Consumer WTP for Carbon Offsets

Choice Probaility by Information Treatment

```
## `summarise()` has grouped output by 'framing_effect', 'scenario'. You can
## override using the `.groups` argument.
```

```
## # A tibble: 10 x 5
## # Groups:   scenario [10]
##    scenario MetOffice     UN baseline consequence
##       <int>     <dbl>  <dbl>    <dbl>       <dbl>
##  1        1    0.0772 0.0603   0.0698      0.0742
##  2        2    0.0713 0.0545   0.0601      0.0742
##  3        3    0.0693 0.0564   0.0698      0.0781
##  4        4    0.0594 0.0486   0.0504      0.0840
##  5        5    0.0624 0.0564   0.0620      0.0781
##  6        6    0.0782 0.0681   0.0659      0.0723
##  7        7    0.0693 0.0661   0.0678      0.0840
##  8        8    0.0624 0.0700   0.0620      0.0723
##  9        9    0.0663 0.0467   0.0562      0.0684
## 10       10    0.0574 0.0506   0.0620      0.0801
```

The above table presents the choice probability of the opt-out option being the best option by information treatment. The probability differences between different information treatments does not appear to be large. Evan when the probaiblity of selecting opt out is larger with consequence framing, the difference at about 0.01 percentage points.

Summary of PCA

for Q9

Factor loadings for Q9:

```
## Standard deviations (1, .., p=15):
##  [1] 2.4449246 1.8707724 0.8688969 0.8126817 0.7717738 0.7367027 0.6726539
##  [8] 0.6458357 0.6225510 0.6218641 0.5661055 0.5478628 0.4985988 0.4942617
## [15] 0.4597596
##
## Rotation (n x k) = (15 x 15):
##               PC1         PC2         PC3          PC4         PC5          PC6
## Q9_1  -0.28055790  0.08969099 -0.01809095  0.465105846  0.51736702 -0.391487380
## Q9_2  -0.30165609  0.06243437 -0.10447931  0.149123245 -0.23976862 -0.633688311
## Q9_3  -0.25534486  0.09965919 -0.38960705  0.641873715 -0.24371138  0.487245142
## Q9_4  -0.29517817  0.08744077  0.11523794 -0.129574023  0.60172841  0.175649519
```

```
## Q9_5   -0.34338927 0.10756369 -0.04558215 -0.216140393 -0.09240375  0.075432130
## Q9_6   -0.32765725 0.13341929  0.05339357 -0.307194312 -0.07027835 -0.033500916
## Q9_7   -0.32313276 0.14438537 -0.09702601 -0.197636025 -0.35408946 -0.108806247
## Q9_8   -0.32109315 0.13885569 -0.06691886 -0.167509966  0.12766305  0.246003811
## Q9_9   -0.31698934 0.13629589  0.03659775 -0.168437063 -0.06257662  0.104621120
## Q9_10 -0.05207092 0.32532352  0.79583861  0.278754931 -0.18758423  0.170994200
## Q9_11  0.13201110 0.39330701  0.19513463  0.058173856 -0.04648334 -0.164470230
## Q9_12  0.15527865 0.39005636 -0.13350031 -0.004979848 -0.12122042 -0.157379077
## Q9_13  0.15097224 0.41115573 -0.21287112 -0.030238104  0.15830757  0.008792343
## Q9_14  0.19498997 0.39490021 -0.16733819 -0.068710882  0.12661099  0.056474782
## Q9_15  0.19905515 0.38044631 -0.20235622 -0.096555857  0.03413161  0.049771980
##              PC7           PC8          PC9         PC10          PC11
## Q9_1    0.30600170 -0.364141155  0.09499251 -0.17099886 -0.046270325
## Q9_2   -0.09093742  0.568195464 -0.18730801  0.12902158  0.149283271
## Q9_3   -0.20166199 -0.000446123 -0.05026494 -0.01202977  0.006464309
## Q9_4   -0.52428739  0.320105704 -0.04109848  0.04828097 -0.263000358
## Q9_5   -0.05989655 -0.117864172 -0.12898073 -0.24114062 -0.161168202
## Q9_6   -0.10940430 -0.158723003  0.12650254 -0.40527713  0.296833851
## Q9_7   -0.03680158 -0.238665332 -0.02268343 -0.18526720 -0.277665005
## Q9_8    0.22057898  0.073073913  0.22851066  0.27064837  0.673824843
## Q9_9    0.42159352 -0.065495041 -0.11366383  0.59286695 -0.399578636
## Q9_10   0.16084983  0.219072722  0.06352699 -0.17351881 -0.028797163
## Q9_11  -0.44746529 -0.481320939 -0.33850675  0.37578837  0.240881406
## Q9_12  -0.19488636  0.018588709  0.77030072  0.12263453 -0.203512537
## Q9_13   0.11777418  0.116921542  0.03148230  0.02520948 -0.027020537
## Q9_14   0.14575234  0.060335128 -0.28453726 -0.18123943  0.016416713
## Q9_15   0.20012005  0.197718389 -0.24381991 -0.22433203 -0.014356284
##             PC12          PC13        PC14         PC15
## Q9_1    0.073959534  0.004850394 -0.03400913 -0.04868215
## Q9_2   -0.012465223 -0.036640130 -0.02273799  0.07586218
## Q9_3    0.012794469 -0.094540477  0.10227418  0.03641470
## Q9_4    0.082998576  0.102227821  0.10281705 -0.06148196
## Q9_5   -0.141995619 -0.220146631 -0.78114317  0.10217376
## Q9_6   -0.035272983 -0.458210195  0.48048566  0.15481320
## Q9_7    0.001066073  0.643258239  0.19542458 -0.25849760
## Q9_8    0.093130890  0.289081548 -0.18050518 -0.09969326
## Q9_9    0.076586110 -0.270051422  0.19351380  0.11842329
## Q9_10  -0.046216945  0.064318958 -0.02519886 -0.01468974
## Q9_11   0.026520867 -0.049810662 -0.04571043 -0.07882435
## Q9_12   0.215115088 -0.073956449 -0.12117409  0.10891120
## Q9_13  -0.820675102 -0.012164001  0.09103065 -0.15795875
## Q9_14   0.182198317  0.287118068  0.04539293  0.70528961
## Q9_15   0.442218904 -0.236378965 -0.01639274 -0.56648333
```

Importance of components:

```
## Importance of components:
##                          PC1    PC2     PC3     PC4     PC5     PC6     PC7
## Standard deviation     2.4449 1.8708 0.86890 0.81268 0.77177 0.73670 0.67265
## Proportion of Variance 0.3985 0.2333 0.05033 0.04403 0.03971 0.03618 0.03016
## Cumulative Proportion  0.3985 0.6318 0.68216 0.72619 0.76590 0.80208 0.83225
##                           PC8     PC9    PC10    PC11    PC12    PC13    PC14
## Standard deviation     0.64584 0.62255 0.62186 0.56611 0.54786 0.49860 0.49426
## Proportion of Variance 0.02781 0.02584 0.02578 0.02137 0.02001 0.01657 0.01629
```

```
## Cumulative Proportion  0.86005 0.88589 0.91167 0.93304 0.95305 0.96962 0.98591
##                                PC15
## Standard deviation      0.45976
## Proportion of Variance 0.01409
## Cumulative Proportion  1.00000
```

for Q10

Factor loadings for Q10:

```
## Standard deviations (1, .., p=13):
##  [1] 3.0450201 0.8133522 0.6909953 0.6552695 0.6336439 0.5355692 0.5154163
##  [8] 0.4956216 0.4868869 0.4713560 0.4280445 0.4228192 0.3722779
##
## Rotation (n x k) = (13 x 13):
##               PC1          PC2         PC3          PC4          PC5          PC6
## Q10_1   0.2390361  0.699421565  0.07516256  0.09251933 -0.46544205  0.08653526
## Q10_2   0.2707082  0.465197906  0.07375957 -0.15583464  0.02421393 -0.27794445
## Q10_3   0.2745820  0.200535143  0.01159933 -0.39953268  0.53671993 -0.08686160
## Q10_4   0.2886799  0.004467465 -0.03767438 -0.25207699  0.38020008  0.19102908
## Q10_5   0.2655558  0.087559382 -0.59124583  0.35370410  0.18850290  0.51873708
## Q10_6   0.2832510 -0.120810474 -0.37585763  0.08093827 -0.08456392 -0.26214102
## Q10_7   0.2829975 -0.255275900 -0.17374929 -0.19373162 -0.16106438 -0.42547667
## Q10_8   0.2812398 -0.184794951 -0.28440972  0.04259160 -0.27827343 -0.21999799
## Q10_9   0.2889450 -0.122221900  0.18379364  0.12084258  0.09842844 -0.12963826
## Q10_10 0.2600478 -0.032261266  0.38318345  0.72239962  0.28816650 -0.23228115
## Q10_11 0.2909976 -0.198363004  0.30746045 -0.13504967 -0.13551275  0.26037770
## Q10_12 0.2906152 -0.206234882  0.31714171 -0.09595646 -0.14719757  0.32221894
## Q10_13 0.2840109 -0.186358836  0.09857721 -0.09525121 -0.26708769  0.24820092
##               PC7          PC8          PC9         PC10          PC11
## Q10_1   -0.13298826  0.31618566 -0.134622560  0.27564788 -0.05850282
## Q10_2    0.16164825 -0.51513390  0.366503161 -0.38222722  0.12660976
## Q10_3    0.03031972  0.16509997 -0.384077518 -0.09734531 -0.29831017
## Q10_4   -0.20866184  0.22223398  0.092914335  0.21791106  0.58341664
## Q10_5   -0.05375803 -0.14104966  0.132213997 -0.11841717 -0.28800562
## Q10_6    0.51487982  0.16267651  0.213439468  0.31391936  0.26580148
## Q10_7   -0.22497287  0.33118235  0.287591106 -0.07948103 -0.46108164
## Q10_8   -0.47604436 -0.26455928 -0.456503957 -0.18966292  0.32200370
## Q10_9    0.11671740 -0.48938556 -0.244114996  0.61058376 -0.25358993
## Q10_10 -0.05259386  0.25351118  0.004264633 -0.22794495  0.07931562
## Q10_11 -0.10564149 -0.03707151  0.327672655  0.04347687  0.01446710
## Q10_12 -0.14878911 -0.09003989  0.156674014 -0.01394474 -0.09552083
## Q10_13  0.56286352  0.13688723 -0.381753451 -0.37315666  0.03702411
##               PC12         PC13
## Q10_1   -0.008778289 -0.008571299
## Q10_2   -0.112789275  0.045572740
## Q10_3    0.389909642 -0.053186685
## Q10_4   -0.418594895  0.077426853
## Q10_5   -0.057724302 -0.044117054
## Q10_6    0.409585403  0.086066627
## Q10_7   -0.342425891  0.029691237
## Q10_8    0.173481472 -0.058795814
## Q10_9   -0.275155286 -0.033929715
```

```
## Q10_10  0.017885707 -0.005207989
## Q10_11  0.267885105 -0.695180660
## Q10_12  0.290907181  0.699280707
## Q10_13 -0.330283135 -0.043423673
```

Importance of components:

```
## Importance of components:
##                            PC1     PC2     PC3     PC4     PC5     PC6     PC7
## Standard deviation      3.0450 0.81335 0.69100 0.65527 0.63364 0.53557 0.51542
## Proportion of Variance  0.7132 0.05089 0.03673 0.03303 0.03088 0.02206 0.02043
## Cumulative Proportion   0.7132 0.76413 0.80086 0.83389 0.86477 0.88684 0.90727
##                            PC8     PC9    PC10    PC11    PC12    PC13
## Standard deviation      0.4956 0.48689 0.47136 0.42804 0.42282 0.37228
## Proportion of Variance  0.0189 0.01824 0.01709 0.01409 0.01375 0.01066
## Cumulative Proportion   0.9262 0.94440 0.96149 0.97559 0.98934 1.00000
```

Basic Logit Model

Basic Logit Model Coefficients

```
##
## Model estimated on: Tue Oct 01 04:19:55 AM 2024
##
## Call:
## gmnl(formula = f, data = dt, model = "mnl", method = "nr")
##
## Frequencies of categories:
##
##        1        2        3        4        5        6
## 0.192868 0.272962 0.158307 0.243260 0.060815 0.071787
##
## The estimation took: 0h:0m:8s
##
## Coefficients:
##                    Estimate Std. Error  z-value  Pr(>|z|)
## I                 -0.9858758  0.0355302 -27.7476 < 2.2e-16 ***
## price             -0.0318596  0.0018653 -17.0803 < 2.2e-16 ***
## location_EU       -0.0193157  0.0179737  -1.0747    0.2825
## location_UK        0.1726739  0.0178102   9.6952 < 2.2e-16 ***
## certificate_NGO    0.0993108  0.0182718   5.4352 5.474e-08 ***
## certificate_UK     0.3372772  0.0185896  18.1433 < 2.2e-16 ***
## project_renewable  0.1324178  0.0209696   6.3148 2.706e-10 ***
## project_landfill  -0.2605849  0.0230259 -11.3170 < 2.2e-16 ***
## project_manure    -0.1361997  0.0209358  -6.5056 7.740e-11 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Optimization of log-likelihood by Newton-Raphson maximisation
## Log Likelihood: -20883
## Number of observations: 12760
## Number of iterations: 4
## Exit of MLE: gradient close to zero (gradtol)
```

