ESM204 HW3

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1. Marginal externality cost (MEC) per gallon

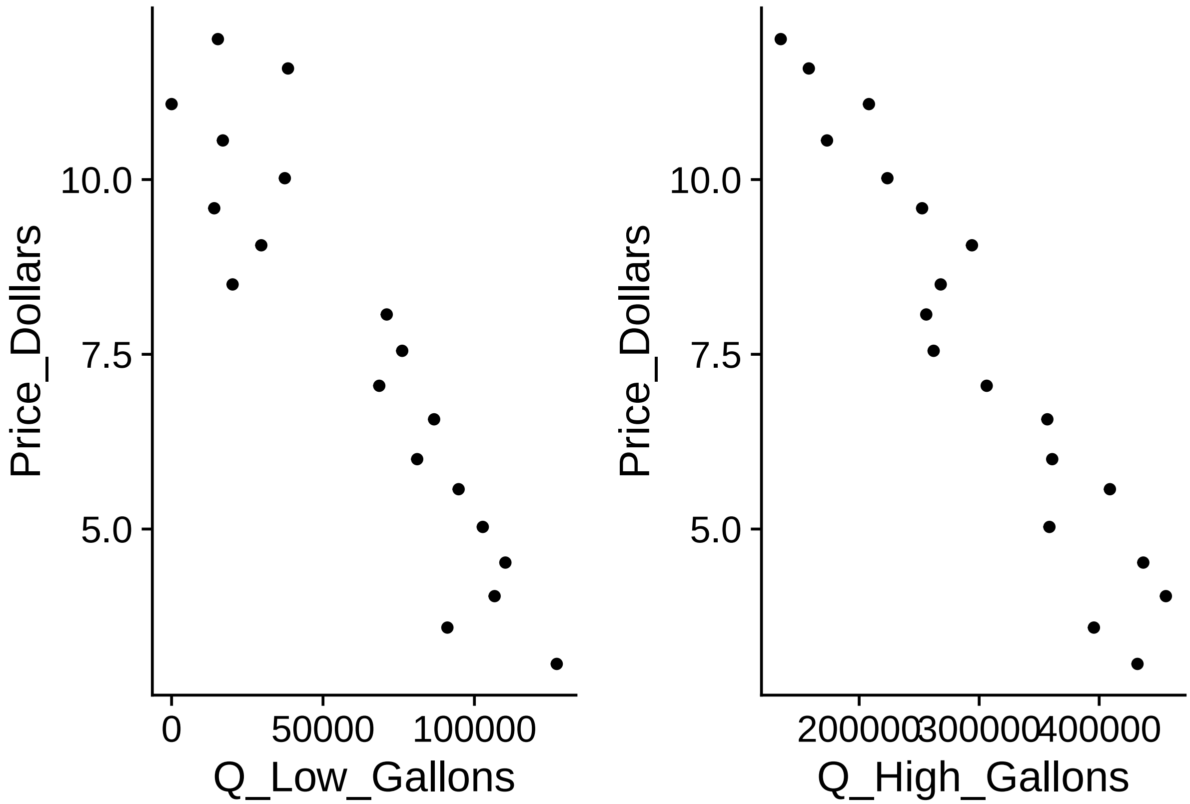
```
mec_gallon <- 51*(1/2000)*19.6
returnValue(mec_gallon)
```

```
## [1] 0.4998
```

Marginal externality cost is approximately $0.50 per gallon of gas.

