

Advanced Industrial Organization I

Lecture 3: Demand & Market Structure

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1. Introduction

[Note: These notes contain the material I presented in lecture 3 - I've just used a different format in order to conserve paper and facilitate printing. I have also corrected some typos].

References for this lecture:

- These notes.
- Chapters 2-3 in Pepall et al. (2008)
- Epple, Dennis and Bennett T. McCallum (2005). "Simultaneous Equation Econometrics: The Missing Example".
- Ashenfelter, Orley, David Ashmore, Jonathan B. Baker, Suzanne Bleason and Daniel S. Hosken (2005). "Econometric Methods in Staples," mimeo, Princeton University.

The papers by Epple & McCallum, and Ashenfelter et al. can be obtained from the course web-page.

- In the **first** part of this lecture I will discuss basic microeconomic theory of supply and demand, and important issues that arise in empirical analysis of supply and demand.
 - I begin by reviewing familiar models of firm behaviour, looking at the case of perfect competition and monopoly, and show how optimal supply is determined in such models.
 - By assuming that the market is in equilibrium, so that demand equals supply, I write down a simple system of equations modelling supply and demand. These equations, no doubt, will be very familiar to you.
 - I then discuss important issues that arise when we want to estimate the parameters in the supply-demand model. I begin by discussing what types of data will be needed. I then discuss identification. Finally, I link these points to choice of estimator.
 - We will follow up on some of these points in the first group assignment, where we will use data on chicken consumption & production in the U.S. for 1960-1999 to attempt to estimate supply

and demand functions. These data, which were used in the paper by Epple and McCallum (2005).

- In the **second** part of the lecture I will discuss market structure and market power.
- In particular, I will focus on empirical methods that can be used for **describing** the market structure, and analyzing the **consequences** of different forms of market structure on firm behaviour and, ultimately, consumer welfare.

2. Perfect Competition & Monopoly: Market Outcomes

References:

- Ch. 2 in Pepall et al.
- Epple and McCallum (2005).
- Theories of perfect competition and monopoly were developed early in the literature and remain central in industrial organization. In this section we review simple models for these types of market structure, and investigate what the implications are for producer decisions.
- We assume that firms seek to **maximize profits**, and make their production decisions accordingly.
- As you know, the **demand** for the firm's product is a fundamental factor determining the production decisions of the firm.
- We take as given the derivation of an aggregate consumer demand curve. That is, we happily assume that quantity demanded is a decreasing function of the price, and don't worry about the details involved in actually deriving this demand curve from consumers' utility maximization problem.
- The two most common functional forms for demand are
 - **Linear** demand function, e.g.

$$Q^D = a - b \times P,$$

where $a > 0$ and $b > 0$ are demand parameters; Q^D denotes quantity demanded; and P is the price.

- Demand function with **constant price elasticity of demand**, e.g.

