

# Appendix: Source code

2024-05-21

```
knitr::opts_chunk$set(echo = TRUE)
rm(list = ls())
gc()
```

```
##           used (Mb) gc trigger (Mb) limit (Mb) max used (Mb)
## Ncells 478484 25.6   1032385 55.2      NA   669422 35.8
## Vcells 899935  6.9    8388608 64.0    36864  1851803 14.2
```

```
set.seed(1)
options(digits=5)
if (!require("pacman")) install.packages("pacman")
```

```
## Loading required package: pacman
```

```
pacman::p_load(
  plm,
  ggplot2,
  tidyverse,
  fixest,
  knitr,
  kableExtra,
  tidymodels,
  modelsummary,
  ggplot2,
  skimr
)
```

## Data

```
orig_df <- read_csv("../input/WSDR.csv")
```

```
## Rows: 15600 Columns: 9
## -- Column specification -----
## Delimiter: ","
## chr (1): descrip
## dbl (8): store, upc, week, move, price, profit, custcoun, Brand
##
## i Use 'spec()' to retrieve the full column specification for this data.
## i Specify the column types or set 'show_col_types = FALSE' to quiet this message.
```

```
head(orig_df, 30)
```

```
## # A tibble: 30 x 9
##   store      upc week move price profit descrip      custcoun Brand
##   <dbl>      <dbl> <dbl> <dbl> <dbl> <dbl> <chr>      <dbl> <dbl>
## 1     5 1200000230     1  158 0.0250  20.1 PEPSI COLA N/R      18820 12000
## 2     5 1200000394     1   47 0.0195   4.02 PEPSI COLA N.R. BO~  18820 12000
## 3     5 1200000396     1   43 0.0195   4.02 DIET PEPSI N.R. BO~  18820 12000
## 4     5 1200000492     1   49 0.0250  20.1 CAFFEINE FREE PEPSI  18820 12000
## 5     5 1200000496     1   61 0.0250  20.1 DIET PEPSI CAFFEINE  18820 12000
## 6     5 3828100261     1   66 0.0208  33.6 DOM ORANGE SODA      18820 38281
## 7     5 4900000634     1   28 0.0388  22.9 COCA-COLA CLASSIC ~  18820 49000
## 8     5 4900000639     1  109 0.0250  20.1 COCA-COLA CLASSIC      18820 49000
## 9     5 4900000658     1   12 0.0388  22.9 COKE DIET CANS        18820 49000
## 10    5 5490000060     1  118 0.0176  13.4 DR PEPPER          18820 54900
## # i 20 more rows
```

## Answer to Q1

```
### Q1 Answer ###
stats <- orig_df %>%
  dplyr::select(move, price, profit, custcoun) %>%
  skimr::skim(.) %>%
  skimr::yank("numeric") %>%
  dplyr::select(skim_variable, mean, sd, p0, p100) %>%
  dplyr::mutate_at(vars(mean, sd, p0, p100), ~round(., 3)) %>%
  kable(format = "latex")
cat(stats)
```

```
##
## \begin{tabular}{l|r|r|r|r}
## \hline
## skim\_variable & mean & sd & p0 & p100\\
## \hline
## move & 132.106 & 263.430 & 1.000 & 6121.00\\
## \hline
## price & 0.024 & 0.007 & 0.008 & 0.04\\
## \hline
## profit & 20.357 & 13.068 & 0.000 & 95.65\\
## \hline
## custcoun & 19154.180 & 4857.582 & 8071.000 & 35340.00\\
## \hline
## \end{tabular}
```