2. Aggregate demand curve, supply curve, consumer benefit, producer benefit, and environmental cost under status quo.

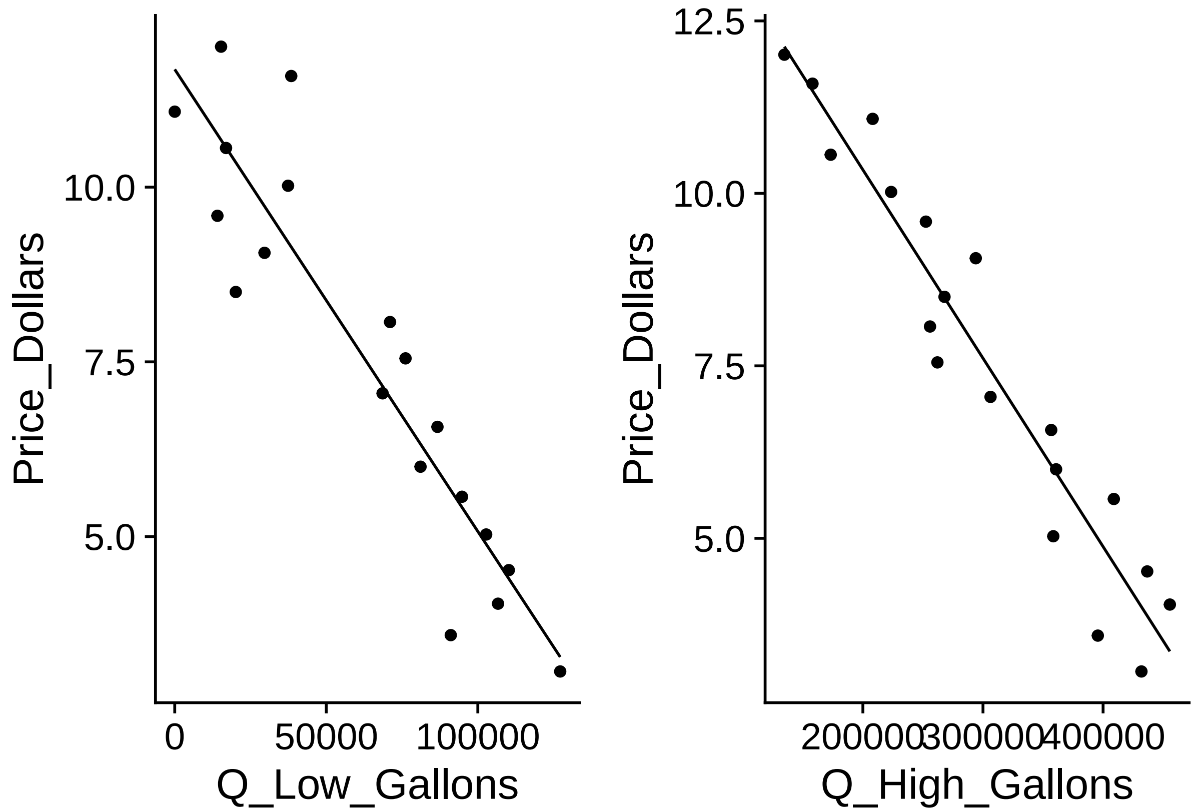
```
# Read in the data

demand_data <- read.csv(here("data", "HW3_data.csv"), stringsAsFactors = F)

# Exploratory plots
plot_1 <- ggplot(data=demand_data, aes(x=Q_Low_Gallons,y=Price_Dollars))+
  geom_point()+
  theme_cowplot(16)

plot_2 <- ggplot(data=demand_data, aes(x=Q_High_Gallons,y=Price_Dollars))+
  geom_point()+
  theme_cowplot(16)

plot_1 + plot_2
```




```r
# Estimate linear models

## Low income group linear models:

low_demand_model <- lm(Price_Dollars ~ Q_Low_Gallons, data = demand_data)
# low_demand_model$coefficients # Call the coefficients

al <- low_demand_model$coefficients[[1]] # "al" is the "a" coeff. for low demand
bl <- low_demand_model$coefficients[[2]] # "bl" is the "b" coeff. for low demand

## High income group linear models:

high_demand_model <- lm(Price_Dollars ~ Q_High_Gallons, data = demand_data)
# high_demand_model$coefficients # Call the coefficients

ah <- high_demand_model$coefficients[[1]] # "ah" is the "a" coeff. for high demand
bh <- high_demand_model$coefficients[[2]] # "bh" is the "b" coeff. for high demand
```

```r
# Add our estimated curves to our exploratory plots

price_low_fitted <- al + bl*demand_data$Q_Low_Gallons
price_high_fitted <- ah + bh*demand_data$Q_High_Gallons

(plot_1+
  geom_line(aes(y=price_low_fitted, x=Q_Low_Gallons))) +
(plot_2+
```

```
  geom_line(aes(y = price_high_fitted, x = Q_High_Gallons)))
```

