Lecture 3: Demand Analysis

Quantitative Methods for Regulation and Competition

Today's Lecture

- Demand analysis:
  - Own-price elasticity analysis
  - Cross-price elasticities
  - Residual demand analysis
  - Critical loss analysis

SSNIP Test and Own-Price Elasticity

- Hypothetical monopolist profitably increase prices? Which effect dominates?
  - Higher revenues from quantity sold (+)
  - Lower revenues from lost sales (-)
  - Lower costs from less quantity sold (+)

- Crucial factor: own-elasticity of demand
  - % change in quantity demanded due to 1% price increase
  - Low elasticity implies that the second effect is not important (SSNIP is profitable, market narrow)
  - High elasticity implies that the second effect is important (SSNIP is profitable, market wide)
  - A price rise increases revenues as long as demand is inelastic (between 0 and -1)
  - If demand is elastic then revenues decrease and we need to assess how lower sales affects costs

Estimating elasticities

- In QT1, you explained the variation in Y with more than one explanatory variable, the X's:

$$Y_i = \beta_0 + \beta_1 X_{1,i} + \beta_2 X_{2,i} + \ldots + \beta_k X_{k,i} + \varepsilon_i$$

- Example: we could estimate the demand for petrol (in logs!)

$$\ln(G_i / pop_i) = \beta_0 + \beta_1 \ln(Income_i) + \beta_2 \ln(priceG_i) + \beta_3 \ln(priceCars_i) + \varepsilon_i$$

- Here, the interpretation of the β's are:
  - β_1 income elasticity of demand
  - β_2 own-price elasticity of demand
  - β_3 cross-price elasticity of demand

Problems: Violations of OLS model (1)

- Excluding a relevant explanatory variable:
  - Suppose the correct model is
    - $Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \varepsilon_i$
  - But we erroneously estimate
    - $Y_i = \tilde{\beta}_0 + \tilde{\beta}_1 X_{1i} + \tilde{\varepsilon}_i$
  - Then one can show that (see Ashenfelter, chapter 13.3):

$$E(\hat{\tilde{\beta}}_1) = \beta_1 + b_{12}\beta_2$$

where b_{12} is the impact of X_1 on X_2 (their "correlation")

- If the variable that we include (X_1) is correlated with a variable that we erroneously exclude (X_2), then our estimates are biased!

Problems: Violations of OLS model (2)

- Including an irrelevant variable:

$$\text{(True specification) } Y_i = \beta_0 + \beta_1 X_{1i} + \varepsilon_i$$

$$\text{(Our specification) } Y_i = \tilde{\beta}_0 + \tilde{\beta}_1 X_{1i} + \tilde{\beta}_2 X_{2i} + \tilde{\varepsilon}_i$$

  - Then one can show that our estimator is unbiased:

