

Hourly EV Charging Demand Model

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```
#load libraries
library(tidyverse)

## -- Attaching packages ----- tidyverse 1.2.1 --

## v ggplot2 3.1.0      v purrr  0.2.5
## v tibble  1.4.2      v dplyr  0.7.8
## v tidyr   0.8.2      v stringr 1.3.1
## v readr   1.1.1      v forcats 0.3.0

## -- Conflicts ----- tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()     masks stats::lag()

library(dplyr)
library(RColorBrewer)

#load data
#Price Schedule
Winter_TOU_2018 <- read.csv("Model_Map/2018_Winter_TOU_EV_D.csv")
Baseline_03_18_WP <- read.csv("Model_Map/03-18_WP_Avg.csv")
Chargers <- read.csv("Model_Map/Chargers_Installed_03-18.csv")

#Price Schedule
price_schedule <- data.frame(Hr = c(1:24)) %>%
  mutate(P0 = Winter_TOU_2018$P0)

#Baseline
WP_Chargers <- Chargers$Workplace #Number of Chargers (C)
EV_Demand <- mutate(price_schedule, Xi = Baseline_03_18_WP$Xi, X0 = Baseline_03_18_WP$Xi/340*WP_Chargers)

#creates our matrix based on the 24 elasticity .csv files.
#uses a for loop to call files rather than individually
#NOTE this matrix has each COLUMN to be used for each hour. Our excel used each ROW if trying to compare

x <- c(1:24) #used for the 24 hours in for loops (24 elasticity columns)
matrix <- data.frame(Hr = c(1:24))
for (val in x) {
  El <- read_csv(sub("XX", val, "Model_Map/Elasticities_XX.csv"))
  El <- El[-1,]
  El <- El[order(El$HR24),]
  matrix <- cbind(matrix, El$ELAST)
}

## Parsed with column specification:
## cols(
##   ELAST = col_double(),
##   HR24 = col_integer()
## )
```

[illegible]

[illegible]

```

##   HR24 = col_integer()
## )
## Parsed with column specification:
## cols(
##   ELAST = col_double(),
##   HR24 = col_integer()
## )

matrix<-matrix[, -1]
colnames(matrix) <- c(1:24)

price_change <- -0.05
intervention_hours <- c(12:15)
EV_Demand <- mutate(EV_Demand, P1 = price_schedule$P0) #Adds price schedule with intervention (P1)

EV_Demand$P1[intervention_hours] <- EV_Demand$P1[intervention_hours] + price_change #updates intervention

EV_Demand <- mutate(EV_Demand, P1p = (P1-P0)/P0) #Adds percentage change in price (P1p)

X1p <- as.vector(0)
for (val in x) {
  mat <- sub("XX", val, "matrix$`XX`")
  sum_prod <- crossprod(EV_Demand$P1p, eval(parse(text = mat)))
  X1p <- append(X1p, sum_prod)
} #crossprod() multiplies sumproduct of the percent change in price with each column in the matrix. This

X1p <- X1p[-1] # gets rid of the first dummy entry to the variable
EV_Demand <- mutate(EV_Demand, X1p = X1p) #add percent change in demand due to price onto EV_Demand (X1p)

EV_Demand <- mutate(EV_Demand, X1 = (1+X1p)*X0) #adds new demand in kW variable (X1)

throttle_amount <- -0.5 #throttling amount -0.5 - 50%
Tp <- rep(0, 24)
throttle_hours <- c(7:11) #hours that throttling occurs
Tp[throttle_hours] <- throttle_amount #Assigns each hour a throttling percentage
EV_Demand <- mutate(EV_Demand, Tp=Tp) #Adds throttling percentage to each hour (Tp)

E <- as.vector(0) #dummy for self-elasticities (E)

for (val in x) {
  self <- matrix[val, val]
  E <- append(E, self)
} #checks the matrix for the self elasticity and adds it to a vector, repeated 24 times as a for loop r

E <- E[-1] #removing dummy

EV_Demand <- mutate(EV_Demand, Ptp = Tp/E, Pt = (1+Ptp)*P1) #Creates an equivalent change in price during

Xtp <- as.vector(0) #Dummy for change in demand due to throttling (Xtp)

for (val in x) {
  mat <- sub("XX", val, "matrix$`XX`")
  sum_prod <- crossprod(EV_Demand$Ptp, eval(parse(text = mat)))
  Xtp <- append(Xtp, sum_prod)
}

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} #uses new price equivalent sumproduct with each hour's elasticities to find percent change in demand
Xtp <- Xtp[-1] #gets rid of dummy

EV_Demand <- mutate(EV_Demand, Xtp = Xtp, Xt = (Xtp+1)*X1) #adds (Xtp) and the new demand in kW due to
#to be completed...

#need to stack both demand curves in one data frame for a legend

graph_table <- EV_Demand[c(1,4,13)] %>%
  gather(condition,value,X0:Xt)

Demand_Graph <- ggplot(data = graph_table, aes(x = Hr)) +
  geom_line(aes(y = value, color=condition)) +
  theme(panel.grid.major = element_blank(), panel.grid.minor = element_blank(),
        panel.background = element_blank(), axis.line = element_line(colour = "black")) +
  labs(title="Hourly Demand Forecast",
        subtitle="$0.05 Discount 11 AM - 3 PM \n 50% Throttling 6 AM - 11 AM",
        y="EV Charging Demand (kW)",
        x="Hour",
        color=NULL) +
  scale_x_continuous(breaks = 1:24, limits = c(1,24), expand = c(0, 0)) +
  scale_color_manual(labels=c("Baseline Demand","Demand with Intervention"), values = c("blue", "red")) +
  geom_rect(aes(xmin=6,xmax=11,ymin=-Inf,ymax=Inf,fill="Throttle"),alpha=0.0075) +
  geom_rect(aes(xmin=11,xmax=15,ymin=-Inf,ymax=Inf, fill = "Discount"),alpha=0.0075) +
  #theme_bw() + # theme_bw() gives grid lines, could remove
  theme(plot.title = element_text(hjust = 0.5)) +
  theme(plot.subtitle = element_text(hjust = 0.5))+
  theme(legend.position="bottom") +
  scale_fill_manual('Interventions',values = c('green','yellow'), guide = guide_legend(override.aes =

# Aesthetic Notes:
# might try to remove space b/w Y-axis and hr0, as well as past hr24
# bold axis titles
# color brewer
# Midnight to 1AM is missing!

Demand_Graph

```

