

# Assignment: Estimating Demand (Panel Data)

## Industrial Organization

This assignment is based on the data posted here for ketchup purchases made by a set of households in two US markets. More information about the data can be found here. We will focus on households in market 1.

Please use whatever package you like (e.g., Stata) to clean the data, but please do all analysis using MATLAB (or R or python if you prefer). You do not need to submit your data cleaning code. In your solutions, please describe the main decisions you made in preparing the data for analysis.

1. *Homogeneous Logit*. Suppose that for each household  $i$  on purchase occasion  $t$  the utility from purchasing ketchup brand  $j$  is given by

$$u_{ijt} = \alpha - \beta p_{ijt} + \varepsilon_{ijt} \quad (1)$$

where  $p_{ijt}$  is the per-unit price and  $\varepsilon_{ijt}$  is a utility shock distributed i.i.d. type-1 extreme value conditional on  $p_{ijt}$ . (There is no outside option.)

- (a) Estimate the parameters of the model and comment on whether the parameter estimates make sense to you.
- (b) Now re-estimate supposing that

$$u_{ijt} = \alpha_j - \beta p_{ijt} + \varepsilon_{ijt} \quad (2)$$

and comment on whether the parameter estimates make sense to you. The remaining problem is based on your estimates in this part.

- (c) What is the average willingness-to-pay for Heinz ketchup relative to store-brand ketchup?
- (d) What is the expected loss in consumer surplus (per purchase occasion) from eliminating the Del Monte brand from the market?
- (e) What is the elasticity of demand for each brand?
- (f) Assume that ketchup is produced with constant marginal cost and that each brand chooses its price to maximize its profit, taking as given the prices of the other brands. Given the elasticity in (e) and the average price of each brand, what is the implied marginal cost of each brand?
- (g) Now estimate a more flexible version of the model with

$$u_{ijt} = \alpha_j - \beta p_{ijt} + \sigma \varepsilon_{ijt} \quad (3)$$

where  $\sigma$  controls the dispersion in preferences. Does this added flexibility lead to more sensible results?

- (h) Return to the model in (2) and suppose that the cost estimates in (f) are correct. Suppose now that Del Monte exits the market and that the remaining brands choose new prices simultaneously. Assuming that the new prices constitute a Nash equilibrium of the price-setting game, what is the resulting loss in consumer surplus?

2. *Heterogeneous Logit*. Let utility now be given by

$$u_{ijt} = \alpha_{ij} - \beta p_{ijt} + \varepsilon_{ijt} \quad (4)$$

where  $\varepsilon_{ijt}$  is type-1 extreme value conditional on  $\alpha_{ij}$  and  $p_{ijt}$ .

- (a) What is the maximum likelihood estimate of this model?
- (b) Now suppose that  $\alpha_i \stackrel{i.i.d.}{\sim} N(\mu, \Sigma)$  where  $\alpha_i$  is the vector of  $\alpha_{ijs}$ ,  $\mu$  is a vector, and  $\Sigma$  is a diagonal matrix. What is the maximum likelihood estimate of this model?
- (c) From the estimates in (b), what is the mean and standard deviation (across households) of the willingness-to-pay for Heinz ketchup relative to store-brand ketchup?
- (d) From the estimates in (b), what is the elasticity of demand for each brand?