Basic Logit Model Willingness to Pay

```
##
## Willigness-to-pay respect to:  price
##
##                   Estimate Std. Error  t-value  Pr(>|t|)
## I                 -30.94442    2.76300 -11.1996 < 2.2e-16 ***
## location_EU        -0.60628    0.56778  -1.0678    0.2856
## location_UK         5.41985    0.64571   8.3936 < 2.2e-16 ***
## certificate_NGO     3.11714    0.60496   5.1526 2.569e-07 ***
## certificate_UK     10.58637    0.94537  11.1981 < 2.2e-16 ***
## project_renewable   4.15630    0.68590   6.0597 1.364e-09 ***
## project_landfill   -8.17917    0.89143  -9.1753 < 2.2e-16 ***
## project_manure     -4.27500    0.66996  -6.3809 1.760e-10 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Mixed Logit Model

Mixed Logit Model Coefficients

```
##
## Model estimated on: Tue Oct 01 04:19:55 AM 2024
##
## Call:
## gmnl(formula = f, data = dt, model = "mixl", ranp = randpar,
##     R = 2000, haltons = NA, panel = T, method = "bhhh", iterlim = 5000)
##
## Frequencies of categories:
##
##        1        2        3        4        5        6
## 0.192868 0.272962 0.158307 0.243260 0.060815 0.071787
##
## The estimation took: 0h:9m:16s
##
## Coefficients:
##                       Estimate Std. Error  z-value  Pr(>|z|)
## I                    -1.4857544  0.0473657 -31.3677 < 2.2e-16 ***
## price                -0.0545757  0.0026568 -20.5420 < 2.2e-16 ***
## location_EU           0.0284154  0.0264183   1.0756    0.2821
## location_UK           0.3646805  0.0256519  14.2165 < 2.2e-16 ***
## certificate_NGO       0.1994266  0.0252803   7.8886 3.109e-15 ***
## certificate_UK        0.6780877  0.0294640  23.0141 < 2.2e-16 ***
## project_renewable     0.3256955  0.0301148  10.8151 < 2.2e-16 ***
## project_landfill     -0.3924930  0.0319928 -12.2682 < 2.2e-16 ***
## project_manure       -0.1786808  0.0286841  -6.2293 4.686e-10 ***
## sd.location_EU        0.9962610  0.0365881  27.2291 < 2.2e-16 ***
## sd.location_UK        1.0581997  0.0354755  29.8291 < 2.2e-16 ***
## sd.certificate_NGO    0.9540021  0.0373045  25.5734 < 2.2e-16 ***
## sd.certificate_UK     0.9802209  0.0376732  26.0191 < 2.2e-16 ***
## sd.project_renewable  1.0999047  0.0417274  26.3593 < 2.2e-16 ***
## sd.project_landfill   0.8566907  0.0454703  18.8407 < 2.2e-16 ***
```

```
## sd.project_manure      1.0135622  0.0398894  25.4093 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Optimization of log-likelihood by BHHH maximisation
## Log Likelihood: -19140
## Number of observations: 12760
## Number of iterations: 15
## Exit of MLE: successive function values within relative tolerance limit (reltol)
## Simulation based on 2000 draws
```

Mixed Logit Model Willingness to Pay

```
##
## Willigness-to-pay respect to:  price
##
##                     Estimate Std. Error  t-value  Pr(>|t|)
## I                   -27.22371    2.09822 -12.9747 < 2.2e-16 ***
## location_EU           0.52066    0.48327   1.0774    0.2813
## location_UK           6.68210    0.61056  10.9441 < 2.2e-16 ***
## certificate_NGO       3.65413    0.51049   7.1581 8.180e-13 ***
## certificate_UK       12.42471    0.90650  13.7062 < 2.2e-16 ***
## project_renewable     5.96777    0.61968   9.6304 < 2.2e-16 ***
## project_landfill     -7.19171    0.69916 -10.2862 < 2.2e-16 ***
## project_manure       -3.27400    0.51388  -6.3711 1.877e-10 ***
## sd.location_EU       18.25465    1.18157  15.4495 < 2.2e-16 ***
## sd.location_UK       19.38956    1.20583  16.0798 < 2.2e-16 ***
## sd.certificate_NGO   17.48033    1.13580  15.3903 < 2.2e-16 ***
## sd.certificate_UK    17.96074    1.18609  15.1428 < 2.2e-16 ***
## sd.project_renewable 20.15373    1.32680  15.1898 < 2.2e-16 ***
## sd.project_landfill  15.69728    1.18394  13.2585 < 2.2e-16 ***
## sd.project_manure    18.57166    1.22403  15.1726 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

mixed logit + co2 consumption + framing effect

mixed logit + co2 consumption + framing effect Coefficients

```
##
## Model estimated on: Tue Oct 01 04:19:55 AM 2024
##
## Call:
## gmnl(formula = f, data = dt, model = "mixl", ranp = randpar,
##      R = 2000, haltons = NA, mvar = mvarlist_1, panel = T, method = "bhhh",
##      iterlim = 5000)
##
## Frequencies of categories:
##
##         1        2        3        4        5        6
## 0.192868 0.272962 0.158307 0.243260 0.060815 0.071787
```

```
##
## The estimation took: 0h:11m:32s
##
## Coefficients:
##                                                 Estimate  Std. Error  z-value    Pr(>|z|)
## I                                              -1.48342075  0.04742020 -31.2825  < 2.2e-16 ***
## price                                          -0.05444378  0.00265716 -20.4895  < 2.2e-16 ***
## location_EU                                     0.27096125  0.06440584   4.2071  2.587e-05 ***
## location_UK                                     0.62597031  0.06206529  10.0857  < 2.2e-16 ***
## certificate_NGO                                 0.40590326  0.06104415   6.6493  2.944e-11 ***
## certificate_UK                                  0.86540767  0.06655847  13.0022  < 2.2e-16 ***
## project_renewable                              0.51720395  0.06988312   7.4010  1.352e-13 ***
## project_landfill                               -0.32652869  0.07763382  -4.2060  2.599e-05 ***
## project_manure                                 -0.13760197  0.06931582  -1.9851   0.047128 *
## location_EU.co2_value                          -0.05817123  0.01969407  -2.9537   0.003139 **
## location_EU.framing_effectconsequence          -0.17380139  0.07793679  -2.2300   0.025745 *
## location_EU.framing_effectMetOffice            -0.21679907  0.06686230  -3.2425   0.001185 **
## location_EU.framing_effectUN                   -0.15509103  0.07689329  -2.0170   0.043699 *
## location_UK.co2_value                          -0.10914014  0.01843639  -5.9198  3.223e-09 ***
## location_UK.framing_effectconsequence          -0.17258197  0.07561872  -2.2823   0.022474 *
## location_UK.framing_effectMetOffice            -0.12210422  0.06457887  -1.8908   0.058654 .
## location_UK.framing_effectUN                   -0.05700486  0.07439191  -0.7663   0.443511
## certificate_NGO.co2_value                      -0.11562304  0.01893290  -6.1070  1.015e-09 ***
## certificate_NGO.framing_effectconsequence       0.00415171  0.07510762   0.0553   0.955918
## certificate_NGO.framing_effectMetOffice        -0.05292553  0.06421762  -0.8242   0.409849
## certificate_NGO.framing_effectUN                0.00038918  0.07418675   0.0052   0.995814
## certificate_UK.co2_value                       -0.09727752  0.01963019  -4.9555  7.214e-07 ***
## certificate_UK.framing_effectconsequence       -0.07977620  0.07821613  -1.0199   0.307754
## certificate_UK.framing_effectMetOffice         -0.05209319  0.06696968  -0.7779   0.436650
## certificate_UK.framing_effectUN                -0.01142996  0.07829506  -0.1460   0.883933
## project_renewable.co2_value                    -0.06674746  0.02076018  -3.2152   0.001304 **
## project_renewable.framing_effectconsequence    -0.01402175  0.08483109  -0.1653   0.868716
## project_renewable.framing_effectMetOffice      -0.21627556  0.07128935  -3.0338   0.002415 **
## project_renewable.framing_effectUN             -0.00893805  0.08297689  -0.1077   0.914220
## project_landfill.co2_value                     -0.00260460  0.02330356  -0.1118   0.911007
## project_landfill.framing_effectconsequence      0.03516618  0.09436451   0.3727   0.709399
## project_landfill.framing_effectMetOffice       -0.16360535  0.08097141  -2.0205   0.043328 *
## project_landfill.framing_effectUN              -0.00592276  0.09249619  -0.0640   0.948944
## project_manure.co2_value                       -0.04095976  0.02118996  -1.9330   0.053239 .
## project_manure.framing_effectconsequence        0.04300060  0.08360151   0.5144   0.607006
## project_manure.framing_effectMetOffice          0.01363501  0.07229196   0.1886   0.850398
## project_manure.framing_effectUN                 0.07275393  0.08338167   0.8725   0.382913
## sd.location_EU                                  0.98687155  0.03666827  26.9135  < 2.2e-16 ***
## sd.location_UK                                  1.04526477  0.03550663  29.4386  < 2.2e-16 ***
## sd.certificate_NGO                              0.93948230  0.03720766  25.2497  < 2.2e-16 ***
## sd.certificate_UK                               0.97555051  0.03778346  25.8195  < 2.2e-16 ***
## sd.project_renewable                            1.08731461  0.04182832  25.9947  < 2.2e-16 ***
## sd.project_landfill                             0.85454267  0.04557075  18.7520  < 2.2e-16 ***
## sd.project_manure                               1.01391111  0.04004516  25.3192  < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Optimization of log-likelihood by BHHH maximisation
## Log Likelihood: -19100
```

```
## Number of observations: 12760
## Number of iterations: 16
## Exit of MLE: successive function values within relative tolerance limit (reltol)
## Simulation based on 2000 draws
```

mixed logit + co2 consumption + framing effect Willingness to Pay

```
##
## Willigness-to-pay respect to:  price
##
##                                                 Estimate  Std. Error  t-value   Pr(>|t|)
## I                                             -27.2468375   2.1055407 -12.9405 < 2.2e-16 ***
## location_EU                                     4.9769002   1.2021757   4.1399 3.474e-05 ***
## location_UK                                    11.4975547   1.3032321   8.8223 < 2.2e-16 ***
## certificate_NGO                                 7.4554574   1.1944882   6.2415 4.333e-10 ***
## certificate_UK                                 15.8954377   1.5257533  10.4181 < 2.2e-16 ***
## project_renewable                               9.4997808   1.3622350   6.9737 3.088e-12 ***
## project_landfill                               -5.9975393   1.4651182  -4.0936 4.248e-05 ***
## project_manure                                 -2.5274141   1.2691064  -1.9915  0.046427 *
## location_EU.co2_value                          -1.0684642   0.3650763  -2.9267  0.003426 **
## location_EU.framing_effectconsequence          -3.1923095   1.4407479  -2.2157  0.026710 *
## location_EU.framing_effectMetOffice            -3.9820725   1.2456188  -3.1969  0.001389 **
## location_EU.framing_effectUN                   -2.8486457   1.4183072  -2.0085  0.044592 *
## location_UK.co2_value                          -2.0046393   0.3538303  -5.6655 1.466e-08 ***
## location_UK.framing_effectconsequence          -3.1699118   1.3959835  -2.2707  0.023163 *
## location_UK.framing_effectMetOffice            -2.2427580   1.1913958  -1.8825  0.059773 .
## location_UK.framing_effectUN                   -1.0470410   1.3669483  -0.7660  0.443694
## certificate_NGO.co2_value                      -2.1237145   0.3652698  -5.8141 6.096e-09 ***
## certificate_NGO.framing_effectconsequence       0.0762568   1.3795647   0.0553  0.955919
## certificate_NGO.framing_effectMetOffice        -0.9721135   1.1806135  -0.8234  0.410282
## certificate_NGO.framing_effectUN                0.0071483   1.3626348   0.0052  0.995814
## certificate_UK.co2_value                       -1.7867519   0.3732646  -4.7868 1.694e-06 ***
## certificate_UK.framing_effectconsequence       -1.4652952   1.4384814  -1.0186  0.308374
## certificate_UK.framing_effectMetOffice         -0.9568253   1.2308983  -0.7773  0.436959
## certificate_UK.framing_effectUN                -0.2099407   1.4380709  -0.1460  0.883931
## project_renewable.co2_value                    -1.2259887   0.3863975  -3.1729  0.001509 **
## project_renewable.framing_effectconsequence    -0.2575454   1.5581309  -0.1653  0.868715
## project_renewable.framing_effectMetOffice      -3.9724569   1.3239246  -3.0005  0.002695 **
## project_renewable.framing_effectUN             -0.1641703   1.5240839  -0.1077  0.914220
## project_landfill.co2_value                     -0.0478402   0.4280280  -0.1118  0.911007
## project_landfill.framing_effectconsequence      0.6459173   1.7340536   0.3725  0.709528
## project_landfill.framing_effectMetOffice       -3.0050331   1.4932958  -2.0123  0.044183 *
## project_landfill.framing_effectUN              -0.1087867   1.6989163  -0.0640  0.948944
## project_manure.co2_value                       -0.7523313   0.3908042  -1.9251  0.054219 .
## project_manure.framing_effectconsequence        0.7898166   1.5368335   0.5139  0.607305
## project_manure.framing_effectMetOffice          0.2504421   1.3279712   0.1886  0.850414
## project_manure.framing_effectUN                 1.3363131   1.5334790   0.8714  0.383522
## sd.location_EU                                 18.1264342   1.1790382  15.3739 < 2.2e-16 ***
## sd.location_UK                                 19.1989760   1.2019257  15.9735 < 2.2e-16 ***
## sd.certificate_NGO                             17.2560089   1.1276482  15.3027 < 2.2e-16 ***
## sd.certificate_UK                              17.9184944   1.1883939  15.0779 < 2.2e-16 ***
## sd.project_renewable                           19.9713295   1.3250501  15.0721 < 2.2e-16 ***
## sd.project_landfill                            15.6958741   1.1885285  13.2061 < 2.2e-16 ***
```

```
## sd.project_manure                        18.6230853   1.2307462  15.1315 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

mixed logit + co2 consumption + framing effect + PCA

We included the first two coponents for Q9 and Q10. Q9 was about respondents' attitude towards carbon offsetting, and Q10 was about respondents' attitude towards climate change.

mixed logit + co2 consumption + framing effect + PCA Coefficients