$$Q^D = X \times P^{-\eta},$$

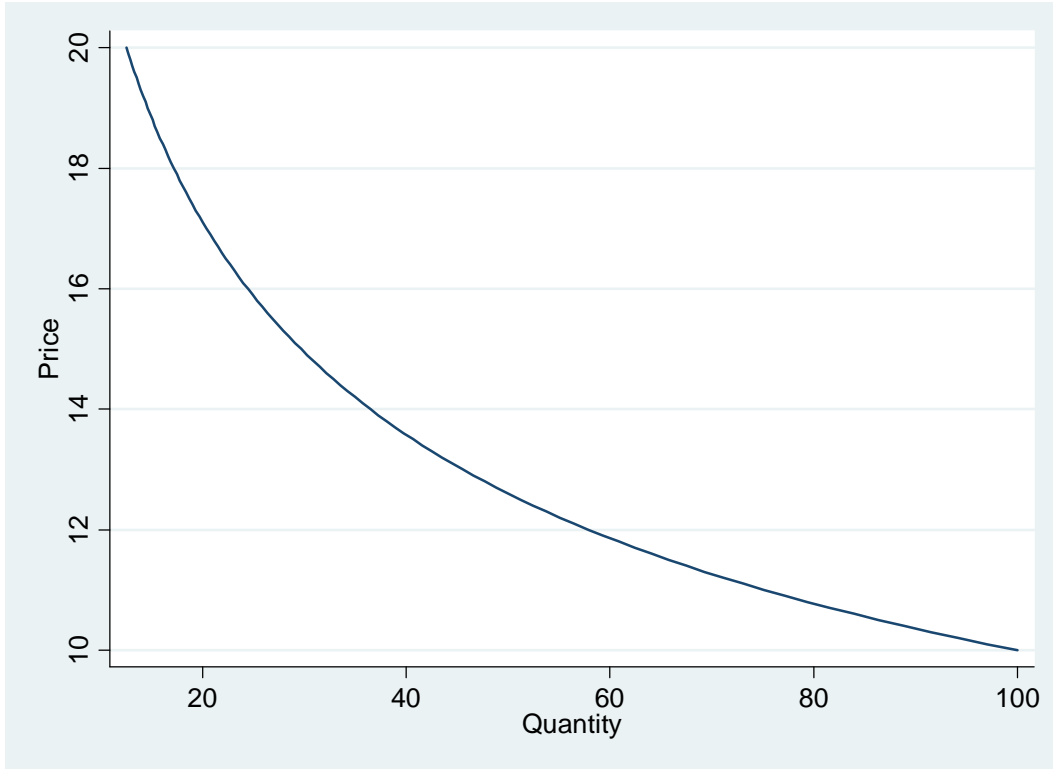
where $-\eta < -1$ is the price elasticity of demand, and X is a demand shift parameter.

- These are illustrated in Figure 1 (notice that, as is customary in the literature, the price appears on the vertical axes in these graphs).
- [Insert Figure 1 here]

