1 ILVLC

Here we describe a latent class model including different latent variables in both the class allocation and utility functions.

We begin by describing the latent variable structural and measurement equations. We consider two latent variables: α_C, which will influence class allocation, and α_X, which will influence the utility of choices. The measurement equations lack an intercept because the indicators have been previously centered around their mean.

$$\begin{aligned}
\alpha_C &= \delta_C Z + \eta_C \\
\alpha_X &= \delta_X Z + \eta_X \\
ind_{C1} &= \lambda_{C1}\alpha_C + \varepsilon_{C1} \\
ind_{C2} &= \lambda_{C2}\alpha_C + \varepsilon_{C2} \\
ind_{C3} &= \lambda_{C3}\alpha_C + \varepsilon_{C3} \\
ind_{X1} &= \lambda_{X1}\alpha_X + \varepsilon_{X1} \\
ind_{X2} &= \lambda_{X2}\alpha_X + \varepsilon_{X2} \\
ind_{X3} &= \lambda_{X3}\alpha_X + \varepsilon_{X3}
\end{aligned}$$

Where α_C and α_X are latent variables, Z are socio-demographic variables, ind are continuous indicator variables, and δ and λ variables are parameters to be estimated. All η and ε variables are independent random error components following normal distributions. While η variables have a standard deviation equal to one, each ε has a different standard deviation to be estimated.

We now describe the class allocation function. We use a binary logit probability to assign between two classes. We let latent variable α_C influence the class allocation.

$$\begin{aligned}
\pi_1 &= \frac{e^{\gamma_0+\gamma_{\alpha_C}\alpha_C}}{1+e^{\gamma_0+\gamma_{\alpha_C}\alpha_C}} \\
\pi_2 &= 1-\pi_1
\end{aligned}$$

We now describe the utility functions used inside each class in the choice model. Their functional form is the same, but their parameters may take different values across classes. The functional form of the utilities for class s is as follows.

$$\begin{aligned}
V_{As} &= \beta_{As} + \beta_{1s}x_{1A} + (\beta_{2s} + \beta_{3s}\alpha_X)\, x_{2A} \\
V_{Bs} &= \beta_{Bs} + \beta_{1s}x_{1B} + (\beta_{2s} + \beta_{3s}\alpha_X)\, x_{2B} \\
V_{Cs} &= 0 + \beta_{1s}x_{1C} + (\beta_{2s} + \beta_{3s}\alpha_X)\, x_{2C}
\end{aligned}$$

The probability of choosing alternative A in scenario t in class s for individual n is a multinomial logit probability:

$$P_{tsn} = \frac{e^{V_{As}}}{e^{V_{As}} + e^{V_{Bs}} + e^{V_{Cs}}}$$

Finally, the likelihood function of the whole model for individual n would be as follows.

$$L_n = \int_{\alpha_C}\int_{\alpha_X}\prod_{i=1}^{3}\left(\phi(ind_{Ci})\phi(ind_{Xi})\right)\sum_s\left(\pi_s\left(\alpha_C\right)\prod_t P_{tsn}\left(\alpha_X\right)\right)\phi\left(\alpha_X\right)\phi\left(\alpha_C\right)d\alpha_X d\alpha_C$$