Assignment 2: Multinomial Choices

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Exercise 1 Data Description

```
## [1] "Average and dispersion in product characteristics (price):"
```

```
##       hhid             choice          PPk_Stk          PBB_Stk
##  Min.   :2100016   Min.   : 1.000   Min.   :0.1900   Min.   :0.1900
##  1st Qu.:2114017   1st Qu.: 1.000   1st Qu.:0.5000   1st Qu.:0.5000
##  Median :2125864   Median : 2.000   Median :0.5800   Median :0.5800
##  Mean   :2125756   Mean   : 3.243   Mean   :0.5184   Mean   :0.5432
##  3rd Qu.:2136937   3rd Qu.: 5.000   3rd Qu.:0.6200   3rd Qu.:0.6100
##  Max.   :2157248   Max.   :10.000   Max.   :0.6700   Max.   :1.0100
##     PFl_Stk         PHse_Stk         PGen_Stk         PImp_Stk
##  Min.   :0.950   Min.   :0.1900   Min.   :0.2500   Min.   :0.3300
##  1st Qu.:0.990   1st Qu.:0.2900   1st Qu.:0.3300   1st Qu.:0.7200
##  Median :0.990   Median :0.4500   Median :0.3300   Median :0.7500
##  Mean   :1.015   Mean   :0.4371   Mean   :0.3453   Mean   :0.7808
##  3rd Qu.:1.080   3rd Qu.:0.5700   3rd Qu.:0.3600   3rd Qu.:0.8800
##  Max.   :1.160   Max.   :0.6400   Max.   :0.5500   Max.   :2.3000
##     PSS_Tub          PPk_Tub         PFl_Tub         PHse_Tub
##  Min.   :0.5000   Min.   :0.980   Min.   :0.690   Min.   :0.3300
##  1st Qu.:0.8000   1st Qu.:1.070   1st Qu.:1.190   1st Qu.:0.5600
##  Median :0.8500   Median :1.090   Median :1.190   Median :0.5900
##  Mean   :0.8251   Mean   :1.077   Mean   :1.189   Mean   :0.5687
##  3rd Qu.:0.8500   3rd Qu.:1.090   3rd Qu.:1.190   3rd Qu.:0.5900
##  Max.   :0.9800   Max.   :1.240   Max.   :1.470   Max.   :1.2700
```

```
##       PPk_Stk   PBB_Stk    PFl_Stk  PHse_Stk   PGen_Stk  PImp_Stk    PSS_Tub
## avg 0.5184362 0.5432103 1.01502013 0.4371477 0.34528188 0.7807785 0.82508949
## sd  0.1505174 0.1203319 0.04289519 0.1188312 0.03516605 0.1146461 0.06121159
##        PPk_Tub    PFl_Tub  PHse_Tub
## avg 1.07740940 1.18937584 0.5686734
## sd  0.02972613 0.01405451 0.0724550
```

```
## [1] "Market share (choice frequency):"
```

```
##
##    1    2    3    4    5    6    7    8    9   10
## 1766  699  243  593  315   74  319  203  225   33
```

```
## [1] "Market share by product characteristics:"
```

```
##           PPk_Stk PBB_Stk PFl_Stk PHse_Stk PGen_Stk PImp_Stk PSS_Tub PPk_Tub
## above avg    3015    2868    1169     2917     1285     1244    3345    2629
## below avg    1455    1602    3301     1553     3185     3226    1125    1841
##           PFl_Tub PHse_Tub
## above avg    4133     3210
## below avg     337     1260
```

```
## [1] "Mapping between observed attributes and choices:"
```

```
##          Income Fs3_4  Fs5. Fam_Size college whtcollar retired
## PPk_Stk  26.713 0.511 0.137    3.175   0.318     0.570   0.199
## PBB_Stk  26.066 0.515 0.112    3.102   0.313     0.544   0.240
## PFl_Stk  30.710 0.255 0.082    2.481   0.453     0.543   0.531
## PHse_Stk 27.643 0.503 0.199    3.470   0.293     0.592   0.153
## PGen_Stk 26.444 0.594 0.200    3.692   0.273     0.714   0.146
## PImp_Stk 39.155 0.243 0.311    3.176   0.432     0.568   0.378
## PSS_Tub  25.321 0.492 0.063    2.890   0.323     0.577   0.147
## PPk_Tub  34.249 0.601 0.054    3.094   0.256     0.571   0.099
## PFl_Tub  31.900 0.302 0.049    2.387   0.276     0.578   0.360
## PHse_Tub 29.470 0.364 0.545    4.424   0.455     0.939   0.121
```

```
##           PPk_Stk PBB_Stk PFl_Stk PHse_Stk PGen_Stk PImp_Stk PSS_Tub PPk_Tub
## college     0.397   0.155   0.078    0.123    0.061    0.023   0.073   0.037
## whtcollar   0.388   0.146   0.051    0.135    0.087    0.016   0.071   0.045
## retired     0.364   0.174   0.134    0.094    0.048    0.029   0.049   0.021
##           PFl_Tub PHse_Tub
## college     0.044    0.011
## whtcollar   0.050    0.012
## retired     0.084    0.004
```