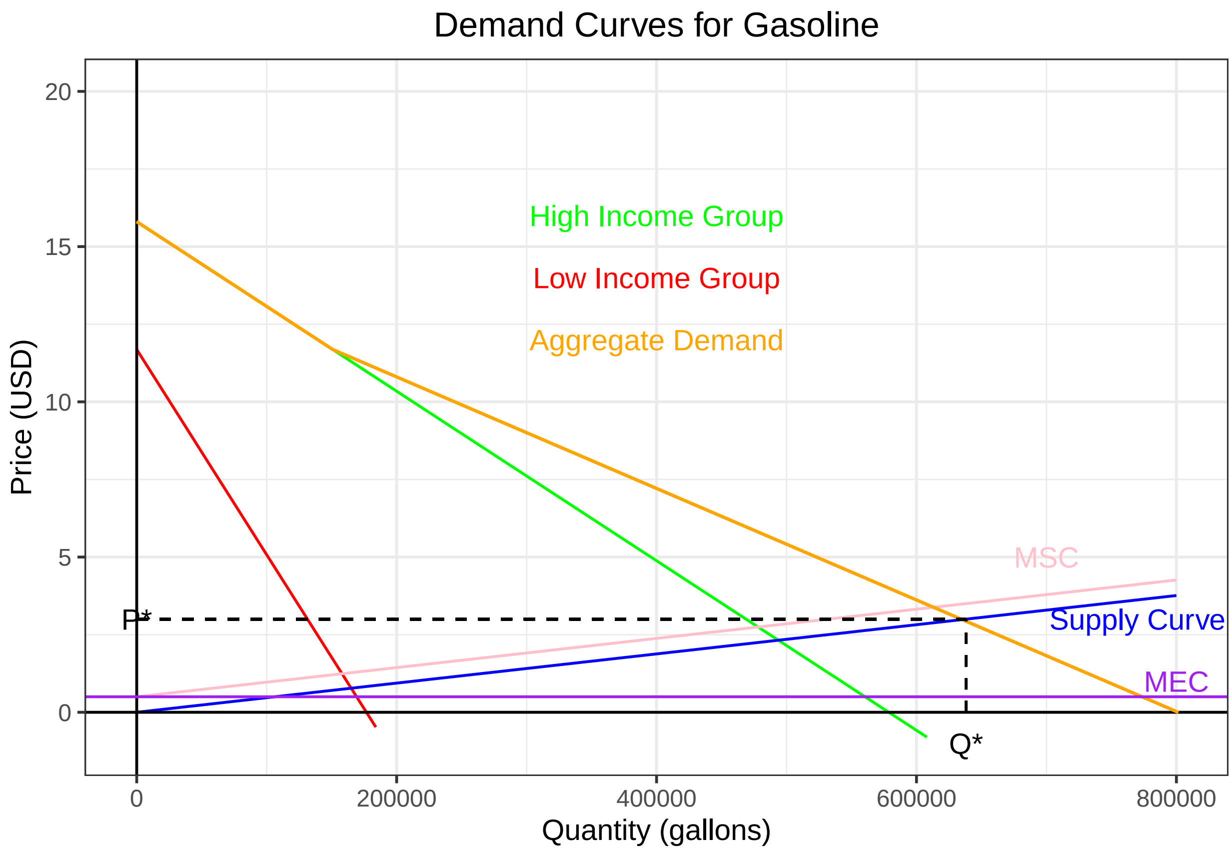



```
# Create models to help us find aggregate demand curve

# P(Q)
inverse_demand <- function(q, model){
  p <- model$coefficients[[1]] + model$coefficients[[2]]*q
return(p)
}

## Inverse P(Q) to get Q(P)
demand <- function(p, model){
  q <- (p - model$coefficients[[1]])/model$coefficients[[2]]
  return(q)
}


# Make aggregate demand model
agg_demand_model <- lm(Price_Dollars ~ Q_High_Gallons+Q_Low_Gallons, data = demand_data)
# agg_demand_model$coefficients # Call the coefficients

at <- agg_demand_model$coefficients[[1]] # "at" is the "a" coeff. for total demand
bt <- agg_demand_model$coefficients[[2]] # "bt" is the "b" coeff. for total demand

# Find q at price given price p ($3)
```

```r
Q_star <- demand(3, agg_demand_model)

# Make supply model
supply <- function(p, agg_demand_model){
  q <- (p - agg_demand_model$coefficients[[1]])/agg_demand_model$coefficients[[2]]
 return(q)
}
```

```r
# Now create functions for our lines, and add them to the same plot

low_demand_curve <- function(x) low_demand_model$coefficients[[1]] + low_demand_model$coefficients[[2]]*
high_demand_curve <- function(x) high_demand_model$coefficients[[1]] + high_demand_model$coefficients[[2
agg_demand_curve <- function(x) agg_demand_model$coefficients[[1]] + agg_demand_model$coefficients[[2]]*

# Find slope of supply curve (we know y-intercept is 0, and current price is $3)
bs <- 3/supply(3, agg_demand_model) ## rise over run
supply_curve <- function(x) bs*x

# Make a MSC curve from supply curve + MEC curve (MEC found in part 1)
msc_curve <- function(x) bs*x + 0.4998


# Make the plot
ggplot(data = demand_data, aes(y = Price_Dollars, x = Q_High_Gallons))+
  stat_function(fun = low_demand_curve,
                color = "red")+
  stat_function(fun = high_demand_curve,
                color = "green")+
  stat_function(fun = supply_curve,
                color = "blue")+
  stat_function(fun = msc_curve,
                color = "pink")+
  annotate("text", x = 400000, y = 14, color = "red", label = "Low Income Group")+
  annotate("text", x = 400000, y = 16, color = "green", label = "High Income Group")+
  annotate("text", x = 400000, y = 12, color = "orange", label = "Aggregate Demand")+
  annotate("text", x = 770000, y = 3, color = "blue", label = "Supply Curve")+
  annotate("text", x = 700000, y = 5, color = "pink", label = "MSC")+
  annotate("text", x = 800000, y = 1, color = "purple", label = "MEC")+
  annotate("text", x = -5, y = 3, color = "black", label = "P*")+
  annotate("text", x = Q_star, y = -1, color = "black", label = "Q*")+
  theme_bw()+
  labs(
    y = "Price (USD)",
    x = "Quantity (gallons)",
    title = "Demand Curves for Gasoline"
  )+
  geom_hline(aes(yintercept = 0))+
  geom_vline(aes(xintercept = 0))+
  theme(plot.title = element_text(hjust = 0.5))+
  ylim(-1, 20)+
  xlim(-5, 800000)+
  geom_segment(x = 0, y = 15.803, xend = 150807, yend = 11.685, color = "orange")+ # Use above models t
  geom_segment(x = 150807, y = 11.685, xend = 801395.3, yend = 0, color = "orange")+ # Use models above
```

```
  geom_segment(linetype = "dashed", col = "black", x = 0, y = 3, xend = Q_star, yend = 3)+
  geom_segment(linetype = "dashed", col = "black", x = Q_star, y = 0, xend = Q_star, yend = 3)+
  geom_hline(aes(yintercept = 0.4998), color = "purple")
```