```
##
## Model estimated on: Tue Oct 01 04:19:55 AM 2024
##
## Call:
## gmnl(formula = f, data = dt, model = "mixl", ranp = randpar,
##     R = 2000, haltons = NA, mvar = mvarlist_2, panel = T, method = "bhhh",
##     iterlim = 5000)
##
## Frequencies of categories:
##
##        1        2        3        4        5        6
## 0.192868 0.272962 0.158307 0.243260 0.060815 0.071787
##
## The estimation took: 0h:12m:41s
##
## Coefficients:
##                                         Estimate  Std. Error  z-value  Pr(>|z|)
## I                                     -1.47026893  0.04710388 -31.2133 < 2.2e-16 ***
## price                                 -0.05330761  0.00262404 -20.3151 < 2.2e-16 ***
## location_EU                            0.18282667  0.06308018   2.8983 0.0037517 **
## location_UK                            0.51058058  0.06046379   8.4444 < 2.2e-16 ***
## certificate_NGO                        0.34060404  0.05977900   5.6977 1.214e-08 ***
## certificate_UK                         0.78764548  0.06486768  12.1423 < 2.2e-16 ***
## project_renewable                      0.44341837  0.06801322   6.5196 7.050e-11 ***
## project_landfill                      -0.31562954  0.07654430  -4.1235 3.732e-05 ***
## project_manure                        -0.15798678  0.06842806  -2.3088 0.0209546 *
## location_EU.co2_value                 -0.02796770  0.01963489  -1.4244 0.1543342
## location_EU.framing_effectconsequence -0.15510579  0.07683989  -2.0186 0.0435332 *
## location_EU.framing_effectMetOffice   -0.18505632  0.06553088  -2.8240 0.0047435 **
## location_EU.framing_effectUN          -0.15126992  0.07558761  -2.0013 0.0453651 *
## location_EU.Q9_PC1                     0.14335968  0.01161698  12.3405 < 2.2e-16 ***
## location_EU.Q9_PC2                     0.01077460  0.01330820   0.8096 0.4181578
## location_EU.Q10_PC1                    0.01744954  0.00803994   2.1704 0.0299798 *
## location_EU.Q10_PC2                   -0.02402029  0.02754465  -0.8720 0.3831814
## location_UK.co2_value                 -0.06851555  0.01833944  -3.7360 0.0001870 ***
## location_UK.framing_effectconsequence -0.18084067  0.07393196  -2.4460 0.0144434 *
## location_UK.framing_effectMetOffice   -0.06763793  0.06300574  -1.0735 0.2830378
## location_UK.framing_effectUN          -0.07001446  0.07294355  -0.9598 0.3371335
## location_UK.Q9_PC1                     0.12095150  0.00994165  12.1661 < 2.2e-16 ***
## location_UK.Q9_PC2                     0.03224580  0.01248039   2.5837 0.0097742 **
## location_UK.Q10_PC1                    0.06476559  0.00791481   8.1828 2.220e-16 ***
```

```
## location_UK.Q10_PC2                           -0.02782876  0.02700235  -1.0306 0.3027261
## certificate_NGO.co2_value                      -0.08220766  0.01879864  -4.3731 1.225e-05 ***
## certificate_NGO.framing_effectconsequence      -0.03539828  0.07363322  -0.4807 0.6307027
## certificate_NGO.framing_effectMetOffice        -0.05219881  0.06263252  -0.8334 0.4046113
## certificate_NGO.framing_effectUN               -0.05901687  0.07274143  -0.8113 0.4171796
## certificate_NGO.Q9_PC1                           0.16602530  0.00990059  16.7692 < 2.2e-16 ***
## certificate_NGO.Q9_PC2                           0.04915647  0.01266824   3.8803 0.0001043 ***
## certificate_NGO.Q10_PC1                          0.00699579  0.00795140   0.8798 0.3789580
## certificate_NGO.Q10_PC2                         -0.08155623  0.02770034  -2.9442 0.0032376 **
## certificate_UK.co2_value                        -0.06361963  0.01969105  -3.2309 0.0012341 **
## certificate_UK.framing_effectconsequence        -0.10930028  0.07689856  -1.4214 0.1552131
## certificate_UK.framing_effectMetOffice          -0.02719546  0.06552118  -0.4151 0.6780953
## certificate_UK.framing_effectUN                 -0.06767551  0.07674313  -0.8818 0.3778609
## certificate_UK.Q9_PC1                            0.16535170  0.01169977  14.1329 < 2.2e-16 ***
## certificate_UK.Q9_PC2                            0.04873628  0.01352402   3.6037 0.0003137 ***
## certificate_UK.Q10_PC1                           0.01174857  0.00816681   1.4386 0.1502711
## certificate_UK.Q10_PC2                          -0.04333585  0.02809553  -1.5424 0.1229652
## project_renewable.co2_value                     -0.03588449  0.02072241  -1.7317 0.0833314 .
## project_renewable.framing_effectconsequence     -0.02527322  0.08299680  -0.3045 0.7607406
## project_renewable.framing_effectMetOffice       -0.19577489  0.06960092  -2.8128 0.0049109 **
## project_renewable.framing_effectUN              -0.06470120  0.08115502  -0.7973 0.4253033
## project_renewable.Q9_PC1                          0.15475482  0.01124535  13.7617 < 2.2e-16 ***
## project_renewable.Q9_PC2                          0.04210708  0.01403949   2.9992 0.0027070 **
## project_renewable.Q10_PC1                         0.00225653  0.00868780   0.2597 0.7950679
## project_renewable.Q10_PC2                        -0.11151279  0.03076743  -3.6244 0.0002897 ***
## project_landfill.co2_value                        0.00838006  0.02356438   0.3556 0.7221223
## project_landfill.framing_effectconsequence       -0.01331815  0.09311875  -0.1430 0.8862718
## project_landfill.framing_effectMetOffice         -0.17762941  0.07957091  -2.2323 0.0255924 *
## project_landfill.framing_effectUN                -0.07160144  0.09113310  -0.7857 0.4320551
## project_landfill.Q9_PC1                           0.12716720  0.01371040   9.2752 < 2.2e-16 ***
## project_landfill.Q9_PC2                           0.02149214  0.01614772   1.3310 0.1831986
## project_landfill.Q10_PC1                         -0.03255943  0.01000728  -3.2536 0.0011396 **
## project_landfill.Q10_PC2                          0.02634585  0.03395836   0.7758 0.4378506
## project_manure.co2_value                         -0.01701421  0.02113548  -0.8050 0.4208156
## project_manure.framing_effectconsequence          0.00237170  0.08295967   0.0286 0.9771927
## project_manure.framing_effectMetOffice            0.00076716  0.07124809   0.0108 0.9914090
## project_manure.framing_effectUN                   0.01433529  0.08237748   0.1740 0.8618501
## project_manure.Q9_PC1                             0.12142771  0.01125334  10.7904 < 2.2e-16 ***
## project_manure.Q9_PC2                             0.04088936  0.01474357   2.7734 0.0055479 **
## project_manure.Q10_PC1                           -0.02272610  0.00893241  -2.5442 0.0109519 *
## project_manure.Q10_PC2                            0.00906077  0.03033887   0.2987 0.7652053
## sd.location_EU                                    0.89410009  0.03535782  25.2872 < 2.2e-16 ***
## sd.location_UK                                    0.95459877  0.03469485  27.5141 < 2.2e-16 ***
## sd.certificate_NGO                                0.82379472  0.03681294  22.3779 < 2.2e-16 ***
## sd.certificate_UK                                 0.83651019  0.03678613  22.7398 < 2.2e-16 ***
## sd.project_renewable                              0.98556679  0.04106756  23.9987 < 2.2e-16 ***
## sd.project_landfill                               0.78778034  0.04456832  17.6758 < 2.2e-16 ***
## sd.project_manure                                 0.96377361  0.03904801  24.6818 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Optimization of log-likelihood by BHHH maximisation
## Log Likelihood: -18662
## Number of observations: 12760
```

```
## Number of iterations: 17
## Exit of MLE: successive function values within relative tolerance limit (reltol)
## Simulation based on 2000 draws
```

mixed logit + co2 consumption + framing effect + PCA Willingness to Pay

```
##
## Willigness-to-pay respect to:  price
##
##                                               Estimate Std. Error  t-value  Pr(>|t|)
## I                                           -27.580846   2.142034 -12.8760 < 2.2e-16 ***
## location_EU                                   3.429654   1.191303   2.8789 0.0039905 **
## location_UK                                   9.578006   1.256983   7.6198 2.531e-14 ***
## certificate_NGO                               6.389408   1.177629   5.4257 5.774e-08 ***
## certificate_UK                               14.775480   1.491935   9.9036 < 2.2e-16 ***
## project_renewable                             8.318107   1.333530   6.2377 4.442e-10 ***
## project_landfill                             -5.920910   1.474451  -4.0157 5.928e-05 ***
## project_manure                               -2.963682   1.280566  -2.3144 0.0206484 *
## location_EU.co2_value                        -0.524647   0.368991  -1.4218 0.1550718
## location_EU.framing_effectconsequence        -2.909637   1.449666  -2.0071 0.0447381 *
## location_EU.framing_effectMetOffice          -3.471480   1.243126  -2.7925 0.0052296 **
## location_EU.framing_effectUN                 -2.837680   1.424070  -1.9927 0.0462992 *
## location_EU.Q9_PC1                            2.689291   0.259727  10.3543 < 2.2e-16 ***
## location_EU.Q9_PC2                            0.202121   0.249952   0.8086 0.4187216
## location_EU.Q10_PC1                           0.327337   0.151852   2.1556 0.0311129 *
## location_EU.Q10_PC2                          -0.450598   0.517448  -0.8708 0.3838588
## location_UK.co2_value                        -1.285287   0.350177  -3.6704 0.0002422 ***
## location_UK.framing_effectconsequence        -3.392399   1.395431  -2.4311 0.0150541 *
## location_UK.framing_effectMetOffice          -1.268823   1.183628  -1.0720 0.2837298
## location_UK.framing_effectUN                 -1.313405   1.369500  -0.9590 0.3375387
## location_UK.Q9_PC1                            2.268935   0.216359  10.4869 < 2.2e-16 ***
## location_UK.Q9_PC2                            0.604901   0.236527   2.5574 0.0105450 *
## location_UK.Q10_PC1                           1.214941   0.163335   7.4383 1.019e-13 ***
## location_UK.Q10_PC2                          -0.522041   0.506500  -1.0307 0.3026898
## certificate_NGO.co2_value                    -1.542137   0.362346  -4.2560 2.081e-05 ***
## certificate_NGO.framing_effectconsequence    -0.664038   1.381535  -0.4807 0.6307635
## certificate_NGO.framing_effectMetOffice      -0.979200   1.175899  -0.8327 0.4050001
## certificate_NGO.framing_effectUN             -1.107100   1.364993  -0.8111 0.4173272
## certificate_NGO.Q9_PC1                        3.114477   0.243297  12.8011 < 2.2e-16 ***
## certificate_NGO.Q9_PC2                        0.922129   0.242066   3.8094 0.0001393 ***
## certificate_NGO.Q10_PC1                       0.131234   0.149380   0.8785 0.3796596
## certificate_NGO.Q10_PC2                      -1.529917   0.524424  -2.9173 0.0035304 **
## certificate_UK.co2_value                     -1.193444   0.375289  -3.1801 0.0014724 **
## certificate_UK.framing_effectconsequence     -2.050369   1.446408  -1.4176 0.1563194
## certificate_UK.framing_effectMetOffice       -0.510161   1.229338  -0.4150 0.6781506
## certificate_UK.framing_effectUN              -1.269528   1.440945  -0.8810 0.3782971
## certificate_UK.Q9_PC1                         3.101841   0.274732  11.2904 < 2.2e-16 ***
## certificate_UK.Q9_PC2                         0.914246   0.256644   3.5623 0.0003676 ***
## certificate_UK.Q10_PC1                        0.220392   0.154042   1.4307 0.1525098
## certificate_UK.Q10_PC2                       -0.812939   0.528331  -1.5387 0.1238794
## project_renewable.co2_value                  -0.673159   0.390360  -1.7245 0.0846255 .
## project_renewable.framing_effectconsequence  -0.474102   1.556996  -0.3045 0.7607487
## project_renewable.framing_effectMetOffice    -3.672551   1.317715  -2.7871 0.0053189 **
```