## Answer to Q2

```
### Q2 Answer ###

# to factor
```

```

df <- orig_df |>
  mutate(upc = factor(upc)) |>
  arrange(week, store, upc)

# create product dummy cols
dummy_vars <- model.matrix(~ upc - 1, data = df)
colnames(dummy_vars) <- gsub("upc", "dummy_", colnames(dummy_vars))
df <- cbind(df, dummy_vars)
# delete reference of dummy col
df <- df |> select(-c(dummy_1200000230))

# compute market share
df <- df |>
  dplyr::group_by(store, week) |>
  mutate(M_t = mean(custcoun),
         tot_quant_t = sum(move),
         s_jt = move / M_t,
         s_0t = (M_t - tot_quant_t) / M_t,
         logit_share = log(s_jt/s_0t)) |>
  ungroup() |>
  select(-c(M_t, tot_quant_t))

# compute iV
df <- df |>
  mutate(whole_p_jt = price * (1 - profit*(0.01)))

# OLS estimation in Berry's logit
model1_OLS <- feols(logit_share ~ price + i(upc),
  df, vcov="hetero"
)

# IV estimation in Berry's logit
model1_IV <- feols(logit_share ~ i(upc) | price ~ whole_p_jt,
  df, vcov="hetero"
)

# First stage
etable(model1_IV, stage = 1, fitstat=~ . + ivfall + ivwaldall.p,
  signif.code=c("***=0.01,**=0.05,*=0.10),
  style.tex = style.tex("aer"), tex = TRUE,
  digits=3, digits.stats=3)

```

```

## \begin{group}
## \centering
## \begin{tabular}{lc}
##   \toprule
##           & price\\
##           & (1)\\
##   \midrule
##   Constant & 0.005$^{***}$\\
##           & ($8.18\times 10^{-5}$)\\
##   whole\_p\_jt & 0.879$^{***}$\\
##           & (0.004)

```

```

## upc $=$ 1200000394 & 0.001$^{***}$\\
## & ($7.49\times 10^{-5}$)$\\
## upc $=$ 1200000396 & 0.001$^{***}$\\
## & ($7.49\times 10^{-5}$)$\\
## upc $=$ 1200000492 & 0.0006$^{***}$\\
## & ($7.55\times 10^{-5}$)$\\
## upc $=$ 1200000496 & 0.0006$^{***}$\\
## & ($7.55\times 10^{-5}$)$\\
## upc $=$ 3828100261 & 0.002$^{***}$\\
## & ($8.77\times 10^{-5}$)$\\
## upc $=$ 4900000634 & 0.006$^{***}$\\
## & ($9.25\times 10^{-5}$)$\\
## upc $=$ 4900000639 & $-6.34\times 10^{-5}$\\
## & ($7.58\times 10^{-5}$)$\\
## upc $=$ 4900000658 & 0.006$^{***}$\\
## & ($9.25\times 10^{-5}$)$\\
## upc $=$ 5490000060 & 0.0006$^{***}$\\
## & ($8.38\times 10^{-5}$)$\\
## \\
## Observations & 15,600\\
## R$^2$ & 0.899\\
## Adjusted R$^2$ & 0.898\\
## F-test (IV only) & 42,461.2\\
## Wald (IV only), p-value & $NaN\times 10^{-Inf}$\\
## \bottomrule
## \end{tabular}
## \par\endgroup

```

*# Estimation result*

```

etable(model1_OLS, model1_IV, stage = 2, fitstat=~ . + ivfall + ivwaldall.p,
  signif.code=c("***=0.01","**=0.05","*=0.10),
  style.tex = style.tex("aer"), tex = TRUE,
  digits=3, digits.stats=3)

```

```

## \begin{group}
## \centering
## \begin{tabular}{lcc}
## \toprule
## & \multicolumn{2}{c}{logit\_share}\\
## & (1) & (2)\\
## \midrule
## Constant & -1.09$^{***}$ & -0.715$^{***}$\\
## & (0.035) & (0.039)\\
## price & -159.7$^{***}$ & -177.8$^{***}$\\
## & (1.40) & (1.63)\\
## upc $=$ 1200000394 & -1.55$^{***}$ & -1.49$^{***}$\\
## & (0.023) & (0.023)\\
## upc $=$ 1200000396 & -1.92$^{***}$ & -1.86$^{***}$\\
## & (0.023) & (0.022)\\
## upc $=$ 1200000492 & -1.23$^{***}$ & -1.22$^{***}$\\
## & (0.023) & (0.022)\\
## upc $=$ 1200000496 & -1.20$^{***}$ & -1.19$^{***}$\\
## & (0.022) & (0.021)\\
## upc $=$ 3828100261 & -1.02$^{***}$ & -1.07$^{***}$