From the above statistics (distribution of choice by demo), we know that: on average

A) By choice:

1) Except for PFl_Stk, younger and lower educated people are the dominant buyer;
2) People with higher income (above 30) tend to buy PImp_Stk, PPk_Tub PFl_Tub and PFl_Stk;
3) larger family size buyers dominate the choice PHse_Tub.

B) By demo:

4) among higher educated people, PPk_Stk is the most preferred choice and PHse_Tub is the least preferred choice (only 1.1% would buy);
5) among the white collars, PPk_Stk is also the most preferred choice and PHse_Tub is also the least preferred choice (only 1.2% would buy);
6) among the retired, PPk_Stk is also the most preferred choice and PHse_Tub is also the least preferred choice (only 0.4% would buy).

Exercise 2 First Model

In order to characterize the relationship between price and demand, we need to use the conditional logit model. This is because we do not need the variation of individual characteristics.

```
## initial  value 11230.437489
## final  value 9402.409352
## converged
```

```
## [1] "The coefficients for the first model:"
```

```
##           cons    price
## [1,] 0.9219114 -2.43062
```

In this model, the coefficient on price is same among all choices. -2.43 means that higher price will decrease the utility of choosing any of the choices.

Exercise 3 Second Model

Since family income is an individual related variable, it is alternative-invariant. Therefore, we use multinomial logit model to characterize the effect of family income on demand.

```
## initial  value 45137.457045
## iter  10 value 33739.354362
## iter  20 value 27741.315723
## iter  30 value 19803.188830
## iter  40 value 13695.326771
## iter  50 value 12316.929006
## iter  60 value 10365.887686
## iter  70 value 9528.392223
## iter  80 value 8987.429964
## iter  90 value 8753.739239
## iter 100 value 8641.814613
## final  value 8641.814613
## stopped after 100 iterations
```

```
## [1] "The coefficients for the second model:"
```

```
##                cons    Income   Fam_Size       college   whtcollar    retired
## PPk_Stk   2.5852239 -3.936913 0.64416069  0.6603363255  0.06257552  0.2755391
## PBB_Stk   2.1127311 -3.940036 0.54660462  0.5918770369 -0.06108287  0.1418831
## PFl_Stk  -1.4554080 -3.912397 0.41646352  1.3614134402  1.32331625  2.8887220
## PHse_Stk  0.6483031 -3.930779 0.87329620  0.3919796344 -0.11906653  0.2301030
## PGen_Stk -0.8517499 -3.945087 1.00176657  0.1261172750  1.00172956  1.0894824
## PImp_Stk  0.5800658 -4.617164 0.05158610 -0.0664694070  0.22995982  0.1614845
## PSS_Tub   1.8573550 -3.938778 0.38420379  0.6561485249 -0.11947142 -0.3769179
## PPk_Tub   1.0542478 -3.910859 0.30637327  0.0003944446 -0.36228994 -0.6607740
## PFl_Tub   0.8589052 -3.906556 0.02187428  0.1274802121  0.66613847  0.9698717
## PHse_Tub -2.7880233 -3.974347 0.96038557  0.8630973858  1.42441335  1.1077531
```

The coefficients of family income is in the second column. We can know that higher family income could increase each choice's utility.