```
## project_renewable.framing_effectUN                -1.213733   1.523133   -0.7969 0.4255287
## project_renewable.Q9_PC1                            2.903053   0.260439   11.1468 < 2.2e-16 ***
## project_renewable.Q9_PC2                            0.789889   0.265152    2.9790 0.0028919 **
## project_renewable.Q10_PC1                           0.042330   0.163033    0.2596 0.7951399
## project_renewable.Q10_PC2                          -2.091874   0.588773   -3.5529 0.0003810 ***
## project_landfill.co2_value                          0.157202   0.442095    0.3556 0.7221524
## project_landfill.framing_effectconsequence         -0.249836   1.746707   -0.1430 0.8862645
## project_landfill.framing_effectMetOffice           -3.332159   1.501104   -2.2198 0.0264320 *
## project_landfill.framing_effectUN                  -1.343175   1.710854   -0.7851 0.4324005
## project_landfill.Q9_PC1                             2.385536   0.285899    8.3440 < 2.2e-16 ***
## project_landfill.Q9_PC2                             0.403172   0.303358    1.3290 0.1838382
## project_landfill.Q10_PC1                           -0.610784   0.190778   -3.2016 0.0013669 **
## project_landfill.Q10_PC2                            0.494223   0.637304    0.7755 0.4380503
## project_manure.co2_value                           -0.319170   0.396783   -0.8044 0.4211682
## project_manure.framing_effectconsequence            0.044491   1.556292    0.0286 0.9771934
## project_manure.framing_effectMetOffice              0.014391   1.336552    0.0108 0.9914090
## project_manure.framing_effectUN                     0.268916   1.545507    0.1740 0.8618663
## project_manure.Q9_PC1                               2.277868   0.239144    9.5251 < 2.2e-16 ***
## project_manure.Q9_PC2                               0.767045   0.279928    2.7401 0.0061411 **
## project_manure.Q10_PC1                             -0.426320   0.169509   -2.5150 0.0119021 *
## project_manure.Q10_PC2                              0.169972   0.569061    0.2987 0.7651783
## sd.location_EU                                     16.772467   1.126092   14.8944 < 2.2e-16 ***
## sd.location_UK                                     17.907365   1.155327   15.4998 < 2.2e-16 ***
## sd.certificate_NGO                                 15.453605   1.071233   14.4260 < 2.2e-16 ***
## sd.certificate_UK                                  15.692135   1.106511   14.1816 < 2.2e-16 ***
## sd.project_renewable                               18.488295   1.277899   14.4677 < 2.2e-16 ***
## sd.project_landfill                                14.778010   1.160884   12.7300 < 2.2e-16 ***
## sd.project_manure                                  18.079476   1.215182   14.8780 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

- Higher meeting consumption, i.e., higher co2 value consistently reduce the WTP.

- The framing effects is either non-significant or seems to mitigate the preference premium relative to the base line for both endosement and carbon offset approaches.

Latent Class Models, Marginal Utiltiy Without Interaction Terms

This specification allows marginal utility paramters varies by class and treating the co2 consumption, framing effect, and PCAs of as demographics.

Latent Class Treating co2 consumption + framing effect + PCA as demographics, 2 classes

The marginal utility coefficients are:

```
##
## Model estimated on: Tue Oct 01 04:19:55 AM 2024
##
## Call:
## gmnl(formula = f1, data = dt, model = "lc", Q = q, panel = TRUE,
```

```
##      method = "bhhh", iterlim = 5000)
##
## Frequencies of categories:
##
##        1        2        3        4        5        6
## 0.192868 0.272962 0.158307 0.243260 0.060815 0.071787
##
## The estimation took: 0h:0m:6s
##
## Coefficients:
##                            Estimate Std. Error  z-value  Pr(>|z|)
## class.1.I                 -0.3412401  0.0444907  -7.6699 1.732e-14 ***
## class.1.price             -0.0392215  0.0021731 -18.0486 < 2.2e-16 ***
## class.1.location_EU       -0.0674888  0.0210293  -3.2093  0.001331 **
## class.1.location_UK        0.1332018  0.0202700   6.5714 4.985e-11 ***
## class.1.certificate_NGO    0.0346578  0.0211352   1.6398  0.101045
## class.1.certificate_UK     0.3286375  0.0214574  15.3158 < 2.2e-16 ***
## class.1.project_renewable  0.1725005  0.0239655   7.1979 6.115e-13 ***
## class.1.project_landfill  -0.2166329  0.0279751  -7.7438 9.548e-15 ***
## class.1.project_manure    -0.1158708  0.0247819  -4.6756 2.931e-06 ***
## class.2.I                 -3.4833513  0.0947536 -36.7622 < 2.2e-16 ***
## class.2.price             -0.0361526  0.0040437  -8.9406 < 2.2e-16 ***
## class.2.location_EU        0.0698498  0.0382584   1.8257  0.067890 .
## class.2.location_UK        0.4050697  0.0368772  10.9843 < 2.2e-16 ***
## class.2.certificate_NGO    0.3069834  0.0368541   8.3297 < 2.2e-16 ***
## class.2.certificate_UK     0.5321108  0.0414124  12.8491 < 2.2e-16 ***
## class.2.project_renewable  0.1321055  0.0441377   2.9930  0.002762 **
## class.2.project_landfill  -0.5899856  0.0512568 -11.5104 < 2.2e-16 ***
## class.2.project_manure    -0.3172132  0.0462331  -6.8612 6.830e-12 ***
## (class)2                  -0.1611202  0.0180500  -8.9263 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Optimization of log-likelihood by BHHH maximisation
## Log Likelihood: -17728
## Number of observations: 12760
## Number of iterations: 17
## Exit of MLE: successive function values within relative tolerance limit (reltol)
```

The class membership probabilities are:

```
##   Class_1   Class_2
## 0.5401931 0.4598069
```

The effects of demographics are:

```
## $Class_2
##                              coef          se           z      p_val
## (Intercept)           -0.149983959 0.31567659 -0.47511904 0.6347021
## co2_value             -0.062426525 0.05376809 -1.16103288 0.2456285
## framing_effectconsequence  0.084897472 0.17910269  0.47401562 0.6354888
## framing_effectMetOffice    0.029019525 0.15531606  0.18684175 0.8517847
## framing_effectUN           0.211272942 0.17884787  1.18129975 0.2374837
```

```
## Q9_PC1                      -0.004564753 0.02456431 -0.18582863 0.8525792
## Q9_PC2                       0.023945740 0.03251407  0.73647310 0.4614428
## Q10_PC1                      0.028215217 0.02405627  1.17288399 0.2408423
## Q10_PC2                     -0.010359090 0.07100578 -0.14589080 0.8840076
## age_group35_54             -0.066550842 0.14920830 -0.44602640 0.6555782
## age_group55_               0.111347702 0.17249486  0.64551315 0.5185947
## is_women                   -0.110452853 0.12078982 -0.91442188 0.3604952
## diet_typeFlexitarian       -0.183729298 0.16724314 -1.09857599 0.2719531
## diet_typeVegan_Vegetarian  -0.096426840 0.22442044 -0.42967048 0.6674354
## education_levelDegree      -0.029093947 0.13310473 -0.21857937 0.8269777
## education_levelPostgraduate -0.011785081 0.17108551 -0.06888416 0.9450818
## hh_size                     0.052519069 0.06372989  0.82408846 0.4098893
## income_level30_50k          0.031553116 0.13564570  0.23261421 0.8160610
## income_level50_            0.121105992 0.15493393  0.78166216 0.4344131
## n_children                 -0.032906571 0.09032623 -0.36430803 0.7156280
## is_shopper                 -0.008792004 0.14447281 -0.06085577 0.9514741
## where_liveRuralarea        -0.165097285 0.19340100 -0.85365268 0.3932975
## where_liveTownorsuburb     -0.025255604 0.14988913 -0.16849523 0.8661937
```

Latent Class Treating co2 consumption + framing effect + PCA as demographics, 3 classes

The marginal utility coefficients are:

```
##
## Model estimated on: Tue Oct 01 04:19:55 AM 2024
##
## Call:
## gmnl(formula = f2, data = dt, model = "lc", Q = q, panel = TRUE,
##     method = "bhhh", iterlim = 5000)
##
## Frequencies of categories:
##
##        1        2        3        4        5        6
## 0.192868 0.272962 0.158307 0.243260 0.060815 0.071787
##
## The estimation took: 0h:0m:7s
##
## Coefficients:
##                          Estimate Std. Error  z-value  Pr(>|z|)
## class.1.I                -0.4745246  0.0471349 -10.0674 < 2.2e-16 ***
## class.1.price            -0.0292255  0.0022267 -13.1249 < 2.2e-16 ***
## class.1.location_EU      -0.0160290  0.0215339  -0.7444 0.4566576
## class.1.location_UK       0.1652015  0.0207310   7.9688 1.554e-15 ***
## class.1.certificate_NGO   0.0831284  0.0215511   3.8573 0.0001147 ***
## class.1.certificate_UK    0.3615126  0.0222526  16.2459 < 2.2e-16 ***
## class.1.project_renewable 0.2162835  0.0249448   8.6705 < 2.2e-16 ***
## class.1.project_landfill -0.2422197  0.0288237  -8.4035 < 2.2e-16 ***
## class.1.project_manure   -0.1329240  0.0257051  -5.1711 2.327e-07 ***
## class.2.I                 0.4650589  0.2682802   1.7335 0.0830101 .
## class.2.price            -0.2428531  0.0126570 -19.1872 < 2.2e-16 ***
## class.2.location_EU      -1.0364971  0.1197874  -8.6528 < 2.2e-16 ***
## class.2.location_UK       0.3849672  0.1132237   3.4001 0.0006737 ***
```

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```
## class.2.certificate_NGO   -0.2754939  0.1083798  -2.5419 0.0110242 *
## class.2.certificate_UK     0.6164478  0.1292306   4.7701 1.841e-06 ***
## class.2.project_renewable -0.5736398  0.1286163  -4.4601 8.193e-06 ***
## class.2.project_landfill  -0.4348426  0.1711899  -2.5401 0.0110815 *
## class.2.project_manure     0.0152187  0.1361393   0.1118 0.9109915
## class.3.I                 -3.8803868  0.1083355 -35.8182 < 2.2e-16 ***
## class.3.price             -0.0374090  0.0042698  -8.7614 < 2.2e-16 ***
## class.3.location_EU        0.0668430  0.0403760   1.6555 0.0978202 .
## class.3.location_UK        0.4087315  0.0387818  10.5393 < 2.2e-16 ***
## class.3.certificate_NGO    0.3206281  0.0387231   8.2800 2.220e-16 ***
## class.3.certificate_UK     0.5416737  0.0437614  12.3779 < 2.2e-16 ***
## class.3.project_renewable  0.1305824  0.0463554   2.8170 0.0048477 **
## class.3.project_landfill  -0.6003817  0.0546129 -10.9934 < 2.2e-16 ***
## class.3.project_manure    -0.3435792  0.0489108  -7.0246 2.147e-12 ***
## (class)2                  -1.6289501  0.0320951 -50.7539 < 2.2e-16 ***
## (class)3                  -0.0863485  0.0189983  -4.5451 5.492e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Optimization of log-likelihood by BHHH maximisation
## Log Likelihood: -16649
## Number of observations: 12760
## Number of iterations: 16
## Exit of MLE: successive function values within relative tolerance limit (reltol)
```

The class membership probabilities are:

```
##    Class_1    Class_2    Class_3
## 0.47316897 0.09280518 0.43402585
```

The effects of demographics are:

```
## $Class_2
##                                 coef         se           z       p_val
## (Intercept)              -1.200192938 0.57146938 -2.10018764 0.035712338
## co2_value                -0.089546545 0.09870194 -0.90724197 0.364278853
## framing_effectconsequence -0.174497590 0.33223056 -0.52523039 0.599423038
## framing_effectMetOffice   0.118729938 0.27258967  0.43556287 0.663153914
## framing_effectUN          0.136305864 0.32163340  0.42379262 0.671717058
## Q9_PC1                   -0.098124991 0.03779067 -2.59654037 0.009416784
## Q9_PC2                   -0.015006169 0.06106078 -0.24575789 0.805869654
## Q10_PC1                   0.046928028 0.04439955  1.05694825 0.290535207
## Q10_PC2                  -0.059367866 0.13124772 -0.45233445 0.651028063
## age_group35_54           -0.211556654 0.27050249 -0.78208765 0.434163065
## age_group55_             -0.155906887 0.30457468 -0.51188394 0.608732238
## is_women                 -0.181161495 0.21687437 -0.83532920 0.403532378
## diet_typeFlexitarian     -0.112570392 0.29519274 -0.38134539 0.702946979
## diet_typeVegan_Vegetarian -0.695311606 0.47459484 -1.46506356 0.142903577
## education_levelDegree     0.144657256 0.23677899  0.61093789 0.541240698
## education_levelPostgraduate 0.124062526 0.31028794  0.39983032 0.689281494
## hh_size                  -0.065718438 0.11891431 -0.55265376 0.580500519
## income_level30_50k       -0.277385197 0.24723136 -1.12196606 0.261876872
## income_level50_          -0.059710521 0.27842045 -0.21446169 0.830187038
```

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```
## n_children             -0.001985845 0.17051358 -0.01164626 0.990707839
## is_shopper              -0.190155187 0.25497474 -0.74578050 0.455800022
## where_liveRuralarea      0.162394440 0.36503317  0.44487584 0.656409480
## where_liveTownorsuburb   0.407572898 0.28731975  1.41853423 0.156034853
##
## $Class_3
##                               coef         se          z      p_val
## (Intercept)             -0.03364188 0.33155043 -0.10146838 0.91917866
## co2_value               -0.08885280 0.05636304 -1.57643724 0.11492507
## framing_effectconsequence 0.05918829 0.18762297  0.31546398 0.75240939
## framing_effectMetOffice  0.07805707 0.16339423  0.47772230 0.63284787
## framing_effectUN         0.28117046 0.18809870  1.49480277 0.13496592
## Q9_PC1                  -0.02518443 0.02709806 -0.92938128 0.35269153
## Q9_PC2                   0.01695829 0.03420063  0.49584725 0.62000219
## Q10_PC1                  0.03002545 0.02515003  1.19385338 0.23253533
## Q10_PC2                 -0.02046908 0.07429723 -0.27550256 0.78293016
## age_group35_54          -0.10412838 0.15642164 -0.66569041 0.50560901
## age_group55_             0.14692233 0.18181488  0.80808752 0.41904020
## is_women                -0.13264861 0.12694275 -1.04494828 0.29604687
## diet_typeFlexitarian    -0.29870212 0.17600798 -1.69709423 0.08967885
## diet_typeVegan_Vegetarian -0.29710989 0.23311372 -1.27452768 0.20247647
## education_levelDegree    0.05773852 0.14002979  0.41233029 0.68009735
## education_levelPostgraduate 0.03462402 0.17962690  0.19275523 0.84715067
## hh_size                  0.03967065 0.06671657  0.59461468 0.55210106
## income_level30_50k       0.01121950 0.14235074  0.07881589 0.93717907
## income_level50_          0.13510254 0.16299918  0.82885414 0.40718695
## n_children              -0.02464829 0.09437299 -0.26117950 0.79395409
## is_shopper              -0.05943277 0.15242382 -0.38991783 0.69659731
## where_liveRuralarea     -0.10522863 0.20199565 -0.52094505 0.60240505
## where_liveTownorsuburb   0.06348247 0.15645723  0.40574965 0.68492655
```