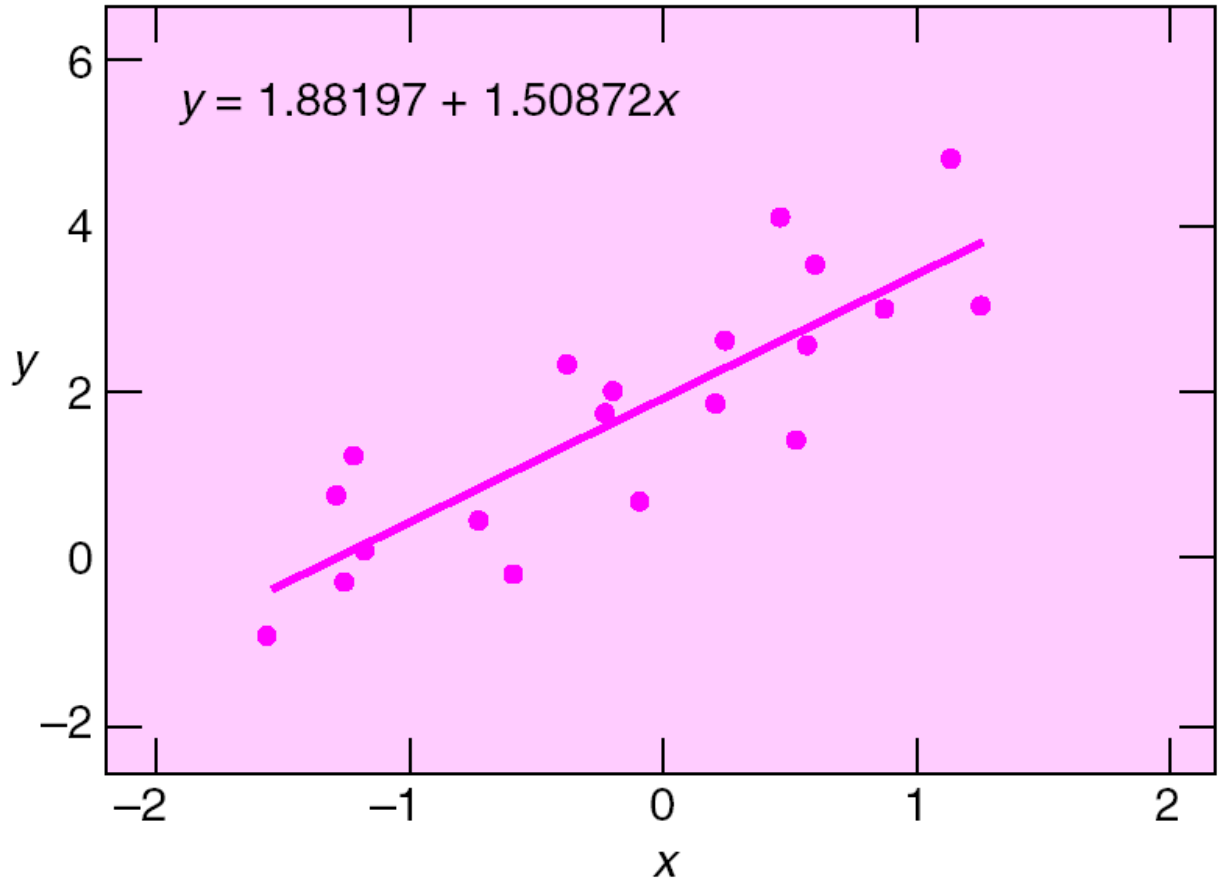
$$E(\tilde{\tilde{\beta}}_1) = \beta_1$$

  - Since the standard errors of these estimates are unbiased, also the constructed confidence intervals are correct
  - However, the estimates are not efficient

Problems: Violations of OLS model (3)

