**Economics 696F, Causal Inference and Program Evaluation**

**Problem Set 3: due Friday, March 30**

1. This question is based on Graddy, "Testing for Imperfect Competition in the Fulton Fish Market," *RAND Journal of Economics*, 1995. Graddy collected data on a market for whiting (a kind of fish) at the Fulton fish market in New York City.

   There are 111 daily observations on $p$ (log price of fish), $q$ (log quantity of fish). A measure of *offshore* weather is recorded in the variable stormy (indicates wave height greater than 4.5 feet and wind speed greater than 1.8 knots). There are also variables characterizing on-shore weather: cold (indicates temperature less than the median average daily temperature of 41.5 degrees), and rainy (indicates any precipitation during the day). In addition, there are dummy variables to indicate the day of the week: mon, tue, wed, and thu. These are contained in the Matlab file `hw3a.mat` and also in the ascii file `hw3a.dat`.

   Consider the following supply and demand model

   $$\text{Demand:} \qquad q = \alpha_0 + \alpha_1 p + \epsilon^d,$$

   $$\text{Supply:} \qquad q = \beta_0 + \beta_1 p + \beta_2 z + \epsilon^s.$$

   Here $z =$ stormy. The interpretation is that bad offshore weather shifts supply but not demand. Assume that $\epsilon^d$ and $\epsilon^s$ satisfy:

   $$E[\epsilon^d|z] = 0, \qquad E[\epsilon^s|z] = 0, \qquad Cov[\epsilon^d, \epsilon^s|z] = 0.$$

   (a) Estimate the least-squares regression of $q$ on a constant and $p$. We expect that the slope coefficient is a biased estimate of the demand elasticity. Determine whether the bias is positive or negative analytically.

   (b) Provide a consistent estimate of the demand elasticity using the data. Interpret the estimated elasticity.

   (c) It could be argued that the stormy variable cannot be excluded from the demand equation, since off-shore weather could affect demand, if only because it is correlated with on-shore weather. One solution is to use the other conditioning variables. Letting $x$ denote the vector containing the variables cold, rainy, mon, tue, wed, and thu, consider the expanded model

   $$\text{Demand:} \qquad q = \alpha_0 + \alpha_1 p + \alpha_2' x + \epsilon^d,$$

   $$\text{Supply:} \qquad q = \beta_0 + \beta_1 p + \beta_2' x + \beta_3 z + \epsilon^s.$$

   Is the exclusion restriction more plausible in the expanded model?

(d) Based on the expanded model of part (c), calculate the 2SLS estimate of the demand elasticity, along with the asymptotic standard error (under homoskedasticity).

(e) Obtain standard errors that are robust to heteroskedasticity, and explain how these are calculated. Do these standard errors differ from the ones obtained in part (d)?

2. The file `hw3b.dat` contains observations on three variables, $Y, X, Z$ assumed to follow the model in Imbens and Newey (2004).

   Write a program to implement the Imbens-Newey estimator. In doing this, you can use a quadratic polynomial in $Z$ when estimating $F_{X|Z}$. In other words, set $q^L(z) = (1, z, z^2)'$.

   Also, use $p^K(w) = p^K(x, \eta) = (1, x, \eta, x \cdot \eta)'$.

   For calculating the integral

$$\hat{\mu}(x) = \int_0^1 \hat{\beta}(x, \eta) d\eta,$$

   you can approximate this by simply averaging $\hat{\beta}(x, \eta)$ over the grid

$$\eta \in \{.01, .02, \ldots, .99\}.$$

   Provide estimates of $\hat{\mu}(x)$ at $x = 0, .5, 1$.

   You do not need to provide standard errors.