**We can't do an LC esimtation with more than 3 classes due to lack of variation and the hessian
matrix would be singular.**

Latent Class Models, Marginal Utiltiy With Interaction Terms

This specification interacts the marginal utility parameters with the co2 consumption, framing effect, and
PCAs. This specification would be similar to the mixed logit model with the exception that the marginal
utility parameters are allowed to vary by class, but without being random parameters.

Latent Class interact with co2 consumption + framing effect + PCA, 2 classes

The marginal utility coefficients are:

```
##
## Model estimated on: Tue Oct 01 04:19:56 AM 2024
##
## Call:
## gmnl(formula = f1, data = dt, model = "lc", Q = q, panel = TRUE,
##     method = "bhhh", iterlim = 5000)
##
```

```
## Frequencies of categories:
##
##        1        2        3        4        5        6
## 0.192868 0.272962 0.158307 0.243260 0.060815 0.071787
##
## The estimation took: 0h:1m:27s
##
## Coefficients:
##                                                   Estimate Std. Error  z-value   Pr(>|z|)
## class.1.I                                       -0.34444834 0.04465853  -7.7129 1.221e-14 ***
## class.1.price                                   -0.03480341 0.00428775  -8.1169 4.441e-16 ***
## class.1.location_EU                              0.02612167 0.05200069   0.5023 0.6154332
## class.1.location_UK                              0.28004120 0.05300178   5.2836 1.267e-07 ***
## class.1.certificate_NGO                          0.02421002 0.05397572   0.4485 0.6537669
## class.1.certificate_UK                           0.26383806 0.05699769   4.6289 3.676e-06 ***
## class.1.project_renewable                        0.21618254 0.05873168   3.6809 0.0002325 ***
## class.1.project_landfill                        -0.31146105 0.06984478  -4.4593 8.222e-06 ***
## class.1.project_manure                          -0.27432365 0.06505697  -4.2167 2.479e-05 ***
## class.1.price:co2_value                         -0.00118238 0.00117883  -1.0030 0.3158573
## class.1.price:framing_effectconsequence         -0.01110029 0.00497544  -2.2310 0.0256799 *
## class.1.price:framing_effectMetOffice            0.00013758 0.00418395   0.0329 0.9737675
## class.1.price:framing_effectUN                  -0.00360270 0.00492740  -0.7312 0.4646829
## class.1.location_EU:co2_value                    0.00519319 0.01502441   0.3456 0.7296058
## class.1.location_EU:framing_effectconsequence   -0.12101755 0.06532170  -1.8526 0.0639341 .
## class.1.location_EU:framing_effectMetOffice     -0.14499036 0.05475179  -2.6481 0.0080936 **
## class.1.location_EU:framing_effectUN            -0.08368630 0.06486678  -1.2901 0.1970070
## class.1.location_UK:co2_value                   -0.06152076 0.01538081  -3.9998 6.339e-05 ***
## class.1.location_UK:framing_effectconsequence   -0.16165232 0.06728477  -2.4025 0.0162830 *
## class.1.location_UK:framing_effectMetOffice     -0.01442206 0.05611382  -0.2570 0.7971676
## class.1.location_UK:framing_effectUN            -0.03514117 0.06516192  -0.5393 0.5896868
## class.1.certificate_NGO:co2_value               -0.02687459 0.01607775  -1.6715 0.0946151 .
## class.1.certificate_NGO:framing_effectconsequence 0.01922058 0.06938931   0.2770 0.7817830
## class.1.certificate_NGO:framing_effectMetOffice  0.08480764 0.05703878   1.4868 0.1370566
## class.1.certificate_NGO:framing_effectUN         0.08119141 0.06727280   1.2069 0.2274715
## class.1.certificate_UK:co2_value                -0.01253344 0.01639282  -0.7646 0.4445284
## class.1.certificate_UK:framing_effectconsequence 0.08814691 0.07180163   1.2276 0.2195803
## class.1.certificate_UK:framing_effectMetOffice   0.09729107 0.06012113   1.6183 0.1056085
## class.1.certificate_UK:framing_effectUN          0.15401325 0.07108767   2.1665 0.0302711 *
## class.1.project_renewable:co2_value             -0.01975792 0.01698424  -1.1633 0.2447039
## class.1.project_renewable:framing_effectconsequence 0.08206402 0.07445929   1.1021 0.2704040
## class.1.project_renewable:framing_effectMetOffice -0.06764584 0.06105159  -1.1080 0.2678570
## class.1.project_renewable:framing_effectUN       0.01889592 0.07202891   0.2623 0.7930609
## class.1.project_landfill:co2_value               0.02645724 0.02043211   1.2949 0.1953597
## class.1.project_landfill:framing_effectconsequence 0.13853136 0.08784221   1.5770 0.1147845
## class.1.project_landfill:framing_effectMetOffice  0.02416044 0.07381056   0.3273 0.7434181
## class.1.project_landfill:framing_effectUN        0.06365703 0.08591901   0.7409 0.4587566
## class.1.project_manure:co2_value                 0.01231719 0.01911689   0.6443 0.5193751
## class.1.project_manure:framing_effectconsequence 0.19157458 0.08244454   2.3237 0.0201428 *
## class.1.project_manure:framing_effectMetOffice   0.14105372 0.06891893   2.0467 0.0406913 *
## class.1.project_manure:framing_effectUN          0.20137745 0.08087882   2.4899 0.0127791 *
## class.2.I                                       -3.51097936 0.09574295 -36.6709 < 2.2e-16 ***
## class.2.price                                   -0.01862446 0.00869673  -2.1415 0.0322298 *
## class.2.location_EU                              0.12893971 0.10025780   1.2861 0.1984146
## class.2.location_UK                              0.39384184 0.09500483   4.1455 3.391e-05 ***
```

```
## class.2.certificate_NGO                                    0.49355358 0.09510959  5.1893 2.111e-07 ***
## class.2.certificate_UK                                     0.70810644 0.10988008  6.4444 1.161e-10 ***
## class.2.project_renewable                                  0.12487839 0.10781826  1.1582 0.2467700
## class.2.project_landfill                                  -0.60118947 0.13401768 -4.4859 7.261e-06 ***
## class.2.project_manure                                    -0.36443608 0.12109770 -3.0094 0.0026173 **
## class.2.price:co2_value                                   -0.00744175 0.00276301 -2.6933 0.0070738 **
## class.2.price:framing_effectconsequence                   -0.00689547 0.00983838 -0.7009 0.4833814
## class.2.price:framing_effectMetOffice                     -0.00248212 0.00882688 -0.2812 0.7785571
## class.2.price:framing_effectUN                            -0.01938214 0.00951650 -2.0367 0.0416813 *
## class.2.location_EU:co2_value                             -0.03902193 0.03419225 -1.1413 0.2537657
## class.2.location_EU:framing_effectconsequence              0.00658105 0.11330094  0.0581 0.9536812
## class.2.location_EU:framing_effectMetOffice                0.03632315 0.10305699  0.3525 0.7244956
## class.2.location_EU:framing_effectUN                      -0.07832540 0.11234401 -0.6972 0.4856823
## class.2.location_UK:co2_value                              0.00105147 0.03417404  0.0308 0.9754544
## class.2.location_UK:framing_effectconsequence              0.08002041 0.11128620  0.7191 0.4721097
## class.2.location_UK:framing_effectMetOffice               -0.03303828 0.09934509 -0.3326 0.7394659
## class.2.location_UK:framing_effectUN                       0.02523403 0.11336272  0.2226 0.8238503
## class.2.certificate_NGO:co2_value                         -0.08788468 0.03354764 -2.6197 0.0088008 **
## class.2.certificate_NGO:framing_effectconsequence          0.02147935 0.10961174  0.1960 0.8446427
## class.2.certificate_NGO:framing_effectMetOffice           -0.10791400 0.09925200 -1.0873 0.2769162
## class.2.certificate_NGO:framing_effectUN                  -0.11398248 0.11259154 -1.0124 0.3113689
## class.2.certificate_UK:co2_value                          -0.05001066 0.03913932 -1.2778 0.2013340
## class.2.certificate_UK:framing_effectconsequence          -0.14405942 0.12596082 -1.1437 0.2527546
## class.2.certificate_UK:framing_effectMetOffice            -0.07019183 0.11402350 -0.6156 0.5381646
## class.2.certificate_UK:framing_effectUN                   -0.21564560 0.12647060 -1.7051 0.0881749 .
## class.2.project_renewable:co2_value                        0.01438950 0.03751145  0.3836 0.7012727
## class.2.project_renewable:framing_effectconsequence        0.00847322 0.12279573  0.0690 0.9449876
## class.2.project_renewable:framing_effectMetOffice         -0.10019856 0.11088217 -0.9036 0.3661816
## class.2.project_renewable:framing_effectUN                 0.11937438 0.12515622  0.9538 0.3401834
## class.2.project_landfill:co2_value                         0.07368949 0.04548708  1.6200 0.1052303
## class.2.project_landfill:framing_effectconsequence        -0.11995387 0.14902724 -0.8049 0.4208702
## class.2.project_landfill:framing_effectMetOffice          -0.17889877 0.13460242 -1.3291 0.1838182
## class.2.project_landfill:framing_effectUN                 -0.05890704 0.15047583 -0.3915 0.6954486
## class.2.project_manure:co2_value                           0.04612135 0.04220569  1.0928 0.2744923
## class.2.project_manure:framing_effectconsequence          -0.05331936 0.13951895 -0.3822 0.7023385
## class.2.project_manure:framing_effectMetOffice             0.03465735 0.12676456  0.2734 0.7845462
## class.2.project_manure:framing_effectUN                   -0.09170416 0.13897237 -0.6599 0.5093351
## (class)2                                                  -0.16251577 0.01804042 -9.0084 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Optimization of log-likelihood by BHHH maximisation
## Log Likelihood: -17660
## Number of observations: 12760
## Number of iterations: 15
## Exit of MLE: successive function values within relative tolerance limit (reltol)


##      AIC      BIC
## 35485.49 36104.18
```

The class membership probabilities are:

```
##   Class_1   Class_2
## 0.5405398 0.4594602
```

The effects of demographics are:

```
## $Class_2
##                                coef         se           z      p_val
## (Intercept)              -0.27706383 0.26928171 -1.02889955 0.3035269
## age_group35_54            0.01687408 0.14393905  0.11723074 0.9066772
## age_group55_             0.21461920 0.16138350  1.32987078 0.1835609
## is_women                 -0.05672937 0.11697192 -0.48498275 0.6276886
## diet_typeFlexitarian     -0.17437595 0.15894831 -1.09706072 0.2726148
## diet_typeVegan_Vegetarian -0.01878985 0.20874883 -0.09001175 0.9282779
## education_levelDegree    -0.03686092 0.13211409 -0.27900827 0.7802385
## education_levelPostgraduate -0.01573016 0.16999594 -0.09253254 0.9262749
## hh_size                   0.04971871 0.06331892  0.78521101 0.4323299
## income_level30_50k        0.03911787 0.13487259  0.29003572 0.7717889
## income_level50_           0.13410448 0.15350885  0.87359447 0.3823391
## n_children               -0.05309249 0.08930491 -0.59450803 0.5521724
## is_shopper               -0.03132222 0.14260838 -0.21963798 0.8261531
## where_liveRuralarea      -0.11939830 0.19058367 -0.62648756 0.5309952
## where_liveTownorsuburb    0.03137536 0.14660774  0.21400888 0.8305401
```