```

```
##          & (0.025)          & (0.025)\\
##   upc $=$ 4900000634      & 0.837$^{***}$ & 1.10$^{***}$\\
##          & (0.033)          & (0.034)\\
##   upc $=$ 4900000639      & -0.300$^{***}$ & -0.300$^{***}$\\
##          & (0.021)          & (0.021)\\
##   upc $=$ 4900000658      & 0.629$^{***}$ & 0.889$^{***}$\\
##          & (0.034)          & (0.035)\\
##   upc $=$ 5490000060      & -2.09$^{***}$ & -2.08$^{***}$\\
##          & (0.022)          & (0.021)\\
##   \\
##   Observations          & 15,600          & 15,600\\
##   R$^2$                  & 0.673          & 0.669\\
##   Adjusted R$^2$        & 0.673          & 0.669\\
##   F-test (IV only)      &                  & 12,273.7\\
##   Wald (IV only), p-value &                  & $NaN\times 10^{-Inf}$\\
##   \bottomrule
## \end{tabular}
## \par\endgroup
```

## Answer to Q4

```
### Q4 Answer ###

# compute own elasticity for each market
own_elas_jt <- df |>
  select(week, store, upc, descrip, price, move, s_jt, Brand) |>
  mutate(own_elas = model1_IV$coefficients["fit_price"] * price * (1 - s_jt))

# take median of own elasticity by upc
own_elas_df <- own_elas_jt |>
  select(upc, descrip, own_elas) |>
  group_by(upc, descrip) |>
  summarize(own_elas = median(own_elas), .groups = 'drop')

# compute cross elasticity for each market
cross_elas_jt <- df |>
  select(week, store, upc, descrip, price, move, s_jt, Brand) |>
  mutate(cross_elas = (-1) * model1_IV$coefficients["fit_price"] * price * s_jt)

# take median of cross elasticity by upc
cross_elas_df <- cross_elas_jt |>
  select(upc, descrip, cross_elas) |>
  group_by(upc, descrip) |>
  summarize(cross_elas = median(cross_elas), .groups = 'drop')

# create elasticity matrix
J <- nrow(cross_elas_df)
elas_mat_med <- matrix( rep(cross_elas_df$cross_elas, J), nrow = J, ncol = J)
diag(elas_mat_med) <- own_elas_df$own_elas
colnames(elas_mat_med) <- rownames(elas_mat_med) <- as.character(cross_elas_df$descrip)
res_elas_mat <- elas_mat_med |>
  knitr::kable(format = "latex", booktabs = TRUE, caption = "Median Elasticity matrix") |>
```

```
kableExtra::kable_styling(latex_options = "hold_position")
cat(res_elas_mat)
```

### Setup function for Q5 & Q6

```

# if multi-product bertrand nash
if (is_Multi) {
  for (j in 1:J) {
    for (k in 1:J) {
      # if j's brand is equal to k's brand, take 1
      if (sub_cross_elas$Brand[j] == sub_cross_elas$Brand[k]){
        owner_mat[j,k] = 1
      }
    }
  }
}

# calculate elasticity matrix
elas_mat <- matrix(rep(sub_cross_elas$cross_elas, J), nrow = J, ncol = J)
diag(elas_mat) <- sub_own_elas$own_elas

# calculate matrix S(p)
price_mat <- matrix(rep((1/sub_cross_elas$price), J), nrow = J, ncol = J)
share_mat <- t(matrix(rep(sub_cross_elas$s_jt, J), nrow = J, ncol = J))
S_p_mat <- (-1) * elas_mat * price_mat * share_mat

# calculate markup for a particular market
D_p_mat <- owner_mat * S_p_mat
markup <- solve(D_p_mat) %*% sub_cross_elas$s_jt
mc <- sub_cross_elas$price - markup

return_df <- data.frame(week = market_comb$week[i],
                        store = market_comb$store[i],
                        Brand = sub_cross_elas$Brand,
                        upc = sub_cross_elas$upc,
                        descrip = sub_cross_elas$descrip,
                        price = sub_cross_elas$price,
                        move = sub_cross_elas$move,
                        markup = markup,
                        mc = mc) %>%
  mutate(markup_dev_p = markup/price)

markup_mc_list[[i]] <- return_df
}

result_df <- do.call(rbind, markup_mc_list)
return(result_df)
}