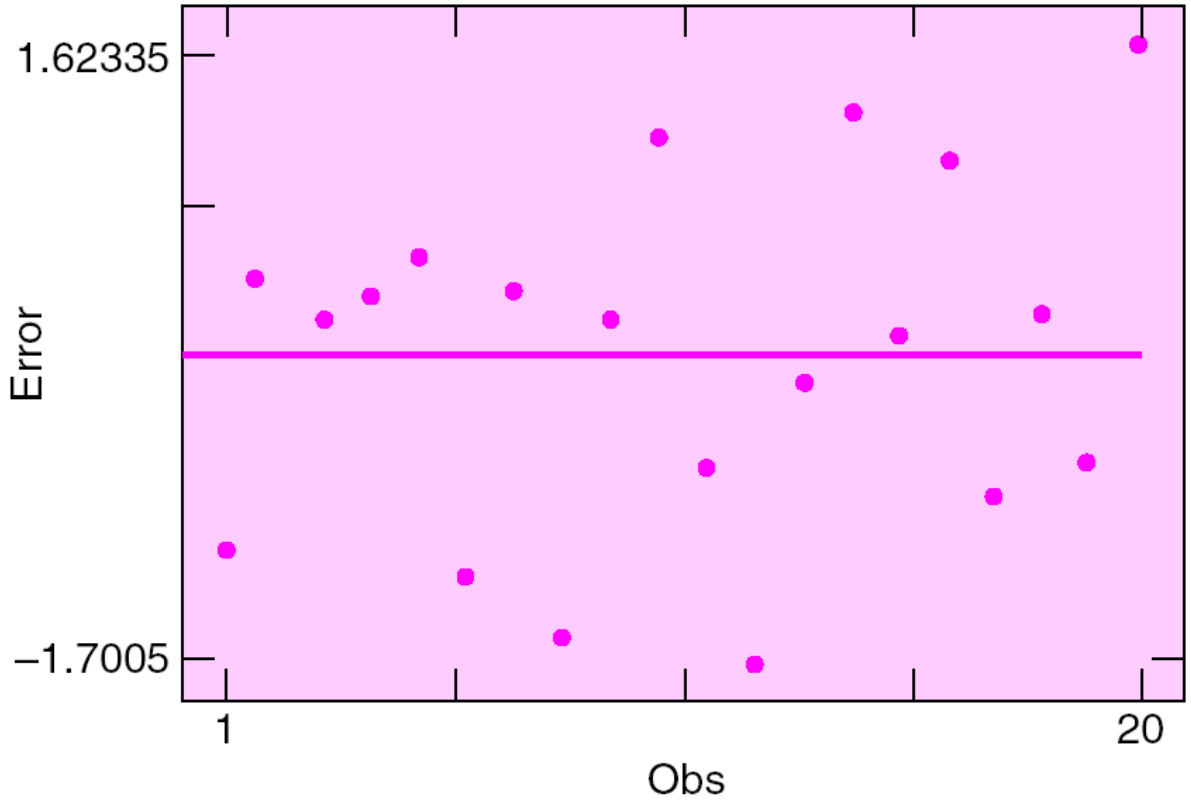
- When using time series data, errors might be serially correlated:
  - Factors omitted (and therefore contained in the error term) might be correlated over time
  - In the previous example, we may forget the price of cars. This variable might be correlated over time.
- Consequences:
  - OLS estimators are unbiased
  - But they are not the best unbiased estimators
  - Hypothesis tests could yield erroneous results, since the estimators of the standard errors are biased
- For detection tests and correcting procedures see Ashenfelter et al.

