# Computational Method Problem Set 3

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June 8 ,2020

## 1 Data

The dataset we use in the problem set was collected by Ciliberto and Tamer(2009) from the second quarter of the 2001 Airline Origin and Des-tination Survey (DB1B), which contains 2,742 airport-to-airport pairs data. For example, pair ATLJFK denotes the airline route from Atlanta airport to JFK airport, NY. Empirically, Each route is regarded as one specific market, where different airlines decide whether to enter or not. Summary statistics is presented in Table 1. The first 6 rows of the table are 6 different firms dummies (From airlineAA to airlineWN). Variables take the value 1 if one firm enter that market and 0 if the firm does not, and their mean entry rate lie between 0.162 to 0.551 across all 2,742 markets(routes).

First, we could see the market-level features. The variable $marketdistance$ captures the distance from one airport to another; mindistance and fromcenterdistance then use different baseline to calculate the distance between 2 airports. Variable $marketsize$ measures the population of each market, the mean $marketsize$ is 2.259.

The firm specific features are $marketpresence$ and $mindistancefromhub$. The market presence are constructed to measure the carriers' heterogeneity; and the min. distance from hub was computed as a proxy for firms' cost.

Lastly, the N denotes the total airline entrants within a market, the mean entrant is about 2.2 firms out of total 6 firms. In addition, we calculate the $log(N)$ value for later use, and its value lie between 0 to 2 with mean .656.

# 2 Identification

## 2.1 Ordered Probit

We first use below model to capture the effect of number of entering firms and the market characteristics.

$$\pi_{ik}(N) = X_i\beta - \delta lnN + u_{i0} \tag{1}$$

The $\pi_{ik}$ denotes the latent profit of firm $k$ in market $i$, and the $X_i$ denotes the market characteristics, including market distance and market size. The former is used as a approximation for the cost, the latter, the demand side. Here, we ignore the heterogeneity between firms and assumed the profit to be decreasing in total entrant $N$. The $u_{i0}$ is assumed to be drawn from standard normal and represent the market features unobserved by researcher.

We employ ordered Probit regression to estimate the model, which using total number of entrants as ordered dependent variable. $(6 > 5 > ... > 1 > 0)$.

## 2.2 Firm Heterogeneity

Secondly, we allow the firms to have their specific characteristics. Extend the original model to equation 2:

$$\pi_{ik}(N) = X_i\beta + Z_{ik} - \delta lnN + \rho u_{i0} + \sigma u_{ik} \tag{2}$$

where $Z_{ik}$ are firms' characteristic, $u_{ik}$ denotes characteristics unobserved by researchers. Additionally, $\sigma$ is assumed to be $\sqrt{1-\rho^2}$, which makes the variance of unobservable be 1. Here I follow the method of Berry(1992). I construct my objective function for optimization as follow:

First create the predicted $N^*$ according to:

$$\hat{\pi}(N, \hat{u}_i) = X_i\beta + Z_{ik}\alpha - \delta lnN + \rho\hat{u}_{i0} + \sqrt{1-\rho^2}\hat{u}_{ik} \tag{3}$$

Then I use this predicted profit to calculate how many firm will keep positive profit given the parameters $(\beta, \alpha, \delta, \rho)$. From above, we could obtain the $\hat{n}$, which is the predicted number of entrants by summing over 6 firms' enter decision $\{1, 0\}$.

With 100 repetitions of above process, we calculate the average predicted $\hat{N} = \frac{1}{R}\sum_r \hat{n}_r$. Then calculate the prediction error $v = N^* - \hat{N}$.

The objective function $Q_N(\theta)$ then using the moment condition that error's expectation should equals to 0.

$$Q_N(\theta) = E[v|\theta, W]'E[v|\theta, W] \tag{4}$$

where $\theta = (\beta, \alpha, \delta, \rho)$. By solving optimization of $Q_N$, the optimal $\theta$ will be calculated.

# 3 Results

## 3.1 Ordered Probit

The result is presented in Table 2. The ordered probit model shows that there is a negative effect of market distance, i.e., the longer distance the route (market) takes, the lower probability for firm to enter the market. Similar effect for market size, and both effect are significant negative. This is a little deviated from the theoretical result, the distance should have negative relation, yet market size should have positive effect on probability of entering market. The $ln(N)$ part shows no significant effect, yet its coefficient is far greater than zero. It is also contradicted to the theory.

## 3.2 Method of Simulated Moments

The MSM (Method of Simulated Moments) results is presented in Table 3. The coefficients will be the column 1, which are mean of 50 repetitions. All the variable appear to be not significant, yet the coefficient $\delta$ has mean of -2.027, appears to be more plausible compared to the ordered probit result in Table 2.

## 3.3 Conclusion

In summary, both results have implausible parts. The ordered probit model have positive $\delta$. Even though we ignore the firms' heterogeneity, the more firms in the market should make the profit decrease. The MSM results, on the other hand, have reasonable $\delta$ estimation, yet still not significant.