Exercise 4 Marginal Effects

```
## [1] "marginal effect of model1"
```

```
## [1] "parameter 1"
```

```
##              PPk_Stk     PBB_Stk     PFl_Stk    PHse_Stk    PGen_Stk
## PPk_Stk   0.12143903 -0.02212937 -0.01615454 -0.02355517 -0.02479417
## PBB_Stk  -0.02212937  0.11997161 -0.01591584 -0.02320711 -0.02442781
## PFl_Stk  -0.01615454 -0.01591584  0.09187703 -0.01694130 -0.01783241
## PHse_Stk -0.02355517 -0.02320711 -0.01694130  0.12620617 -0.02600170
## PGen_Stk -0.02479417 -0.02442781 -0.01783241 -0.02600170  0.13147692
## PImp_Stk -0.01901902 -0.01873799 -0.01367882 -0.01994528 -0.02099440
## PSS_Tub  -0.01845900 -0.01818624 -0.01327604 -0.01935798 -0.02037621
## PPk_Tub  -0.01543545 -0.01520737 -0.01110145 -0.01618719 -0.01703863
## PFl_Tub  -0.01419634 -0.01398657 -0.01021026 -0.01488773 -0.01567082
## PHse_Tub -0.02178929 -0.02146732 -0.01567125 -0.02285047 -0.02405240
##              PImp_Stk     PSS_Tub      PPk_Tub      PFl_Tub    PHse_Tub
## PPk_Stk  -0.01901902 -0.01845900 -0.015435451 -0.014196339 -0.02178929
## PBB_Stk  -0.01873799 -0.01818624 -0.015207373 -0.013986571 -0.02146732
## PFl_Stk  -0.01367882 -0.01327604 -0.011101453 -0.010210261 -0.01567125
## PHse_Stk -0.01994528 -0.01935798 -0.016187187 -0.014887728 -0.02285047
```

```
## PGen_Stk -0.02099440 -0.02037621 -0.017038633 -0.015670822 -0.02405240
## PImp_Stk  0.10574290 -0.01563011 -0.013069928 -0.012020714 -0.01845002
## PSS_Tub  -0.01563011  0.10308950 -0.012685080 -0.011666760 -0.01790676
## PPk_Tub  -0.01306993 -0.01268508  0.088281446 -0.009755769 -0.01497367
## PFl_Tub  -0.01202071 -0.01166676 -0.009755769  0.081977640 -0.01377163
## PHse_Tub -0.01845002 -0.01790676 -0.014973667 -0.013771626  0.11845780
```

```
## [1] "parameter 2"
```

```
##              PPk_Stk     PBB_Stk     PFl_Stk    PHse_Stk    PGen_Stk
## PPk_Stk  -0.32017414  0.05834411  0.04259147  0.06210323  0.06536986
## PBB_Stk   0.05834411 -0.31630529  0.04196213  0.06118558  0.06440394
## PFl_Stk   0.04259147  0.04196213 -0.24223390  0.04466576  0.04701517
## PHse_Stk  0.06210323  0.06118558  0.04466576 -0.33274269  0.06855350
## PGen_Stk  0.06536986  0.06440394  0.04701517  0.06855350 -0.34663904
## PImp_Stk  0.05014366  0.04940273  0.03606422  0.05258575  0.05535176
## PSS_Tub   0.04866716  0.04794805  0.03500229  0.05103735  0.05372191
## PPk_Tub   0.04069558  0.04009426  0.02926899  0.04267754  0.04492237
## PFl_Tub   0.03742866  0.03687561  0.02691937  0.03925151  0.04131614
## PHse_Tub  0.05744748  0.05659863  0.04131726  0.06024528  0.06341419
##              PImp_Stk     PSS_Tub     PPk_Tub     PFl_Tub    PHse_Tub
## PPk_Stk   0.05014366  0.04866716  0.04069558  0.03742866  0.05744748
## PBB_Stk   0.04940273  0.04794805  0.04009426  0.03687561  0.05659863
## PFl_Stk   0.03606422  0.03500229  0.02926899  0.02691937  0.04131726
## PHse_Stk  0.05258575  0.05103735  0.04267754  0.03925151  0.06024528
## PGen_Stk  0.05535176  0.05372191  0.04492237  0.04131614  0.06341419
## PImp_Stk -0.27879127  0.04120879  0.03445888  0.03169262  0.04864351
## PSS_Tub   0.04120879 -0.27179558  0.03344423  0.03075943  0.04721118
## PPk_Tub   0.03445888  0.03344423 -0.23275413  0.02572110  0.03947809
## PFl_Tub   0.03169262  0.03075943  0.02572110 -0.21613414  0.03630891
## PHse_Tub  0.04864351  0.04721118  0.03947809  0.03630891 -0.31231413
```

```
## [1] "marginal effect of model2"
```

```
##                    cons        Income     Fam_Size       college     whtcollar
## PPk_Stk   1.773701e-45 -2.701084e-45 4.419534e-46  4.530513e-46  4.293255e-47
## PBB_Stk   5.395339e-46 -1.006178e-45 1.395879e-46  1.511492e-46 -1.559890e-47
## PFl_Stk  -7.721405e-47 -2.075652e-46 2.209472e-47  7.222734e-47  7.020616e-47
## PHse_Stk  1.278923e-46 -7.754339e-46 1.722772e-46  7.732673e-47 -2.348853e-47
## PGen_Stk -8.028537e-47 -3.718612e-46 9.442584e-47  1.188773e-47  9.442235e-47
## PImp_Stk  4.765811e-56 -3.793454e-55 4.238305e-57 -5.461115e-57  1.889346e-56
## PSS_Tub   2.012416e-46 -4.267607e-46 4.162791e-47  7.109271e-47 -1.294455e-47
## PPk_Tub   5.754596e-47 -2.134737e-46 1.672334e-47  2.153070e-50 -1.977554e-47
## PFl_Tub   4.776835e-47 -2.172646e-46 1.216547e-48  7.089862e-48  3.704755e-47
## PHse_Tub -2.400347e-47 -3.421711e-47 8.268433e-48  7.430831e-48  1.226348e-47
##                 retired
## PPk_Stk   1.890451e-46
## PBB_Stk   3.623306e-47
## PFl_Stk   1.532559e-46
## PHse_Stk  4.539295e-47
## PGen_Stk  1.026939e-46
## PImp_Stk  1.326754e-56
## PSS_Tub  -4.083849e-47
## PPk_Tub  -3.606825e-47
## PFl_Tub   5.393980e-47
## PHse_Tub  9.537193e-48
```

