Assignment 3

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b. Run a multinomial logit model with installation cost, operating cost, and no intercepts.

```
library(mlogit)
data("Heating", package = "mlogit")
H <- dfidx(Heating, choice = "depvar", varying = c(3:12))
reg1 <- mlogit(depvar ~ ic + oc | 0, H)
summary(reg1)
```

```
##
## Call:
## mlogit(formula = depvar ~ ic + oc | 0, data = H, method = "nr")
##
## Frequencies of alternatives:choice
##       ec       er       gc       gr       hp
## 0.071111 0.093333 0.636667 0.143333 0.055556
##
## nr method
## 4 iterations, 0h:0m:0s
## g'(-H)^-1g = 1.56E-07
## gradient close to zero
##
## Coefficients :
##       Estimate  Std. Error z-value  Pr(>|z|)
## ic -0.00623187  0.00035277 -17.665 < 2.2e-16 ***
## oc -0.00458008  0.00032216 -14.217 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log-Likelihood: -1095.2
```

Discuss the coefficients and their signs.

The coefficients are negative as expected, meaning that as the cost of a system rises (and the costs of the other systems remain the same) the probability of that system being chosen falls. Their t-statistics are greater than 1.96, which is the critical level for 95% confidence level and hence, the coefficients significantly different from zero

c. How closely do the average probabilities match the shares of customers choosing each alternative?

```
apply(fitted(reg1, outcome = FALSE), 2, mean)
```

```
##         ec         er         gc         gr         hp
## 0.10413057 0.05141477 0.51695653 0.24030898 0.08718915
```

Not very well. 63.67% of the sample chose gc (as shown at the top of the summary) and yet the estimated model gives an average probability of only 51.695%. The other alternatives are also fairly poorly predicted. We will find how to fix this problem in one of the models below.

d. Define the willingness to pay (WTP) as the ratio of the operating cost coefficient to the installation cost coefficient. This measure indicates the willingness to pay for a higher installation cost in order to reduce operating costs by one dollar. Calculate and discuss the estimated WTP for this model.

```
wtp1 <- coef(reg1)["oc"]/coef(reg1)["ic"]
wtp1
```

```
##        oc
## 0.7349453
```

The model implies that the decision-maker is willing to pay $0.73 (ie., 73 cents) in higher installation cost in order to reduce annual operating costs by $1.

A $1 reduction in annual operating costs recurs each year. It is unreasonable to think that the decision-maker is only willing to pay only 73 cents as a one-time payment in return for a $1/year stream of saving. This unreasonable implication is another reason (along with the inaccurate average probabilities) to believe this model is not so good.

e. Add alternative-specific constants to the model (normalize the constant for hp to zero in this case). Compare the estimated probabilities to the observed shares for each alternative.

```
reg2 <- mlogit(depvar ~ ic + oc, H, reflevel = 'hp')
summary(reg2)
```

```
##
## Call:
## mlogit(formula = depvar ~ ic + oc, data = H, reflevel = "hp",
##     method = "nr")
##
## Frequencies of alternatives:choice
##       hp       ec       er       gc       gr
## 0.055556 0.071111 0.093333 0.636667 0.143333
##
## nr method
## 6 iterations, 0h:0m:0s
## g'(-H)^-1g = 9.58E-06
## successive function values within tolerance limits
##
## Coefficients :
##                   Estimate  Std. Error z-value  Pr(>|z|)
## (Intercept):ec  1.65884594  0.44841936  3.6993 0.0002162 ***
## (Intercept):er  1.85343697  0.36195509  5.1206 3.045e-07 ***
```

```
## (Intercept):gc  1.71097930  0.22674214  7.5459 4.485e-14 ***
## (Intercept):gr  0.30826328  0.20659222  1.4921 0.1356640
## ic             -0.00153315  0.00062086 -2.4694 0.0135333 *
## oc             -0.00699637  0.00155408 -4.5019 6.734e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log-Likelihood: -1008.2
## McFadden R^2:  0.013691
## Likelihood ratio test : chisq = 27.99 (p.value = 8.3572e-07)
```

```
apply(fitted(reg2, outcome = FALSE), 2, mean)
```

```
##         hp         ec         er         gc         gr
## 0.05555556 0.07111111 0.09333333 0.63666667 0.14333333
```

This time the probabilities match exactly: alternative-specific constants in a logit model insure that the average probabilities equal the observed shares.

f. What is the WTP now? Does it seem reasonable?

```
wtp2 <- coef(reg2)["oc"] / coef(reg2)["ic"]
wtp2
```

```
##       oc
## 4.563385
```

The decision-maker is willing to pay $4.56 for a $1 year stream of savings. This result is certainly more reasonable than the previous model.