Serial Correlation



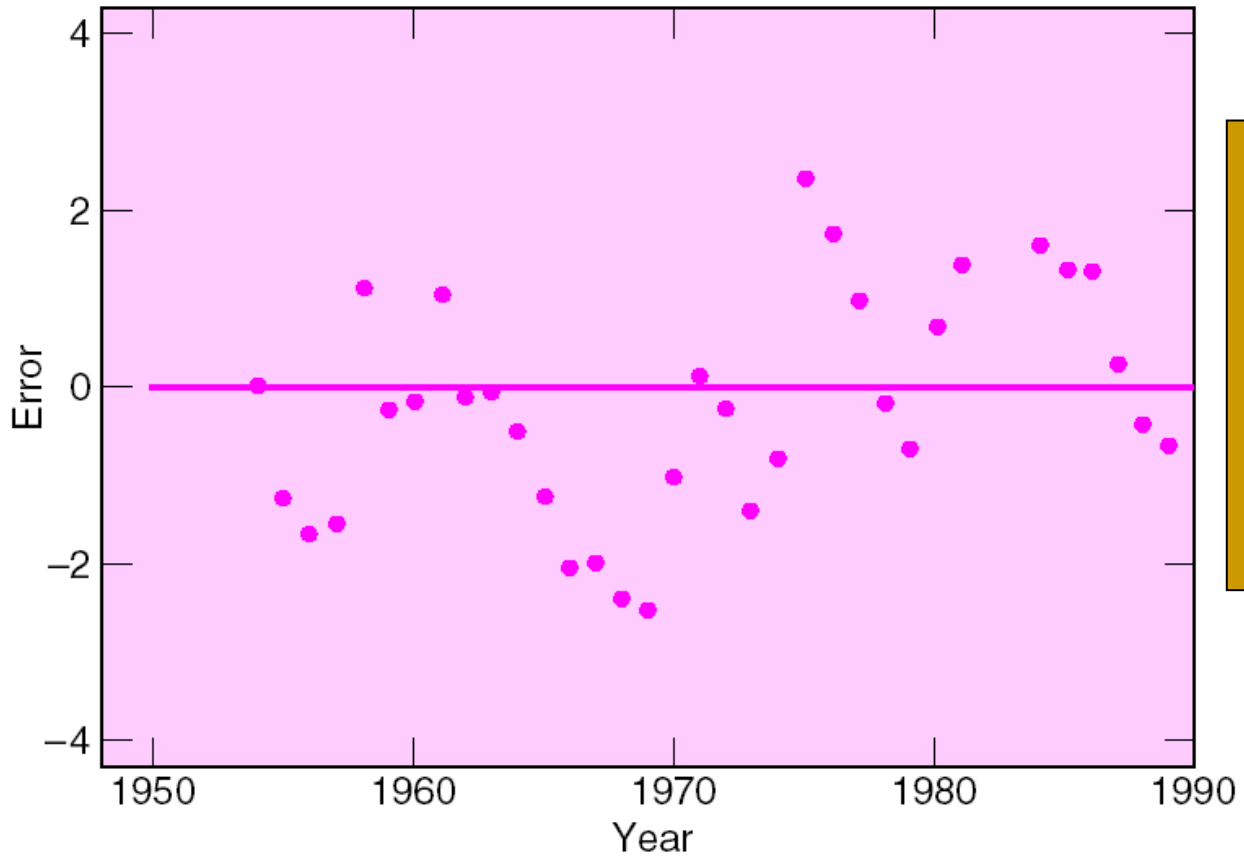
Graph shows the scatterplot of *Y* against *X*.

Serial Correlation



Graph shows the errors for the different observations, which exhibit no obvious pattern—the errors seem random. Sometimes, however, the errors follow a pattern—they are correlated across observations, creating a situation in which the observations are not independent with one another.

Serial Correlation



This graph shows another example of residuals that do not seem to be random, but rather seem to follow a pattern.

How elastic?

- How elastic does the demand need to be to make the increase in price unprofitable?
  - Costs also need to be taken into account
  - For an X% price increase is unprofitable iff

$$\beta_2 \geq \frac{1}{X+m} \text{ where } m = \frac{\text{Initial Price} - \text{Average Variable Cost}}{\text{Initial Price}}$$

  - Higher margins means lower critical values
  - Higher X means lower critical values

Applications

- Consumer toiletries:
  - Do certain specialty shampoos, such as anti-dandruff, form a separate market?
  - Own-price elasticity for anti-dandruff shampoo 1.6% (greater for others) and margins between 70-80%
  - Since $1.6 > \frac{1}{.05+.70} = 1.33$

    the market should be wider than for specialty shampoos
- Software:
  - Distinct market of software used for certain applications?
  - Own-price elasticity 1.1 and margins between 35-45%
  - Since $1.1 < \frac{1}{.10+.35} = 1.25$

    the market should only be for software for these applications (narrow)

Cross-price elasticities

- In principle, two product are in same market = high cross-price elasticity
- However, cross price elasticity might be low among products in the same market if there are a high number of weak substitutes
- Hence, technique not able to answer market definition question directly
- But it always provides evidence as to which products are substitutes