Exercise 5 IIA

```
## [1] "Estimated coefficients for mixed logit model"
```

```
##                 cons      Income    Fam_Size    college  whtcollar     retired
## PPk_Stk   0.56429017   2.9722324  0.99475662 0.80555584 0.52436949  0.56925366
## PBB_Stk  -0.29965659   2.9699422  0.97039136 0.82489214 0.47450956  0.79593336
## PFl_Stk  -0.81946634 -18.8507170 -2.75353389 0.31680626 0.11356037  0.02925765
## PHse_Stk -1.75744335   2.9737315  1.15945160 0.55814138 0.59471055  0.52004069
## PGen_Stk -3.64323679   2.9648081  1.28471962 0.41002595 1.22164746  0.88755444
## PImp_Stk -0.04117762   1.1187555  0.44312814 0.08450822 0.57160553  0.68662047
## PSS_Tub   2.07703547   2.9668990  0.72880049 0.83934126 0.43001153 -0.08122946
## PPk_Tub   2.73383993   3.0008974  0.73520514 0.34714357 0.07800989 -0.31625857
## PFl_Tub   3.95365111   3.0040252  0.29518016 0.48206651 0.82066425  1.30965157
## PHse_Tub  0.48808757   0.4508178  0.04320738 0.04471320 0.64158681  0.76434032
##             price
## PPk_Stk  -7.14027
## PBB_Stk  -7.14027
## PFl_Stk  -7.14027
## PHse_Stk -7.14027
## PGen_Stk -7.14027
## PImp_Stk -7.14027
## PSS_Tub  -7.14027
## PPk_Tub  -7.14027
## PFl_Tub  -7.14027
## PHse_Tub -7.14027
```

```
## [1] "Estimated coefficients for the second mixed logit model"
```

```
##                cons       Income    Fam_Size      college   whtcollar
## PPk_Stk   44.390915  1292.951016  142.267354  14.71182413  27.4518283
## PBB_Stk   12.498433   184.089742   32.944212   3.03201022   7.2274607
## PFl_Stk   -3.456644    -5.839029   -6.980301   0.07340074  -1.2849441
## PHse_Stk  17.809710   540.888106   68.118503   5.78581374  11.6275459
## PGen_Stk   3.330967    32.432134    8.920396   1.19857197   1.5894625
## PImp_Stk -80.560278 -2167.733891 -261.382444 -24.60367875 -47.4737347
## PSS_Tub    4.969103    58.775689   11.587204   2.39225026   2.5971240
## PPk_Tub    2.695812    36.604902    5.383885   0.41116728   1.1217390
## PFl_Tub    3.541112    33.229504    4.631714   0.75410977   0.9440687
##              retired     price
## PPk_Stk    8.4030055 -27.25613
## PBB_Stk    3.6646725 -27.25613
## PFl_Stk    0.7869891 -27.25613
## PHse_Stk   1.9295075 -27.25613
## PGen_Stk   1.1799801 -27.25613
## PImp_Stk -15.9535454 -27.25613
## PSS_Tub    2.4176099 -27.25613
## PPk_Tub    0.6074413 -27.25613
## PFl_Tub    2.5526433 -27.25613
```

```
## [1] "At 95% statistical level, the critical value is 38.9580265267851 and the MTT is  -54020.4098630
```

```
## [1] "Therefore, the model satisfies IIA assumption."
```