Latent Class interact with co2 consumption + framing effect + PCA, 3 classes

The marginal utility coefficients are:

```
##
## Model estimated on: Tue Oct 01 04:19:56 AM 2024
##
## Call:
## gmnl(formula = f1, data = dt, model = "lc", Q = q, panel = TRUE,
##     method = "bhhh", iterlim = 5000)
##
## Frequencies of categories:
##
##        1        2        3        4        5        6
## 0.192868 0.272962 0.158307 0.243260 0.060815 0.071787
##
## The estimation took: 0h:1m:33s
##
## Coefficients:
##                                        Estimate  Std. Error  z-value  Pr(>|z|)
## class.1.I                            9.4246e-01  3.0266e-01   3.1140  0.001846 **
## class.1.price                       -1.2806e-01  2.7608e-02  -4.6387 3.507e-06 ***
## class.1.location_EU                 -2.4175e-01  2.9770e-01  -0.8121  0.416755
## class.1.location_UK                 -1.4595e-01  3.0339e-01  -0.4811  0.630474
## class.1.certificate_NGO             -5.2612e-01  2.9135e-01  -1.8058  0.070949 .
## class.1.certificate_UK               2.1375e-01  3.2835e-01   0.6510  0.515052
## class.1.project_renewable           -1.5500e-01  3.1028e-01  -0.4996  0.617388
## class.1.project_landfill            -5.8410e-01  4.5701e-01  -1.2781  0.201215
## class.1.project_manure              -4.6515e-01  3.6559e-01  -1.2723  0.203253
## class.1.price:co2_value             -6.4195e-02  1.1018e-02  -5.8266 5.656e-09 ***
## class.1.price:framing_effectconsequence -4.1486e-01 1.0495e-01 -3.9528 7.724e-05 ***
## class.1.price:framing_effectMetOffice  3.5668e-03  2.9495e-02   0.1209  0.903749
## class.1.price:framing_effectUN       7.5184e-02  3.1682e-02   2.3731  0.017641 *
```

```
## class.1.location_EU:co2_value                         -5.1618e-01  1.2591e-01  -4.0995 4.141e-05 ***
## class.1.location_EU:framing_effectconsequence         -1.4785e+00  5.7819e-01  -2.5572  0.010553 *
## class.1.location_EU:framing_effectMetOffice           -1.7969e-02  3.1090e-01  -0.0578  0.953911
## class.1.location_EU:framing_effectUN                   6.5970e-01  3.7485e-01   1.7599  0.078426 .
## class.1.location_UK:co2_value                          1.2103e-01  1.3127e-01   0.9220  0.356542
## class.1.location_UK:framing_effectconsequence          1.4041e+00  6.5843e-01   2.1324  0.032971 *
## class.1.location_UK:framing_effectMetOffice            5.9197e-01  3.1197e-01   1.8975  0.057760 .
## class.1.location_UK:framing_effectUN                   5.2634e-01  3.3509e-01   1.5707  0.116242
## class.1.certificate_NGO:co2_value                      1.1433e-01  1.0273e-01   1.1129  0.265733
## class.1.certificate_NGO:framing_effectconsequence      7.2350e-01  4.6665e-01   1.5504  0.121038
## class.1.certificate_NGO:framing_effectMetOffice        1.6847e-01  3.0499e-01   0.5524  0.580688
## class.1.certificate_NGO:framing_effectUN               2.4260e-01  3.3107e-01   0.7328  0.463687
## class.1.certificate_UK:co2_value                       1.5870e-01  1.4649e-01   1.0834  0.278644
## class.1.certificate_UK:framing_effectconsequence       2.6371e+00  9.9760e-01   2.6434  0.008208 **
## class.1.certificate_UK:framing_effectMetOffice         9.3959e-02  3.3512e-01   0.2804  0.779189
## class.1.certificate_UK:framing_effectUN                2.6252e-02  3.8768e-01   0.0677  0.946013
## class.1.project_renewable:co2_value                   -3.6505e-01  1.3133e-01  -2.7797  0.005441 **
## class.1.project_renewable:framing_effectconsequence   -2.3363e+00  7.9826e-01  -2.9267  0.003426 **
## class.1.project_renewable:framing_effectMetOffice     -2.3689e-02  3.3737e-01  -0.0702  0.944021
## class.1.project_renewable:framing_effectUN             8.2095e-01  3.4592e-01   2.3732  0.017633 *
## class.1.project_landfill:co2_value                    -7.7735e-02  2.1836e-01  -0.3560  0.721846
## class.1.project_landfill:framing_effectconsequence    -4.6354e-01  6.5379e-01  -0.7090  0.478322
## class.1.project_landfill:framing_effectMetOffice       2.2359e-01  4.6146e-01   0.4845  0.628018
## class.1.project_landfill:framing_effectUN              4.4343e-01  4.7500e-01   0.9335  0.350553
## class.1.project_manure:co2_value                       1.8140e-01  1.2946e-01   1.4013  0.161134
## class.1.project_manure:framing_effectconsequence      -5.6272e-01  6.1190e-01  -0.9196  0.357769
## class.1.project_manure:framing_effectMetOffice         2.3315e-01  3.8354e-01   0.6079  0.543257
## class.1.project_manure:framing_effectUN                1.2914e-01  4.2719e-01   0.3023  0.762430
## class.2.I                                             -4.9159e-01  4.7498e-02 -10.3497 < 2.2e-16 ***
## class.2.price                                         -2.6927e-02  4.6463e-03  -5.7954 6.817e-09 ***
## class.2.location_EU                                    6.8386e-02  5.3860e-02   1.2697  0.204187
## class.2.location_UK                                    3.4737e-01  5.4544e-02   6.3686 1.908e-10 ***
## class.2.certificate_NGO                                6.0734e-02  5.5372e-02   1.0968  0.272716
## class.2.certificate_UK                                 2.8855e-01  5.9639e-02   4.8382 1.310e-06 ***
## class.2.project_renewable                              2.8167e-01  6.2050e-02   4.5394 5.642e-06 ***
## class.2.project_landfill                              -3.2662e-01  7.2499e-02  -4.5051 6.634e-06 ***
## class.2.project_manure                                -2.9661e-01  6.7826e-02  -4.3731 1.225e-05 ***
## class.2.price:co2_value                               -4.2102e-05  1.2866e-03  -0.0327  0.973896
## class.2.price:framing_effectconsequence               -7.5795e-03  5.3534e-03  -1.4158  0.156826
## class.2.price:framing_effectMetOffice                 -2.3168e-03  4.5017e-03  -0.5147  0.606794
## class.2.price:framing_effectUN                        -3.9420e-03  5.2792e-03  -0.7467  0.455246
## class.2.location_EU:co2_value                          1.5244e-02  1.5549e-02   0.9804  0.326892
## class.2.location_EU:framing_effectconsequence         -1.0652e-01  6.7123e-02  -1.5870  0.112518
## class.2.location_EU:framing_effectMetOffice           -1.6806e-01  5.6072e-02  -2.9973  0.002724 **
## class.2.location_EU:framing_effectUN                  -1.0104e-01  6.5958e-02  -1.5320  0.125535
## class.2.location_UK:co2_value                         -7.2556e-02  1.5699e-02  -4.6217 3.806e-06 ***
## class.2.location_UK:framing_effectconsequence         -1.7722e-01  6.8571e-02  -2.5845  0.009753 **
## class.2.location_UK:framing_effectMetOffice           -5.0987e-02  5.7364e-02  -0.8888  0.374092
## class.2.location_UK:framing_effectUN                  -6.5545e-02  6.6602e-02  -0.9841  0.325050
## class.2.certificate_NGO:co2_value                     -3.8290e-02  1.6393e-02  -2.3358  0.019503 *
## class.2.certificate_NGO:framing_effectconsequence      5.2684e-02  7.0825e-02   0.7439  0.456962
## class.2.certificate_NGO:framing_effectMetOffice        1.1083e-01  5.8297e-02   1.9012  0.057280 .
## class.2.certificate_NGO:framing_effectUN               1.1444e-01  6.8687e-02   1.6661  0.095703 .
## class.2.certificate_UK:co2_value                      -1.8145e-02  1.7014e-02  -1.0665  0.286205
```

```
## class.2.certificate_UK:framing_effectconsequence          9.0454e-02  7.4295e-02    1.2175  0.223415
## class.2.certificate_UK:framing_effectMetOffice            1.1649e-01  6.2208e-02    1.8725  0.061132 .
## class.2.certificate_UK:framing_effectUN                   1.8892e-01  7.3257e-02    2.5789  0.009912 **
## class.2.project_renewable:co2_value                      -2.9870e-02  1.7588e-02   -1.6983  0.089446 .
## class.2.project_renewable:framing_effectconsequence       6.9914e-02  7.7210e-02    0.9055  0.365200
## class.2.project_renewable:framing_effectMetOffice        -7.8536e-02  6.3681e-02   -1.2333  0.217476
## class.2.project_renewable:framing_effectUN                1.4431e-02  7.5161e-02    0.1920  0.847742
## class.2.project_landfill:co2_value                        2.4840e-02  2.1069e-02    1.1790  0.238398
## class.2.project_landfill:framing_effectconsequence        1.1003e-01  9.0539e-02    1.2153  0.224267
## class.2.project_landfill:framing_effectMetOffice          2.2018e-02  7.5803e-02    0.2905  0.771459
## class.2.project_landfill:framing_effectUN                 5.2984e-02  8.8231e-02    0.6005  0.548159
## class.2.project_manure:co2_value                          3.4390e-03  1.9824e-02    0.1735  0.862277
## class.2.project_manure:framing_effectconsequence          1.9544e-01  8.5460e-02    2.2869  0.022204 *
## class.2.project_manure:framing_effectMetOffice            1.5758e-01  7.1241e-02    2.2119  0.026976 *
## class.2.project_manure:framing_effectUN                   2.5416e-01  8.3192e-02    3.0551  0.002250 **
## class.3.I                                                -3.8842e+00  1.0851e-01  -35.7948 < 2.2e-16 ***
## class.3.price                                            -2.2838e-02  9.3090e-03   -2.4533  0.014155 *
## class.3.location_EU                                       1.0964e-01  1.0398e-01    1.0544  0.291697
## class.3.location_UK                                       4.0228e-01  9.8569e-02    4.0812 4.481e-05 ***
## class.3.certificate_NGO                                   5.4044e-01  9.8463e-02    5.4888 4.047e-08 ***
## class.3.certificate_UK                                    7.4559e-01  1.1418e-01    6.5300 6.576e-11 ***
## class.3.project_renewable                                 1.0558e-01  1.1194e-01    0.9432  0.345579
## class.3.project_landfill                                 -6.2394e-01  1.3935e-01   -4.4774 7.555e-06 ***
## class.3.project_manure                                   -3.6422e-01  1.2603e-01   -2.8898  0.003854 **
## class.3.price:co2_value                                  -7.3738e-03  3.0899e-03   -2.3864  0.017014 *
## class.3.price:framing_effectconsequence                  -7.1791e-03  1.0723e-02   -0.6695  0.503185
## class.3.price:framing_effectMetOffice                     5.2119e-04  9.6674e-03    0.0539  0.957005
## class.3.price:framing_effectUN                           -1.1849e-02  1.0628e-02   -1.1148  0.264916
## class.3.location_EU:co2_value                            -3.6130e-02  3.6627e-02   -0.9864  0.323921
## class.3.location_EU:framing_effectconsequence             1.1301e-02  1.1936e-01    0.0947  0.924571
## class.3.location_EU:framing_effectMetOffice               4.6343e-02  1.0843e-01    0.4274  0.669092
## class.3.location_EU:framing_effectUN                     -5.0398e-02  1.2002e-01   -0.4199  0.674550
## class.3.location_UK:co2_value                             1.2403e-02  3.6049e-02    0.3441  0.730801
## class.3.location_UK:framing_effectconsequence             4.6445e-02  1.1725e-01    0.3961  0.692025
## class.3.location_UK:framing_effectMetOffice              -5.3508e-02  1.0416e-01   -0.5137  0.607460
## class.3.location_UK:framing_effectUN                      1.0064e-02  1.2013e-01    0.0838  0.933234
## class.3.certificate_NGO:co2_value                        -8.1317e-02  3.5599e-02   -2.2843  0.022356 *
## class.3.certificate_NGO:framing_effectconsequence        -4.1883e-02  1.1523e-01   -0.3635  0.716252
## class.3.certificate_NGO:framing_effectMetOffice          -1.6773e-01  1.0415e-01   -1.6105  0.107286
## class.3.certificate_NGO:framing_effectUN                 -1.5476e-01  1.1946e-01   -1.2954  0.195167
## class.3.certificate_UK:co2_value                         -4.7332e-02  4.1912e-02   -1.1293  0.258763
## class.3.certificate_UK:framing_effectconsequence         -1.9442e-01  1.3232e-01   -1.4693  0.141760
## class.3.certificate_UK:framing_effectMetOffice           -1.0071e-01  1.1990e-01   -0.8400  0.400912
## class.3.certificate_UK:framing_effectUN                  -2.6999e-01  1.3483e-01   -2.0025  0.045233 *
## class.3.project_renewable:co2_value                       2.9007e-02  4.0387e-02    0.7182  0.472612
## class.3.project_renewable:framing_effectconsequence      -8.5450e-03  1.2904e-01   -0.0662  0.947204
## class.3.project_renewable:framing_effectMetOffice        -1.1759e-01  1.1710e-01   -1.0042  0.315305
## class.3.project_renewable:framing_effectUN                1.3785e-01  1.3311e-01    1.0356  0.300375
## class.3.project_landfill:co2_value                        9.0391e-02  4.9439e-02    1.8283  0.067500 .
## class.3.project_landfill:framing_effectconsequence       -1.2499e-01  1.5964e-01   -0.7829  0.433667
## class.3.project_landfill:framing_effectMetOffice         -2.2470e-01  1.4255e-01   -1.5763  0.114953
## class.3.project_landfill:framing_effectUN                -2.8256e-02  1.6306e-01   -0.1733  0.862426
## class.3.project_manure:co2_value                          5.1839e-02  4.4595e-02    1.1624  0.245055
## class.3.project_manure:framing_effectconsequence         -7.1217e-02  1.4704e-01   -0.4843  0.628148
```

```
## class.3.project_manure:framing_effectMetOffice      1.4519e-05  1.3354e-01   0.0001  0.999913
## class.3.project_manure:framing_effectUN            -1.6684e-01  1.4920e-01  -1.1182  0.263475
## (class)2                                            1.6297e+00  3.2013e-02  50.9085 < 2.2e-16 ***
## (class)3                                            1.5476e+00  3.2200e-02  48.0636 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Optimization of log-likelihood by BHHH maximisation
## Log Likelihood: -16556
## Number of observations: 12760
## Number of iterations: 25
## Exit of MLE: successive function values within relative tolerance limit (reltol)


##        AIC        BIC
## 33362.41 34294.16
```