```

## Answer to Q5

```

### Q5 Answer ###

# compute single product Nash equilibrium for each market
J <- nrow(cross_elas_df)
Omega_sin <- diag(J)

```

```

markup_sin <- compute_markup(own_elas_jt, cross_elas_jt, Omega_sin)
markup_sin_med <- markup_sin |>
  select(Brand, descrip, markup, markup_dev_p, mc) |>
  group_by(Brand, descrip) |>
  summarize(markup = median(markup), markup_dev_p = median(markup_dev_p),
            mc = median(mc), .groups = 'drop')

# compute multi product Nash equilibrium for each market
Omega_multi <- matrix(0, J, J)
markup_multi <- compute_markup(own_elas_jt, cross_elas_jt, Omega_multi, is_Multi=TRUE)
markup_multi_med <- markup_multi |>
  select(Brand, descrip, markup, markup_dev_p, mc) |>
  group_by(Brand, descrip) |>
  summarize(markup = median(markup), markup_dev_p = median(markup_dev_p),
            mc = median(mc), .groups = 'drop')

# joint pricing of all brands
J <- nrow(cross_elas_df)
Omega_joint <- matrix(1, nrow = J, ncol = J)
markup_joint <- compute_markup(own_elas_jt, cross_elas_jt, Omega_joint)
markup_joint_med <- markup_joint |>
  select(Brand, descrip, markup, markup_dev_p, mc) |>
  group_by(Brand, descrip) |>
  summarize(markup = median(markup), markup_dev_p = median(markup_dev_p),
            mc = median(mc), .groups = 'drop')

res_markup <- left_join(markup_sin_med |> select(Brand, descrip, markup, markup_dev_p),
                        markup_multi_med |> select(Brand, descrip, markup, markup_dev_p),
                        by = c("Brand", "descrip")) |>
  left_join(markup_joint_med |> select(Brand, descrip, markup, markup_dev_p),
            by = c("Brand", "descrip"), suffix = c(".multi", ".joint"))

res_markup <- res_markup %>%
  knitr::kable(format = "latex", booktabs = TRUE, caption = "Estimated markup") %>%
  kableExtra::kable_styling(latex_options = "hold_position")
cat(res_markup)

```

```

## \begin{table}[!h]
## \centering
## \caption{\label{tab:unnamed-chunk-6}Estimated markup}
## \centering
## \begin{tabular}[t]{t}{rlrrrrrr}
## \toprule
## Brand & descrip & markup.x & markup\_dev\_p.x & markup.y & markup\_dev\_p.y & markup & markup\_dev\_p
## \midrule
## 12000 & CAFFEINE FREE PEPSI & 0.00564 & 0.25597 & 0.00574 & 0.25908 & 0.00594 & 0.27667\\
## 12000 & DIET PEPSI CAFFEINE & 0.00564 & 0.25593 & 0.00574 & 0.25908 & 0.00594 & 0.27667\\
## 12000 & DIET PEPSI N.R. BOTTL & 0.00563 & 0.24103 & 0.00574 & 0.24528 & 0.00594 & 0.25294\\
## 12000 & PEPSI COLA N.R. BOTTL & 0.00563 & 0.24115 & 0.00574 & 0.24528 & 0.00594 & 0.25294\\
## 12000 & PEPSI COLA N/R & 0.00568 & 0.27697 & 0.00574 & 0.27895 & 0.00594 & 0.29092\\
## \addlinespace
## 38281 & DOM ORANGE SODA & 0.00566 & 0.30487 & 0.00566 & 0.30487 & 0.00594 & 0.31504\\
## 49000 & COCA-COLA CLASSIC & 0.00566 & 0.27557 & 0.00570 & 0.27836 & 0.00594 & 0.29169\\

```



```
## 49000 & COCA-COLA CLASSIC CA & 0.00564 & 0.14544 & 0.00570 & 0.14748 & 0.00594 & 0.15593\\
## 49000 & COKE DIET CANS & 0.00563 & 0.14539 & 0.00570 & 0.14748 & 0.00594 & 0.15593\\
## 54900 & DR PEPPER & 0.00563 & 0.27412 & 0.00563 & 0.27412 & 0.00594 & 0.29885\\
## \bottomrule
## \end{tabular}
## \end{table}
```