# 4 Remarks

I first use R and its 'MASS' package for ordered probit model. However, the inclusion of $ln(N)$ variable makes the probit model calculation fail. The Stata oprobit could still yield the estimation provided in Table 2, yet the coefficients seem to be odd.

For the simulation part, I use R's maxLik package for optimization, yet the BFGS, Nelder-Mead, and the BHHH method both fail, they are all easy to change with the different initial values. Only BFGSR method could provide solid results. Hence in Table 3, the result was calculated using BFGSR method.

R scripts and Stata .do file will be attached when submitting homework.

Table 1: Summary Statistics

| Statistic | N | Mean | St. Dev. | Min | Max |
|---|---|---|---|---|---|
| airlineAA | 2,742 | 0.426 | 0.495 | 0 | 1 |
| airlineDL | 2,742 | 0.551 | 0.497 | 0 | 1 |
| airlineUA | 2,742 | 0.275 | 0.447 | 0 | 1 |
| airlineAL | 2,742 | 0.548 | 0.498 | 0 | 1 |
| airlineLCC | 2,742 | 0.162 | 0.369 | 0 | 1 |
| airlineWN | 2,742 | 0.247 | 0.431 | 0 | 1 |
| marketdistance | 2,742 | 1.085 | 0.624 | 0.067 | 2.724 |
| fromcenterdistance | 2,742 | 1.571 | 0.594 | 0.283 | 3.390 |
| mindistance | 2,742 | 0.346 | 0.205 | 0.102 | 1.505 |
| changeincmarket | 2,742 | 4.051 | 1.478 | −0.300 | 10.050 |
| percapitaincmarket | 2,742 | 3.240 | 0.391 | 1.702 | 4.580 |
| marketsize | 2,742 | 2.259 | 1.846 | 0.310 | 15.236 |
| wrightamendmDAL | 2,742 | 0.030 | 0.169 | 0 | 1 |
| dallasmarket | 2,742 | 0.070 | 0.255 | 0 | 1 |
| marketpresenceAA | 2,742 | 0.422 | 0.167 | 0.000 | 0.873 |
| marketpresenceDL | 2,742 | 0.540 | 0.181 | 0.000 | 0.987 |
| marketpresenceUA | 2,742 | 0.265 | 0.153 | 0.000 | 0.689 |
| marketpresenceAL | 2,742 | 0.376 | 0.135 | 0.000 | 0.850 |
| marketpresenceLCC | 2,742 | 0.098 | 0.077 | 0.000 | 0.650 |
| marketpresenceWN | 2,742 | 0.242 | 0.176 | 0 | 1 |
| mindistancefromhubAA | 2,742 | 0.736 | 1.609 | 0.000 | 27.570 |
| mindistancefromhubDL | 2,742 | 0.420 | 1.322 | 0 | 28 |
| mindistancefromhubUA | 2,742 | 0.784 | 1.476 | 0.000 | 21.096 |
| mindistancefromhubAL | 2,742 | 0.229 | 0.615 | 0.000 | 11.620 |
| mindistancefromhubLCC | 2,742 | 0.043 | 0.174 | 0 | 3 |
| mindistancefromhubWN | 2,742 | 0.303 | 0.860 | 0.000 | 16.180 |
| lnN | 2,742 | 0.656 | 0.582 | 0 | 2 |
| totalN | 2,742 | 2.209 | 1.423 | 0 | 6 |

Table 2: Ordered Probit

| | (1) |
|---|---|
| | N |
| marketdistance | -0.202** |
| | (-2.69) |
| marketsize | -0.0889*** |
| | (-3.66) |
| lnN | 90.63 |
| | (0.00) |
| _cut1 | -1.244*** |
| | (-12.90) |
| _cut2 | 52.98 |
| | (0.00) |
| _cut3 | 71.72 |
| | (0.00) |
| _cut4 | 108.0 |
| | (0.00) |
| _cut5 | 134.0 |
| | (0.00) |
| _cut6 | 153.6 |
| | (0.00) |
| *N* | 2742 |

$t$ statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3: Simulation results

| Statistic | Mean | St. Dev. | Min | Pctl(25) | Pctl(75) | Max |
|---|---|---|---|---|---|---|
| mkt. dist. | 4.574 | 7.635 | −1.597 | 0.261 | 5.463 | 25.804 |
| mkt. size | 6.793 | 15.599 | −5.480 | −0.291 | 6.517 | 68.186 |
| mkt.hub dist. | 1.917 | 5.233 | −4.502 | −0.150 | 2.399 | 22.311 |
| mkt. presense | 8.602 | 24.977 | −1.553 | 0.172 | 4.443 | 112.513 |
| $\delta$ | −2.027 | 5.450 | −18.628 | −3.039 | 1.175 | 4.137 |
| $\rho$ | −0.195 | 0.727 | −0.998 | −0.921 | 0.572 | 1.000 |