The benefit to consumers under the status quo will be equal to the consumer surplus. We can approximate this as follows:

```
CS_p <- function(p, model){
  q <- demand(p, model)
  cs <- 0.5*(model$coefficients[[1]] - p)*q
  return(cs)
}

CS_p(3, agg_demand_model)
```

```
## [1] 3741094
```

Therefore we see that the consumer surplus is approximately $3,741,094. **Note:** It is worth noting that this is not an exact value, as this is the area under the aggregate demand curve from 0 to Q*. In the above graph we can see that the aggregate demand curve is actually kinked, and is therefore not a perfect triangle, so our obtained value is actually a slight overestimation.

The benefit to producers will be equal to producer surplus. This is as follows:

```
PS_p <- function(p, model){
  q <- supply(p, model)
  ps <- 0.5*p*q
  return(ps)
}

PS_p(3, agg_demand_model)
```

```
## [1] 957188.6
```

The producer surplus is approximately $957,188.60. We can see that this is much less than the consumer surplus.

The environmental cost under the status quo is as follows:

```
env_cost <- mec_gallon*Q_star
returnValue(env_cost)
```

```
## [1] 318935.3
```

The environmental cost is equal to $318,935.30.

3. Consumer benefit between high and low income consumers

Just looking at the graph in part 2, we can see that the lower income group holds a smaller share of consumer benefit than the higher income group.

```
CS_p(3, high_demand_model)
```

```
## [1] 3001322
```

```
CS_p(3, low_demand_model)
```

```
## [1] 570508.5
```

These computed values show us that the lower income group has approximately $ 2430813.0362964 less consumer surplus than the higher income group.