## Answer to Q6

```
res_mc <- left_join(markup_sin_med |> select(Brand, descrip, mc),
                    markup_multi_med |> select(Brand, descrip, mc),
                    by = c("Brand", "descrip")) |>
left_join(markup_joint_med |> select(Brand, descrip, mc),
          by = c("Brand", "descrip"), suffix = c(".multi", ".joint"))

res_mc <- res_mc %>%
  knitr::kable(format = "latex", booktabs = TRUE, caption = "Estimated markup") %>%
  kableExtra::kable_styling(latex_options = "hold_position")
cat(res_mc)
```

```
## \begin{table}[!h]
## \centering
## \caption{\label{tab:unnamed-chunk-7}Estimated markup}
## \centering
## \begin{tabular}[t]{t}{rlrrr}
## \toprule
## Brand & descrip & mc.x & mc.y & mc\\.
## \midrule
## 12000 & CAFFEINE FREE PEPSI & 0.01639 & 0.01632 & 0.01601\\
## 12000 & DIET PEPSI CAFFEINE & 0.01639 & 0.01632 & 0.01601\\
## 12000 & DIET PEPSI N.R. BOTTL & 0.01773 & 0.01763 & 0.01746\\
## 12000 & PEPSI COLA N.R. BOTTL & 0.01773 & 0.01763 & 0.01746\\
## 12000 & PEPSI COLA N/R & 0.01486 & 0.01482 & 0.01461\\
## \addlinespace
## 38281 & DOM ORANGE SODA & 0.01289 & 0.01289 & 0.01274\\
## 49000 & COCA-COLA CLASSIC & 0.01489 & 0.01486 & 0.01461\\
## 49000 & COCA-COLA CLASSIC CA & 0.03311 & 0.03304 & 0.03277\\
## 49000 & COKE DIET CANS & 0.03312 & 0.03304 & 0.03277\\
## 54900 & DR PEPPER & 0.01492 & 0.01492 & 0.01434\\
## \bottomrule
## \end{tabular}
## \end{table}
```

## Setup function for Q7

```
compute_price_eq = function(df, init_p, owner_mat, alpha_hat, beta_hat, is_Multi = TRUE){
  # iteration stop parameters
  epsilon <- 1e-5
  df$price <- init_p
```

```

error <- 10000
count_max <- 20
counter <- 0

while (error > epsilon & counter < count_max) {
  # check counter
  counter = counter + 1
  print(counter)
  print(error)

  unique_week <- unique(df$week)
  unique_store <- unique(df$store)

  market_comb <- expand.grid(week = unique_week, store = unique_store)

  # store list of p
  p_k_list <- vector("list", nrow(market_comb))

  # calc eta(p) for each market
  for (i in 1:nrow(market_comb)) {

    week_i <- market_comb$week[i]
    store_i <- market_comb$store[i]

    # subset of a particular market
    df_t <- df |> filter(week == week_i & store == store_i)

    # compute own elasticity for each market
    sub_own_elas <- df_t |>
      select(week, store, upc, descrip, price, move, s_jt, Brand, mc) |>
      mutate(own_elas = alpha_hat * price * (1 - s_jt))

    # compute cross elasticity for each market
    sub_cross_elas <- df_t |>
      select(week, store, upc, descrip, price, move, s_jt, Brand, mc) |>
      mutate(cross_elas = (-1) * alpha_hat * price * s_jt)

    # number of product
    J <- nrow(sub_cross_elas)

    # if multi-product bertrand nash
    if (is_Multi) {
      for (j in 1:J) {
        for (k in 1:J) {
          # if j's brand is equal to k's brand, take 1
          if (sub_cross_elas$Brand[j] == sub_cross_elas$Brand[k]){
            owner_mat[j,k] = 1
          }
        }
      }
    }
  }

  # calculate elasticity matrix

