Problem Set #[4]

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I analyze the market for radio station mergers from the years 2007 and 2008 using the data provided. For the first model, I parameterize the payoff from a merger as shown in Equation (1).

$$f_m(b,t) = x_{1bm}y_{1tm} + \alpha x_{2bm}y_{1tm} + \beta distance_{btm} + \epsilon_{btm} \tag{1}$$

where x_{1bm} is the number of stations owned by the parent company of the buyer and y_{1tm} is the population (in millions) in range of the target in market m, x_{2bm} is an indicator for corporate ownership, and $distance_{btm}$ is the distance (in miles) between the buyer and target. The match-specific error term, ϵ_{btm} is independent across matches.

I begin by reading in the data and converting the population and price variables into millions. The geographical distances are computed using the `geopy.distance.vincenty` class as suggested.

In order to estimate the parameters α and β defined in Equation (1), I define the objective function used to compute the maximum score estimator. This involves computing the payoff of an actual observed match, and comparing it with every other possible match involving the acquirer and target from a pair of observed matches. Thus, I end up constructing matrices $f_{07}(b,t)$ and $f_{08}(b,t)$, where each entry corresponds to the value of a match between the acquirer-target pair (b,t). The elements along the diagonal represent the actual matches while all others represent counterfactual matches.

In order to compute each indicator function in the objective function, I compare the sum of the $f(b,t)$ values for each pair along the diagonal with the sum of the targets switched between these buyers. For example, assume buyer 1 acquires target 1, while buyer 2 acquires target 2. Then, the sum of the payoffs from these acquisitions is compared with the sum of the payoff from buyer 1 acquiring target 2 and the payoff from buyer 2 acquiring target 1. Finally, the indicator functions across each pair, and both years are summed to provide the objective function. This objective function is then passed to a differential evolution optimizer that is available in the `scipy` package.

This optimizer is very sensitive to the bounds specified on the parameters that are to be estimated. After playing around with the bounds, I was finally able to narrow down the ranges that seem to give me the best value of the objective function. I then ran the optimizer multiple times with these seemingly better bounds to see if I can observe any further improvement on the objective function. Unfortunately, I did not observe any difference across multiple (10) runs. Further, the running time of the differential evolution optimizer seems very sensitive to the specified bounds. Tight bounds seem to increase running time greatly.

The parameter estimates for this model without considering the price are as follows: $\alpha = 2271.12$ and $\beta = -0.11$. While the statistical significance of these estimates is unknown given that I do not construct confidence intervals, the magnitudes can be interpreted. Firstly, these coefficients are relative to the first term $x_{1bm}y_{1tm}$. I believe that α tells us that the impact of corporate ownership on a match is much higher than the number of stations owned by the parent company of the buyer. More specifically, buyers that are corporately owned obtain a higher payoff than those that aren't, and this effect of corporate ownership on payoff is far more pronounced than the effect of the size (number of stations owned by the buyer) of the buyer. This indicates that corporately owned stations obtain more value from such mergers. On the other hand, I see that geographical proximity has a negative impact on the value obtained from a merger. That is, the further away a station is from the buyer, the less value the buyer obtains from the merger. In terms of the magnitude of this impact, I conclude that distance has a very small impact on merger payoff compared to corporate ownership.

I follow this by estimating a model that accounts for the price of the merger. In this model, we also account for target characteristics as shown in Equation (2).

$$f_m(b,t) = \delta x_{1bm} y_{1tm} + \alpha x_{2bm} y_{1tm} + \gamma HHI_{tm} + \beta distance_{btm} + \epsilon_{btm} \tag{2}$$

where HHI_{tm} is the Hindahl-Hirschman Index measuring market concentration (a higher index means a more concentrated market) in the location of the target in market m.

In estimating this model, the indicator functions that are to be computed are of the form

$$\mathbb{1}\left[f(b,t \mid \beta) - f(b,t' \mid \beta) \geq p_{bt} - p_{b't'} \wedge f(b',t' \mid \beta) - f(b',t \mid \beta) \geq p_{b't'} - p_{bt}\right] \tag{3}$$

These indicator functions are computed for each pair of observed matches and their corresponding counterfactuals. Returning to the earlier example, $f(1,1)$ and $f(2,2)$ are the observed matches, while $f(1,2)$ and $f(2,1)$ are the counterfactuals. I require only the true observed prices since a structural estimation approach assumes that the system is in equilibrium.

Once again, I use the differential evolution routine, but running times are awfully high. The bounds once again seem to affect the actual parameter estimates very significantly. In fact, this effect is far more pronounced for this model. I use the bounds $(-1e+9, 1e+9), (-1e+9, 1e+9), (-1e+9, 1e+9), (-1e+9, 1e+9)$ for $\delta, \alpha, \beta, \gamma$ respectively. Nonetheless, the parameter estimates are as follows: $delta = -720211904.03$, $\alpha = -634677701.09$, $\gamma = 4848800.46$ and $\beta = -583555503.27$. While interpreting the quantities themselves seems unimportant, it is worthwhile considering the directional impact of these variables. All the estimates are relative to the price of the merger. I observe that corporate ownership has the opposite impact on the value of the merger i.e., buyers that are corporately owned obtain less value from these mergers than those that are not. Similarly, buyers with more number of stations obtain lower payoffs from these mergers, and the distance between buyers and targets is inversely related to the value that the two obtain from the merger. On the other hand, acquiring targets in more concentrated markets yields higher total payoff. It is worthwhile noting that the estimate for γ is two orders of magnitude smaller than all the other estimates. This indicates that the impact of market concentration is far less pronounced than the other factors.

Additional comments:

1. The convergence of the differential evolution routine is highly dependent on the bounds specified for the parameter. I did try using Nelder-Mead but unless I am very close to what seems to be the optimum, the output of the optimization routine is the same as the initial points. It seems like the initial hypercube that differential evolution uses is somehow dependent on the specified bounds. It is strange that wider parametric ranges work better than smaller ones.

2. The switch in the sign of the estimate of α across the two models is surprising. This is probably due to the fact that the initial model is poorly specified.

3. The objective function definitions themselves seem to run very fast. The matrices used have dimensions of only about 200×200 and evaluating them with pre-specified parameter values takes just seconds. I am pretty certain that it is the differential evolution routine that is taking extremely long.

4. I was able to obtain parameter estimates for the model that includes price with narrower parametric bounds ($(-1e+3, 1e+3)$ for all parameters but the objective value was worse off).