The class membership probabilities are:

```
##    Class_1    Class_2    Class_3
## 0.09256792 0.47232955 0.43510253
```

The effects of demographics are:

```
## $Class_2
##                                  coef        se           z       p_val
## (Intercept)               1.42033718 0.4901568   2.89771992 0.003758861
## age_group35_54            0.11413038 0.2583437   0.44177730 0.658650369
## age_group55_             -0.02728599 0.2845539  -0.09589043 0.923607597
## is_women                  0.13761868 0.2099346   0.65553128 0.512125752
## diet_typeFlexitarian      0.14294429 0.2815017   0.50779199 0.611599229
## diet_typeVegan_Vegetarian 0.36951400 0.4095747   0.90218940 0.366956263
## education_levelDegree    -0.23355034 0.2348208  -0.99458983 0.319935797
## education_levelPostgraduate -0.21926346 0.3041742 -0.72084831 0.471002847
## hh_size                   0.05996884 0.1182586   0.50709904 0.612085325
## income_level30_50k        0.42410286 0.2503298   1.69417639 0.090231769
## income_level50_           0.10943850 0.2717746   0.40268110 0.687182841
## n_children               -0.02812311 0.1659385  -0.16947910 0.865419813
## is_shopper                0.29530823 0.2494918   1.18363886 0.236556050
## where_liveRuralarea      -0.27292285 0.3581150  -0.76210960 0.445994593
## where_liveTownorsuburb   -0.49091146 0.2804028  -1.75073649 0.079991311
##
## $Class_3
##                                  coef        se          z      p_val
## (Intercept)               1.23982900 0.4936895   2.5113539 0.01202691
## age_group35_54            0.10524975 0.2614839   0.4025095 0.68730910
## age_group55_              0.23870679 0.2856290   0.8357232 0.40331066
## is_women                  0.04658651 0.2110631   0.2207232 0.82530800
## diet_typeFlexitarian     -0.11556784 0.2870557  -0.4025973 0.68724452
## diet_typeVegan_Vegetarian 0.20181526 0.4150824   0.4862052 0.62682165
## education_levelDegree    -0.17302596 0.2359466  -0.7333267 0.46335921
## education_levelPostgraduate -0.17146327 0.3059652 -0.5604012 0.57520580
## hh_size                   0.10242903 0.1187729   0.8623939 0.38847079
## income_level30_50k        0.41480235 0.2519150   1.6465965 0.09964102
```

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```
## income_level50_              0.23050778 0.2723096  0.8464916 0.39727854
## n_children                   -0.06707639 0.1671427 -0.4013122 0.68819030
## is_shopper                    0.20504090 0.2491996  0.8227979 0.41062294
## where_liveRuralarea          -0.33795452 0.3621879 -0.9330917 0.35077261
## where_liveTownorsuburb       -0.38035762 0.2832444 -1.3428601 0.17931729
```

Latent Class interact with co2 consumption + framing effect + PCA, 4 classes

The marginal utility coefficients are:

```
##
## Model estimated on: Tue Oct 01 04:19:56 AM 2024
##
## Call:
## gmnl(formula = f1, data = dt, model = "lc", Q = q, panel = TRUE,
##     method = "bhhh", iterlim = 5000)
##
## Frequencies of categories:
##
##        1        2        3        4        5        6
## 0.192868 0.272962 0.158307 0.243260 0.060815 0.071787
##
## The estimation took: 0h:2m:21s
##
## Coefficients:
##                                                  Estimate  Std. Error  z-value  Pr(>|z|)
## class.1.I                                        0.93491282 0.29950199  3.1216 0.0017990 **
## class.1.price                                   -0.13301316 0.02812733 -4.7290 2.257e-06 ***
## class.1.location_EU                             -0.26789962 0.30160634 -0.8882 0.3744102
## class.1.location_UK                             -0.13757511 0.30802181 -0.4466 0.6551344
## class.1.certificate_NGO                         -0.52626124 0.29546792 -1.7811 0.0748943 .
## class.1.certificate_UK                           0.22597339 0.33375718  0.6771 0.4983683
## class.1.project_renewable                       -0.18084439 0.31575655 -0.5727 0.5668251
## class.1.project_landfill                        -0.60072841 0.46240724 -1.2991 0.1938984
## class.1.project_manure                          -0.47129605 0.37074828 -1.2712 0.2036567
## class.1.price:co2_value                         -0.06197079 0.01103819 -5.6142 1.975e-08 ***
## class.1.price:framing_effectconsequence         -0.41421570 0.10503356 -3.9437 8.025e-05 ***
## class.1.price:framing_effectMetOffice            0.00820898 0.02978220  0.2756 0.7828294
## class.1.price:framing_effectUN                   0.07759499 0.03200208  2.4247 0.0153216 *
## class.1.location_EU:co2_value                   -0.50197199 0.12607206 -3.9816 6.844e-05 ***
## class.1.location_EU:framing_effectconsequence   -1.46765008 0.58029861 -2.5291 0.0114346 *
## class.1.location_EU:framing_effectMetOffice     -0.00245198 0.31285898 -0.0078 0.9937468
## class.1.location_EU:framing_effectUN             0.67170779 0.37626769  1.7852 0.0742312 .
## class.1.location_UK:co2_value                    0.11179022 0.13104250  0.8531 0.3936129
## class.1.location_UK:framing_effectconsequence    1.41364758 0.65989897  2.1422 0.0321759 *
## class.1.location_UK:framing_effectMetOffice      0.58078003 0.31414304  1.8488 0.0644902 .
## class.1.location_UK:framing_effectUN             0.53462603 0.33626351  1.5899 0.1118569
## class.1.certificate_NGO:co2_value                0.11076307 0.10279841  1.0775 0.2812666
## class.1.certificate_NGO:framing_effectconsequence 0.73096268 0.46881158  1.5592 0.1189533
## class.1.certificate_NGO:framing_effectMetOffice  0.16831937 0.30808470  0.5463 0.5848314
## class.1.certificate_NGO:framing_effectUN         0.25631533 0.33237047  0.7712 0.4406041
## class.1.certificate_UK:co2_value                 0.15549474 0.14620484  1.0635 0.2875370
## class.1.certificate_UK:framing_effectconsequence 2.64095067 0.99853229  2.6448 0.0081731 **
```

```
## class.1.certificate_UK:framing_effectMetOffice          0.08767646  0.33704333   0.2601 0.7947603
## class.1.certificate_UK:framing_effectUN                 0.01474483  0.38819659   0.0380 0.9697013
## class.1.project_renewable:co2_value                     -0.34748220  0.13167445  -2.6389 0.0083163 **
## class.1.project_renewable:framing_effectconsequence     -2.34183888  0.80008053  -2.9270 0.0034224 **
## class.1.project_renewable:framing_effectMetOffice        0.00048447  0.34042585   0.0014 0.9988645
## class.1.project_renewable:framing_effectUN               0.84817405  0.34909027   2.4297 0.0151126 *
## class.1.project_landfill:co2_value                      -0.06490451  0.21742185  -0.2985 0.7653072
## class.1.project_landfill:framing_effectconsequence      -0.47033812  0.65649764  -0.7164 0.4737226
## class.1.project_landfill:framing_effectMetOffice         0.24578345  0.46252383   0.5314 0.5951442
## class.1.project_landfill:framing_effectUN                0.42166512  0.47540490   0.8870 0.3751004
## class.1.project_manure:co2_value                         0.18562217  0.12930848   1.4355 0.1511450
## class.1.project_manure:framing_effectconsequence        -0.57002009  0.61457709  -0.9275 0.3536671
## class.1.project_manure:framing_effectMetOffice           0.24229893  0.38725424   0.6257 0.5315220
## class.1.project_manure:framing_effectUN                  0.12770044  0.42925533   0.2975 0.7660902
## class.2.I                                               -2.44343672  0.13502879 -18.0957 < 2.2e-16 ***
## class.2.price                                           -0.17001480  0.01631934 -10.4180 < 2.2e-16 ***
## class.2.location_EU                                      0.00411192  0.14786648   0.0278 0.9778150
## class.2.location_UK                                     -0.76101005  0.13647254  -5.5763 2.457e-08 ***
## class.2.certificate_NGO                                  0.44521879  0.18953590   2.3490 0.0188242 *
## class.2.certificate_UK                                   0.99754422  0.20017246   4.9834 6.247e-07 ***
## class.2.project_renewable                                0.95981443  0.20366037   4.7128 2.443e-06 ***
## class.2.project_landfill                                -0.07199254  0.18403067  -0.3912 0.6956504
## class.2.project_manure                                  -0.61913265  0.18630902  -3.3231 0.0008901 ***
## class.2.price:co2_value                                  0.00681815  0.00323897   2.1050 0.0352885 *
## class.2.price:framing_effectconsequence                 -0.03203964  0.02106695  -1.5208 0.1282978
## class.2.price:framing_effectMetOffice                    0.07374143  0.01520333   4.8503 1.232e-06 ***
## class.2.price:framing_effectUN                           0.02124769  0.01784582   1.1906 0.2338005
## class.2.location_EU:co2_value                           -0.10385518  0.03828943  -2.7124 0.0066803 **
## class.2.location_EU:framing_effectconsequence            0.15060570  0.19773340   0.7617 0.4462627
## class.2.location_EU:framing_effectMetOffice             -0.65948526  0.15142058  -4.3553 1.329e-05 ***
## class.2.location_EU:framing_effectUN                    -0.74511870  0.18599427  -4.0061 6.172e-05 ***
## class.2.location_UK:co2_value                           -0.11926238  0.03731753  -3.1959 0.0013940 **
## class.2.location_UK:framing_effectconsequence            0.91980992  0.17151947   5.3627 8.198e-08 ***
## class.2.location_UK:framing_effectMetOffice              0.01148416  0.14155518   0.0811 0.9353397
## class.2.location_UK:framing_effectUN                     0.13648422  0.16501821   0.8271 0.4081884
## class.2.certificate_NGO:co2_value                       -0.12523153  0.04881946  -2.5652 0.0103117 *
## class.2.certificate_NGO:framing_effectconsequence        0.46393518  0.24029764   1.9307 0.0535240 .
## class.2.certificate_NGO:framing_effectMetOffice         -0.87216367  0.19800859  -4.4047 1.059e-05 ***
## class.2.certificate_NGO:framing_effectUN                -0.39394530  0.24325191  -1.6195 0.1053408
## class.2.certificate_UK:co2_value                        -0.05101603  0.03893106  -1.3104 0.1900539
## class.2.certificate_UK:framing_effectconsequence         0.61884645  0.28707070   2.1557 0.0311049 *
## class.2.certificate_UK:framing_effectMetOffice          -0.61669362  0.19859699  -3.1053 0.0019012 **
## class.2.certificate_UK:framing_effectUN                 -0.32899817  0.22976397  -1.4319 0.1521735
## class.2.project_renewable:co2_value                      0.06398402  0.04531591   1.4120 0.1579632
## class.2.project_renewable:framing_effectconsequence     -0.18128845  0.27915812  -0.6494 0.5160725
## class.2.project_renewable:framing_effectMetOffice       -1.09244643  0.20668077  -5.2857 1.252e-07 ***
## class.2.project_renewable:framing_effectUN              -0.40674477  0.25436883  -1.5990 0.1098127
## class.2.project_landfill:co2_value                       0.03034245  0.04502547   0.6739 0.5003779
## class.2.project_landfill:framing_effectconsequence      -0.38777745  0.23151451  -1.6750 0.0939422 .
## class.2.project_landfill:framing_effectMetOffice        -0.56757497  0.18973484  -2.9914 0.0027769 **
## class.2.project_landfill:framing_effectUN                0.31108269  0.23708786   1.3121 0.1894868
## class.2.project_manure:co2_value                        -0.12415808  0.05116767  -2.4265 0.0152455 *
## class.2.project_manure:framing_effectconsequence         0.39251102  0.22111336   1.7752 0.0758719 .
## class.2.project_manure:framing_effectMetOffice          -0.28734360  0.19610194  -1.4653 0.1428454
```