```

```

elas_mat <- matrix(rep(sub_cross_elas$cross_elas, J), nrow = J, ncol = J)
diag(elas_mat) <- sub_own_elas$own_elas

# calculate matrix S(p)
price_mat <- matrix(rep((1/sub_cross_elas$price), J), nrow = J, ncol = J)
share_mat <- t(matrix(rep(sub_cross_elas$s_jt, J), nrow = J, ncol = J))
S_p_mat <- (-1) * elas_mat * price_mat * share_mat

# calculate p_k for a particular market
D_p_mat <- owner_mat * S_p_mat
p_k <- sub_cross_elas$mc + solve(D_p_mat) %*% sub_cross_elas$s_jt

# calculate new share
X_j <- as.matrix(df_t[, grepl("dummy_", colnames(df_t))])
xi_hat <- log(df_t$s_jt/df_t$s_0t) - (alpha_hat * df_t$price + X_j %*% beta_hat)
numerator <- exp(alpha_hat * p_k + X_j %*% beta_hat + xi_hat)
s_jt_old <- df$s_jt
s_jt <- numerator / (1 + sum(numerator))

# to dataframe
market_df <- data.frame(week = market_comb$week[i],
                        store = market_comb$store[i],
                        upc = sub_cross_elas$upc,
                        s_jt_post = s_jt,
                        price_post = p_k)

# store dataframe
p_k_list[[i]] <- market_df
}
return_df <- do.call(rbind, p_k_list)

#update
error <- max(abs(return_df$price_post - df$price))
df$price <- return_df$price_post
df$s_jt <- return_df$s_jt_post
}
return(return_df)
}

```

## Answer to Q7

```

# compute price equilibrium for counterfactual exercise
df <- left_join(df, markup_multi |> select(store, week, upc, mc),
               by = c("store", "week", "upc"))

# initial price
init_p <- rep(0.02, nrow(df))

# computation result
alpha_hat <- model1_IV$coefficients["fit_price"]
beta_hat <- as.vector(model1_IV$coefficients)[3:11]
df <- df |> mutate(mc_post = mc * 1.1) # add 10% increase
p_eq_ct <- df %>%

```

```
mutate(mc = mc_post) %>% # set marginal cost 10% increase
compute_price_eq(., init_p, Omega_multi, alpha_hat, beta_hat)
```

```
## [1] 1
## [1] 10000
## [1] 2
## [1] 0.02359
## [1] 3
## [1] 0.012056
## [1] 4
## [1] 0.011396
## [1] 5
## [1] 0.0026598
## [1] 6
## [1] 0.0026449
## [1] 7
## [1] 0.0021411
## [1] 8
## [1] 0.002671
## [1] 9
## [1] 0.0028222
## [1] 10
## [1] 0.0024052
## [1] 11
## [1] 0.001942
## [1] 12
## [1] 0.00187
## [1] 13
## [1] 0.0018562
## [1] 14
## [1] 0.0020517
## [1] 15
## [1] 0.0021951
## [1] 16
## [1] 0.0026261
## [1] 17
## [1] 0.0025461
## [1] 18
## [1] 0.00263
## [1] 19
## [1] 0.0020928
## [1] 20
## [1] 0.0013085
```

```
# join result
df <- left_join(df, p_eq_ct, c("store", "week", "upc")) |>
  mutate(price_pre = price)

# results to tex
res_p_eq_ct <- df |>
  select(Brand, descrip, price_pre, price_post, mc, mc_post) |>
  group_by(Brand, descrip) |>
  summarize(price_pre = median(price_pre),
```

```

    price_post = median(price_post),
    mc_price_share_diff = median((mc_post - mc)/price_post),
    .groups = 'drop') |>
knitr::kable(format = "latex", booktabs = TRUE,
              caption = "Counterfactual Exercise (MC increases by 10%)") |>
kableExtra::kable_styling(latex_options = "hold_position")
cat(res_p_eq_ct)

## \begin{table}[!h]
## \centering
## \caption{\label{tab:unnamed-chunk-9}Counterfactual Exercise (MC increases by 10%)}
## \centering
## \begin{tabular}[t]{t}{rlrrr}
## \toprule
## Brand & descrip & price\_pre & price\_post & mc\_price\_share\_diff\\
## \midrule
## 12000 & CAFFEINE FREE PEPSI & 0.02203 & 0.02370 & 0.06888\\
## 12000 & DIET PEPSI CAFFEINE & 0.02203 & 0.02370 & 0.06888\\
## 12000 & DIET PEPSI N.R. BOTTL & 0.02336 & 0.02513 & 0.07015\\
## 12000 & PEPSI COLA N.R. BOTTL & 0.02336 & 0.02513 & 0.07015\\
## 12000 & PEPSI COLA N/R & 0.02055 & 0.02202 & 0.06730\\
## \addlinespace
## 38281 & DOM ORANGE SODA & 0.01854 & 0.01988 & 0.06484\\
## 49000 & COCA-COLA CLASSIC & 0.02055 & 0.02200 & 0.06752\\
## 49000 & COCA-COLA CLASSIC CA & 0.03875 & 0.04202 & 0.07863\\
## 49000 & COKE DIET CANS & 0.03875 & 0.04202 & 0.07863\\
## 54900 & DR PEPPER & 0.02055 & 0.02204 & 0.06770\\
## \bottomrule
## \end{tabular}
## \end{table}