Residual demand analysis

- In the previous analysis: demand-side substitutability
- But, we should also take into account the reaction of the other firms (supply-side substitutability):

$$D_i(p) = D(p) - S_{-i}(p)$$

- This technique estimates the demand allowing for the reactions of competitors
- For details, see LECG (1999) and Motta (2004). See Baker and Bresnahan (1985) for an example

The problem

- A firm (or group of firms) have residual demand function:

$$q_i = f(p_i, y, x)$$

where x are cost shifting variable(s) such as (industry) input prices and y are demand-shifting variable(s) such as income

- Example in the beer industry (Baker and Bresnahan, 1985):
  - Quantity sold in a given year (adjusted per capita)
  - Prices (from trade publications) in real terms
  - Cost side variables: index of short-run average cost for the industry, including labour (average hourly wage of brewing production workers), agricultural and energy inputs
  - Demand side variables: per capita disposable income, percentage of drinking population,…
- Problem: quantity sold and price charged simultaneously determined

The solution: instrumental variables (IV)

- Find variable z that affect the cost of firm i but not those of the rival firms ("instrument")
- Step 1: Regress quantity on (z,x,y)

$$q_i = \beta_0 + \beta_1 z_i + \beta_2 y + \beta_3 x + \varepsilon_i$$

- Step 2: Compute fitted values for q_i

$$\hat{q}_i = \hat{\beta}_0 + \hat{\beta}_1 z_i + \hat{\beta}_2 y + \hat{\beta}_3 x$$

- Step 3: Regress prices on fitted values of q_i

$$p_i = \delta_0 + \delta_1 \hat{q}_i + \delta_2 y + \delta_3 x + u_i$$

- Elasticity of residual demand: $1/\delta_1$

Caveats

- Need in-depth knowledge of the industry
- Important to choose instrument correctly:
  - Does it affect only the firm(s) of interest? Not possible to test
  - Estimates are not very precise
  - Baker and Bresnahan (1985): brewer plant capacity

Critical Loss Analysis

- This techniques asks…

  "given an X% price increase, what would the % loss in unit sales have to be to make it unprofitable?"

- Then the price increase is…
  - Profitable if actual loss is lower than critical loss
  - Unprofitable if actual loss is higher than critical loss
- Alternative method for applying SSNIP test when demand elasticities cannot be estimated

Description

- For a price increase of X%, we have that:

$$\text{Critical Loss} = \frac{X}{X+m} * 100 \text{ where } \quad m = \frac{\text{Initial Price} - \text{Average Variable Cost}}{\text{Initial Price}}$$

- Example:
  - If the margin is 60%, the critical loss from a 5% price increase is:

$$\text{Critical Loss} = \frac{.05}{.05+.6} * 100 = 7.7\%$$

- Higher margins means lower critical values
- Higher X means higher critical values

Critical Loss Estimates

	Price increase (percentage)		
Gross margin (percentage)	5%	7.5%	10%
10%	33%	43%	50%
20%	20%	27%	33%
30%	14%	20%	25%
40%	11%	16%	20%
50%	9%	13%	17%

Source: Lexecon (2005)

Application

- Tenet Healthcare Corporation:
  - Merger between the only two general hospitals in Poplar Bluff, Missouri
  - Is the geographical market wider? FTC only local
  - Critical loss analysis: margin of 65% and therefore a 5% price increase gives CL=7%
  - Parties claimed that more would have switched:
    - 55% of current patients come from areas where other people use hospitals from other places

Caveats

- Firm's margins also provides information about the magnitude of sales likely to be lost, for example…
  - High price margin because customers are not price sensitive
  - Small number of lost sales then
- Ignorance of degree of substitutability among products
  - In a merger, if substitutability between the products is…
    - Low, then a price increase of one product does not increase the sales of the other
    - High, then a price increase of one results in substantial sales to the other (and they are more important as margins grow)
  - Similarly, in market definition cases, one needs to take into account the substitution between the products of the hypothetical monopolist
  - See O'Brien and Wickelgren (2003), FTC