name <- store[1]
    }
    else{
        idx_group <- (group_idx[i-1]+1):group_idx[i]
        store_name <- store[group_idx[i]]
    }
    X_i <- X[idx_group, ]
    Y_i <- Y[idx_group]
    X_1 <- X_i[X_i[,3] == 1, ]
    X_0 <- X_i[X_i[,3] == 0, ]
    temp_beta <- apply(beta_arr[,i,],2,mean)
    plot(X_i[,2],Y_i, main = store_name, cex.main = 0.8, xlab = "logP", ylab = "logQ")
    red_idx <- X_i[,3] == 1
    blue_idx <- X_i[,3] == 0
    points(X_i[red_idx,2],Y_i[red_idx], col="red", pch = 19)
    points(X_i[blue_idx,2],Y_i[blue_idx], col="cyan4", pch = 19)
    abline(a = temp_beta[1], b = temp_beta[2], col = "cyan4", lwd = 2)
    abline(a = temp_beta[1] + temp_beta[3], b = temp_beta[2] + temp_beta[4], col = "red", lwd = 2)
}
```



```r
par(mfrow = c(4,4))
par(mai = c(0.3,0.3,0.3,0.3))
for(i in 76:88){
    if(i == 1){
        idx_group <- 1:group_idx[i]
        store_name <- store[1]
    }
    else{
        idx_group <- (group_idx[i-1]+1):group_idx[i]
        store_name <- store[group_idx[i]]
    }
    X_i <- X[idx_group, ]
    Y_i <- Y[idx_group]
    X_1 <- X_i[X_i[,3] == 1, ]
    X_0 <- X_i[X_i[,3] == 0, ]
    temp_beta <- apply(beta_arr[,i,],2,mean)
    plot(X_i[,2],Y_i, main = store_name, cex.main = 0.8, xlab = "logP", ylab = "logQ")
    red_idx <- X_i[,3] == 1
    blue_idx <- X_i[,3] == 0
    points(X_i[red_idx,2],Y_i[red_idx], col="red", pch = 19)
    points(X_i[blue_idx,2],Y_i[blue_idx], col="cyan4", pch = 19)
    abline(a = temp_beta[1], b = temp_beta[2], col = "cyan4", lwd = 2)
    abline(a = temp_beta[1] + temp_beta[3], b = temp_beta[2] + temp_beta[4], col = "red", lwd = 2)
}
```


SAN FRANCISCO − LUCKY
10.0
8.5
0.6
0.8
1.0
1.2
SOUTH CAROLINA − BI LO
9.2
8.8
0.850
0.860
0.870
SOUTH CAROLINA − FOOD LION
8.4
7.8
0.80
0.95
SOUTH CAROLINA − WINN DIXIE
8.0
6.5
0.850
0.860
0.870
ST. LOUIS − NATIONAL SUPER
8.5
7.0
0.9
1.1
1.3
ST. LOUIS − SCHNUCK MARKETS
10.0
8.5
0.7
0.9
1.1
SYRACUSE − P & C FOOD MARKE
10
8
6
0.4
0.8
1.2
SYRACUSE − PRICE CHOPPER
7.0
5.5
0.7
0.9
1.1
SYRACUSE − WEGMANS
8.5
6.5
0.6
0.8
1.0
1.2
TAMPA/ST. PETE − KASH N KARRY
8.6
8.0
0.95
1.05
1.15
TAMPA/ST. PETE − PUBLIX
8.8
8.2
0.90
1.00
1.10
TAMPA/ST. PETE − WINN DIXIE
8.6
8.0
0.90
1.00
WICHITA − DILLON COMPANIES
7.4
6.8
1.00
1.15
1.30