```

## Setup function for Q8

```

compute_welfare = function(df, alpha_hat, beta_hat){

  unique_week <- unique(df$week)
  unique_store <- unique(df$store)

  # market list
  market_comb <- expand.grid(week = unique_week, store = unique_store)

  # store list of p
  welfare_list <- vector("list", nrow(market_comb))

  # calculating welfare for each market
  for (i in 1:nrow(market_comb)) {
    week_i <- market_comb$week[i]
    store_i <- market_comb$store[i]

    # subset of a particular market
    df_t <- df |> filter(week == week_i & store == store_i)
  }
}

```

```

# matrix X_j
X_j <- as.matrix(df_t[, grepl("dummy_", colnames(df_t))])

# calculate pre delta_jt
xi_hat <- log(df_t$s_jt_old/df_t$s_0t) - (alpha_hat * df_t$price_old + X_j %*% beta_hat)
delta<- alpha_hat * df_t$price + X_j %*% beta_hat + xi_hat

# calculate CV based on Small and Rosen (1981)
#CV <- (1 / (-1) * alpha_hat) * (1+log(sum(exp(delta_post))) - (1+ log(sum(exp(delta_pre)))))
CS <- 1+log(sum(exp(delta)))

# calculate producer surplus for each brand in a particular market
M_t <- mean(df_t$custcoun)
PS_f_t <- df_t |>
  mutate(calc_profit = (price - mc) * s_jt * M_t) |>
  group_by(Brand, week, store) |>
  summarize(calc_profit = sum(calc_profit), .groups = 'drop')

# summation accross firm in the market
PS <- PS_f_t |>
  summarize(calc_profit = sum(calc_profit), .groups = 'drop')

# to dataframe
walfare_df <- data.frame(week = week_i,
                        store = store_i,
                        CS = CS,
                        PS = PS$calc_profit,
                        TS = CS + PS$calc_profit)

# store dataframe
walfare_list[[i]] <- walfare_df
}
return_df <- do.call(rbind, walfare_list)
return(return_df)
}

```

## Answer to Q8

```

# walfare in pre counter factual exercise
walfare_pre <- df |>
  mutate(price_old = price, s_jt_old = s_jt) |> # set variables for xi
  compute_walfare(alpha_hat, beta_hat)

# walfare in counter factual exercise
walfare_post <- df |>
  mutate(price_old = price, s_jt_old = s_jt,
         price = price_post, mc = mc_post, s_jt = s_jt_post) |> # use updated variables
  compute_walfare(alpha_hat, beta_hat)

# take difference of each surplus
Diff_CS <- walfare_post$CS - walfare_pre$CS

```

```

Diff_PS <- walfare_post$PS - walfare_pre$PS
Diff_TS <- walfare_post$TS - walfare_pre$TS

# results to tex
res_walfare <- walfare_post |>
  mutate(Diff_CS = Diff_CS, Diff_PS = Diff_PS, Diff_TS = Diff_TS) |>
  select(week, store, Diff_CS, Diff_PS, Diff_TS) |>
  summarize(sum_Diff_CS = sum(Diff_CS), sum_Diff_PS = sum(Diff_PS), sum_Diff_TS = sum(Diff_TS),
            mean_Diff_CS = mean(Diff_CS), mean_Diff_PS = mean(Diff_PS), mean_Diff_TS = mean(Diff_TS),
            .groups = 'drop') |>
  knitr::kable(format = "latex", booktabs = TRUE,
               caption = "Summary of each surplus difference") |>
  kableExtra::kable_styling(latex_options = "hold_position")
cat(res_walfare)

## \begin{table}[!h]
## \centering
## \caption{\label{tab:unnamed-chunk-11}Summary of each surplus difference}
## \centering
## \begin{tabular}[t]{t}{rrrrrr}
## \toprule
## sum\_Diff\_CS & sum\_Diff\_PS & sum\_Diff\_TS & mean\_Diff\_CS & mean\_Diff\_PS & mean\_Diff\_TS\\
## \midrule
## -393.04 & -2170.7 & -2563.7 & -0.25195 & -1.3915 & -1.6434\\
## \bottomrule
## \end{tabular}
## \end{table}