```
## class.2.project_manure:framing_effectUN                      0.40761864  0.22876390   1.7818 0.0747768 .
## class.3.I                                                     0.03489706  0.05956543   0.5859 0.5579689
## class.3.price                                                 0.00337758  0.00568987   0.5936 0.5527715
## class.3.location_EU                                           0.11711902  0.06576252   1.7809 0.0749224 .
## class.3.location_UK                                           0.63999952  0.06852087   9.3402 < 2.2e-16 ***
## class.3.certificate_NGO                                       0.06467655  0.07008464   0.9228 0.3560933
## class.3.certificate_UK                                        0.25603530  0.07275109   3.5193 0.0004326 ***
## class.3.project_renewable                                     0.25531176  0.07785290   3.2794 0.0010402 **
## class.3.project_landfill                                     -0.34558864  0.08948905  -3.8618 0.0001126 ***
## class.3.project_manure                                       -0.21932096  0.08503452  -2.5792 0.0099030 **
## class.3.price:co2_value                                      -0.00128335  0.00156926  -0.8178 0.4134665
## class.3.price:framing_effectconsequence                      0.00103962  0.00660980   0.1573 0.8750208
## class.3.price:framing_effectMetOffice                       -0.01523893  0.00554028  -2.7506 0.0059492 **
## class.3.price:framing_effectUN                              -0.00587870  0.00635099  -0.9256 0.3546357
## class.3.location_EU:co2_value                                0.05744765  0.02037925   2.8189 0.0048184 **
## class.3.location_EU:framing_effectconsequence              -0.11702320  0.08374969  -1.3973 0.1623242
## class.3.location_EU:framing_effectMetOffice                -0.05006687  0.06862186  -0.7296 0.4656315
## class.3.location_EU:framing_effectUN                        0.02117966  0.08032398   0.2637 0.7920281
## class.3.location_UK:co2_value                               -0.07380883  0.02023556  -3.6475 0.0002648 ***
## class.3.location_UK:framing_effectconsequence              -0.46288496  0.08665611  -5.3416 9.211e-08 ***
## class.3.location_UK:framing_effectMetOffice                 0.01304941  0.07334704   0.1779 0.8587911
## class.3.location_UK:framing_effectUN                       -0.13071717  0.08294268  -1.5760 0.1150272
## class.3.certificate_NGO:co2_value                          -0.04253414  0.02163486  -1.9660 0.0492986 *
## class.3.certificate_NGO:framing_effectconsequence          -0.07261584  0.09004715  -0.8064 0.4200006
## class.3.certificate_NGO:framing_effectMetOffice             0.27754591  0.07478347   3.7113 0.0002062 ***
## class.3.certificate_NGO:framing_effectUN                    0.18687931  0.08613028   2.1697 0.0300274 *
## class.3.certificate_UK:co2_value                           -0.01970934  0.02202853  -0.8947 0.3709374
## class.3.certificate_UK:framing_effectconsequence           -0.12913475  0.09217252  -1.4010 0.1612107
## class.3.certificate_UK:framing_effectMetOffice              0.17894306  0.07653210   2.3381 0.0193798 *
## class.3.certificate_UK:framing_effectUN                     0.24614985  0.08936606   2.7544 0.0058800 **
## class.3.project_renewable:co2_value                        -0.07470769  0.02235010  -3.3426 0.0008299 ***
## class.3.project_renewable:framing_effectconsequence         0.05549296  0.09762365   0.5684 0.5697378
## class.3.project_renewable:framing_effectMetOffice           0.06547472  0.08009311   0.8175 0.4136527
## class.3.project_renewable:framing_effectUN                  0.09094448  0.09196528   0.9889 0.3227120
## class.3.project_landfill:co2_value                          0.01029564  0.02663912   0.3865 0.6991369
## class.3.project_landfill:framing_effectconsequence          0.24488636  0.11394096   2.1492 0.0316155 *
## class.3.project_landfill:framing_effectMetOffice            0.10546358  0.09452303   1.1157 0.2645314
## class.3.project_landfill:framing_effectUN                  -0.03763644  0.10808894  -0.3482 0.7276909
## class.3.project_manure:co2_value                            0.05233896  0.02578545   2.0298 0.0423782 *
## class.3.project_manure:framing_effectconsequence            0.14339547  0.10803896   1.3273 0.1844237
## class.3.project_manure:framing_effectMetOffice              0.29754609  0.09074768   3.2788 0.0010424 **
## class.3.project_manure:framing_effectUN                     0.24790486  0.10380416   2.3882 0.0169312 *
## class.4.I                                                   -3.86197929  0.10750149 -35.9249 < 2.2e-16 ***
## class.4.price                                               -0.02268608  0.00926321  -2.4491 0.0143233 *
## class.4.location_EU                                          0.10705932  0.10349180   1.0345 0.3009158
## class.4.location_UK                                          0.39607308  0.09833092   4.0280 5.626e-05 ***
## class.4.certificate_NGO                                      0.53933524  0.09822232   5.4910 3.997e-08 ***
## class.4.certificate_UK                                       0.73211690  0.11390229   6.4276 1.296e-10 ***
## class.4.project_renewable                                    0.10265946  0.11168833   0.9192 0.3580118
## class.4.project_landfill                                    -0.63063714  0.13882817  -4.5426 5.557e-06 ***
## class.4.project_manure                                      -0.37683191  0.12547149  -3.0033 0.0026705 **
## class.4.price:co2_value                                     -0.00764752  0.00306660  -2.4938 0.0126379 *
## class.4.price:framing_effectconsequence                    -0.00712198  0.01062107  -0.6706 0.5025059
## class.4.price:framing_effectMetOffice                       0.00115340  0.00957836   0.1204 0.9041524
```

```
## class.4.price:framing_effectUN                         -0.01383465  0.01043882  -1.3253 0.1850692
## class.4.location_EU:co2_value                           -0.03677785  0.03636723  -1.0113 0.3118772
## class.4.location_EU:framing_effectconsequence            0.01511458  0.11875803   0.1273 0.8987250
## class.4.location_EU:framing_effectMetOffice              0.04798024  0.10788603   0.4447 0.6565143
## class.4.location_EU:framing_effectUN                    -0.05617214  0.11885485  -0.4726 0.6364906
## class.4.location_UK:co2_value                            0.01134849  0.03599215   0.3153 0.7525305
## class.4.location_UK:framing_effectconsequence            0.05674605  0.11687227   0.4855 0.6272940
## class.4.location_UK:framing_effectMetOffice             -0.05057450  0.10374814  -0.4875 0.6259226
## class.4.location_UK:framing_effectUN                     0.01428942  0.11924078   0.1198 0.9046126
## class.4.certificate_NGO:co2_value                       -0.08167483  0.03547650  -2.3022 0.0213226 *
## class.4.certificate_NGO:framing_effectconsequence       -0.03326725  0.11496389  -0.2894 0.7722972
## class.4.certificate_NGO:framing_effectMetOffice         -0.16516494  0.10389199  -1.5898 0.1118854
## class.4.certificate_NGO:framing_effectUN                -0.15858245  0.11874001  -1.3355 0.1816985
## class.4.certificate_UK:co2_value                        -0.04599070  0.04183172  -1.0994 0.2715841
## class.4.certificate_UK:framing_effectconsequence        -0.18368780  0.13167757  -1.3950 0.1630213
## class.4.certificate_UK:framing_effectMetOffice          -0.09021296  0.11929826  -0.7562 0.4495312
## class.4.certificate_UK:framing_effectUN                 -0.25885996  0.13360316  -1.9375 0.0526808 .
## class.4.project_renewable:co2_value                      0.02761830  0.04034589   0.6845 0.4936353
## class.4.project_renewable:framing_effectconsequence    -0.00136319  0.12845506  -0.0106 0.9915329
## class.4.project_renewable:framing_effectMetOffice       -0.11048382  0.11646802  -0.9486 0.3428142
## class.4.project_renewable:framing_effectUN              0.14002259  0.13203958   1.0605 0.2889357
## class.4.project_landfill:co2_value                       0.09072550  0.04911887   1.8471 0.0647385 .
## class.4.project_landfill:framing_effectconsequence     -0.12342370  0.15860970  -0.7782 0.4364748
## class.4.project_landfill:framing_effectMetOffice        -0.21850955  0.14170483  -1.5420 0.1230724
## class.4.project_landfill:framing_effectUN               -0.02583993  0.16129189  -0.1602 0.8727188
## class.4.project_manure:co2_value                         0.05187437  0.04431592   1.1706 0.2417763
## class.4.project_manure:framing_effectconsequence        -0.06362698  0.14619326  -0.4352 0.6633990
## class.4.project_manure:framing_effectMetOffice           0.00969077  0.13279813   0.0730 0.9418271
## class.4.project_manure:framing_effectUN                 -0.14273028  0.14764287  -0.9667 0.3336808
## (class)2                                                 0.40326138  0.03892915  10.3589 < 2.2e-16 ***
## (class)3                                                 1.27127005  0.03335901  38.1087 < 2.2e-16 ***
## (class)4                                                 1.55010850  0.03213413  48.2387 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Optimization of log-likelihood by BHHH maximisation
## Log Likelihood: -16296
## Number of observations: 12760
## Number of iterations: 113
## Exit of MLE: successive function values within relative tolerance limit (reltol)


##       AIC       BIC
## 32926.45 34171.28
```

The class membership probabilities are:

```
##    Class_1    Class_2    Class_3    Class_4
## 0.09281554 0.13891684 0.33092249 0.43734512
```

The effects of demographics are:

```
## $Class_2
##                                      coef        se         z       p_val
```

```
## (Intercept)                     0.18961199 0.5777249  0.32820465 0.74275693
## age_group35_54                   0.08982129 0.3011930  0.29821834 0.76553653
## age_group55_                    -0.20755904 0.3381053 -0.61388867 0.53928890
## is_women                         0.11357565 0.2476398  0.45863238 0.64649818
## diet_typeFlexitarian            -0.08472921 0.3366959 -0.25164907 0.80131233
## diet_typeVegan_Vegetarian        0.25879796 0.4663583  0.55493379 0.57893995
## education_levelDegree           -0.13561100 0.2780009 -0.48780778 0.62568600
## education_levelPostgraduate      0.02813733 0.3541981  0.07943954 0.93668302
## hh_size                          0.03493024 0.1387731  0.25170762 0.80126707
## income_level30_50k               0.25311800 0.2911211  0.86945950 0.38459585
## income_level50_                 -0.18657428 0.3283436 -0.56822872 0.56987967
## n_children                      -0.05636437 0.1955410 -0.28824834 0.77315665
## is_shopper                       0.52282270 0.3073336  1.70115673 0.08891356
## where_liveRuralarea             -0.02684468 0.4094247 -0.06556684 0.94772269
## where_liveTownorsuburb          -0.46631408 0.3234287 -1.44178318 0.14936355
##
## $Class_3
##                                        coef        se           z      p_val
## (Intercept)                      1.01254944 0.5053865  2.00351520 0.04512202
## age_group35_54                   0.13347585 0.2667834  0.50031539 0.61685302
## age_group55_                     0.06326645 0.2945461  0.21479302 0.82992870
## is_women                         0.13753404 0.2170218  0.63373361 0.52625469
## diet_typeFlexitarian             0.22370593 0.2888025  0.77459845 0.43857697
## diet_typeVegan_Vegetarian        0.37556575 0.4178818  0.89873677 0.36879289
## education_levelDegree           -0.27207858 0.2426838 -1.12112387 0.26223514
## education_levelPostgraduate     -0.31432279 0.3164033 -0.99342450 0.32050313
## hh_size                          0.07955556 0.1220602  0.65177296 0.51454765
## income_level30_50k               0.48765094 0.2578450  1.89125596 0.05859018
## income_level50_                  0.23072792 0.2810215  0.82103306 0.41162744
## n_children                      -0.01210209 0.1709181 -0.07080635 0.94355188
## is_shopper                       0.20907560 0.2575477  0.81179357 0.41691009
## where_liveRuralarea             -0.36117513 0.3696592 -0.97704894 0.32854493
## where_liveTownorsuburb          -0.49192081 0.2876992 -1.70984397 0.08729473
##
## $Class_4
##                                        coef        se          z      p_val
## (Intercept)                      1.22662184 0.4926588  2.4897998 0.01278151
## age_group35_54                   0.11683214 0.2608767  0.4478443 0.65426556
## age_group55_                     0.24822526 0.2850002  0.8709653 0.38377308
## is_women                         0.04018989 0.2107522  0.1906974 0.84876271
## diet_typeFlexitarian            -0.11841969 0.2862535 -0.4136882 0.67910245
## diet_typeVegan_Vegetarian        0.19630185 0.4116360  0.4768822 0.63344604
## education_levelDegree           -0.17665350 0.2354536 -0.7502689 0.45309279
## education_levelPostgraduate     -0.16190327 0.3061758 -0.5287918 0.59694990
## hh_size                          0.10758422 0.1188829  0.9049596 0.36548681
## income_level30_50k               0.40740149 0.2512431  1.6215433 0.10490118
## income_level50_                  0.23352192 0.2723584  0.8574066 0.39122019
## n_children                      -0.07196474 0.1673134 -0.4301193 0.66710886
## is_shopper                       0.20576885 0.2489528  0.8265377 0.40849914
## where_liveRuralarea             -0.33366663 0.3616905 -0.9225198 0.35625752
## where_liveTownorsuburb          -0.37794358 0.2822510 -1.3390335 0.18055976
```

Based on BIC, the optimal number of classes is 3. Also, we could not estiamte a model with more than 4 classes due to lack of variation, i.e., singular hessian matrix.