```

## Answer to Q9

```

### Q9 Answer ###

# set merged brand code 99999
## Note: Ownership matrix is automatically calculated based on merged brand code in this function
df <- df %>%
  mutate(Brand_merged = if_else(Brand %in% c(12000, 49000), 99999, Brand))

res_merged <- df %>%
  mutate(Brand = Brand_merged) %>% # set merged brand code
  compute_price_eq(., init_p, Omega_multi, alpha_hat, beta_hat) %>%
  rename(price_merged = price_post)

## [1] 1
## [1] 10000
## [1] 2
## [1] 0.023056
## [1] 3
## [1] 0.012322
## [1] 4
## [1] 0.011583

```

```
## [1] 5
## [1] 0.0029313
## [1] 6
## [1] 0.0028164
## [1] 7
## [1] 0.0027058
## [1] 8
## [1] 0.0029035
## [1] 9
## [1] 0.0036082
## [1] 10
## [1] 0.0021974
## [1] 11
## [1] 0.0020698
## [1] 12
## [1] 0.0028186
## [1] 13
## [1] 0.0018424
## [1] 14
## [1] 0.0019761
## [1] 15
## [1] 0.0022941
## [1] 16
## [1] 0.0027406
## [1] 17
## [1] 0.0024507
## [1] 18
## [1] 0.0026737
## [1] 19
## [1] 0.0019289
## [1] 20
## [1] 0.0012749
```

```
# join result
df <- left_join(df, res_merged, c("store", "week", "upc")) |>
  mutate(price_pre = price)

res_merged <- df |>
  select(Brand, Brand_merged, descrip, price_pre, price_merged) |>
  group_by(Brand, Brand_merged, descrip) |>
  summarize(price_pre = median(price_pre),
            price_merged = median(price_merged),
            .groups = 'drop') |>
  knitr::kable(format = "latex", booktabs = TRUE,
               caption = "Merge impact on the equilibrium price (median across market)") |>
  kableExtra::kable_styling(latex_options = "hold_position")
cat(res_merged)
```

```
## \begin{table}[!h]
## \centering
## \caption{\label{tab:unnamed-chunk-12}Merge impact on the equilibrium price (median across market)}
## \centering
## \begin{tabular}[t]{t}{rrlrr}
## \toprule
```



```

## Brand & Brand\_merged & descrip & price\_pre & price\_merged\\
## \midrule
## 12000 & 99999 & CAFFEINE FREE PEPSI & 0.02203 & 0.02213\\
## 12000 & 99999 & DIET PEPSI CAFFEINE & 0.02203 & 0.02213\\
## 12000 & 99999 & DIET PEPSI N.R. BOTT & 0.02336 & 0.02347\\
## 12000 & 99999 & PEPSI COLA N.R. BOTT & 0.02336 & 0.02347\\
## 12000 & 99999 & PEPSI COLA N/R & 0.02055 & 0.02062\\
## \addlinespace
## 38281 & 38281 & DOM ORANGE SODA & 0.01854 & 0.01859\\
## 49000 & 99999 & COCA-COLA CLASSIC & 0.02055 & 0.02063\\
## 49000 & 99999 & COCA-COLA CLASSIC CA & 0.03875 & 0.03882\\
## 49000 & 99999 & COKE DIET CANS & 0.03875 & 0.03882\\
## 54900 & 54900 & DR PEPPER & 0.02055 & 0.02055\\
## \bottomrule
## \end{tabular}
## \end{table}

```