Figure 1: Two common demand functions

A. Demand Function: Constant Price Elasticity of Demand

Quantity Demanded = $100,000 * Price^{-3}$



B. Demand Function: Linear

Quantity Demanded = $200 - 10 * Price$

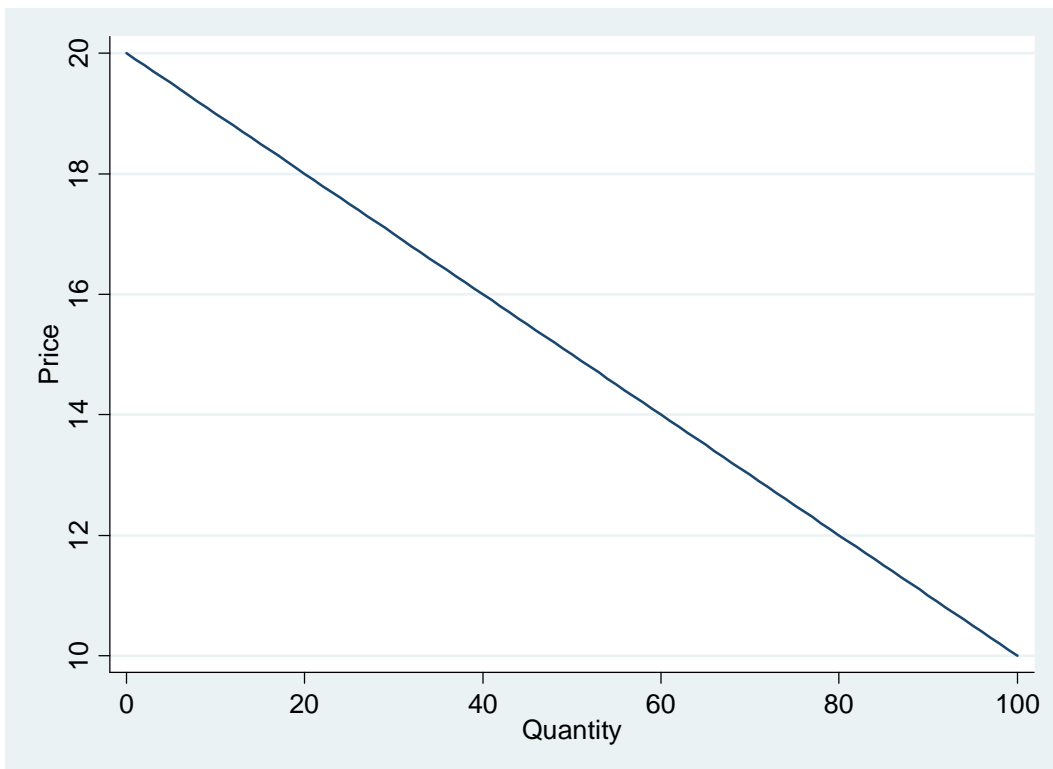
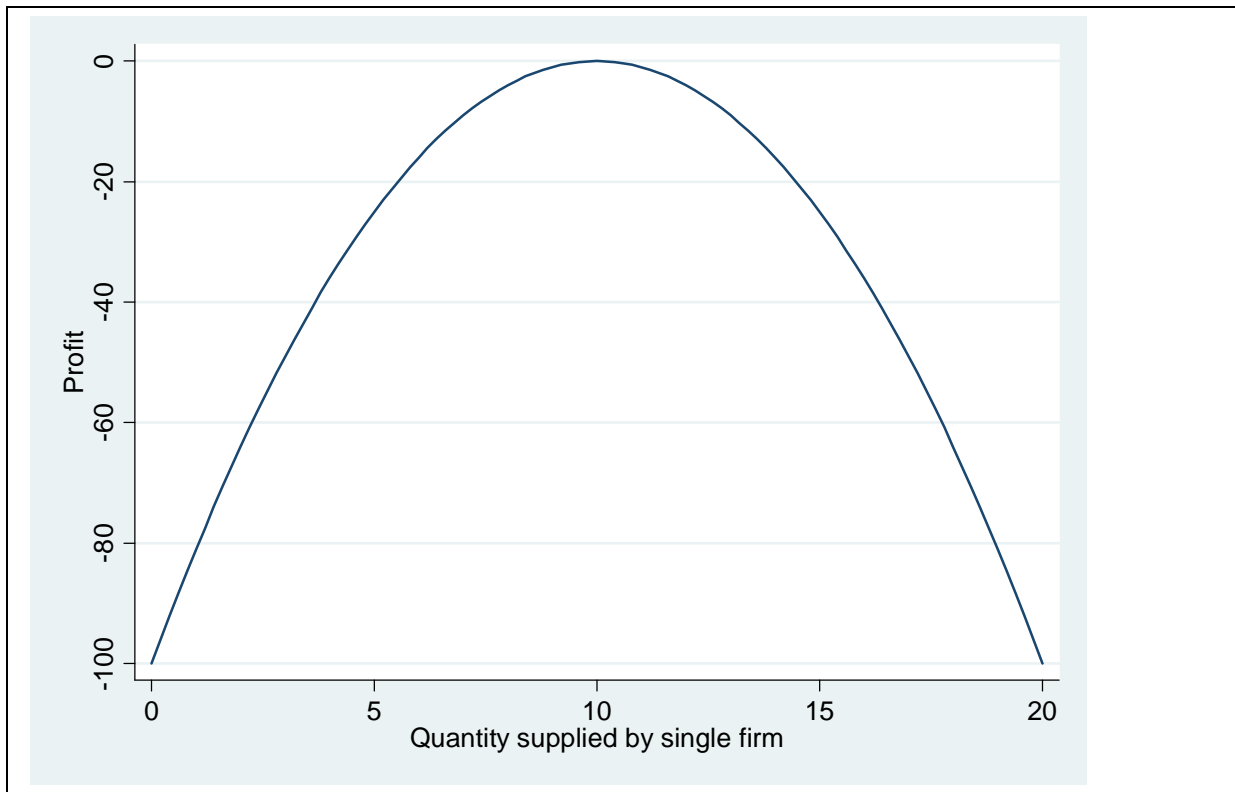


Figure 2: Profits and quantity supplied for a single firm in a competitive market



Note: $P = 30$, and $C(q) = 100 + q^2 + 10q$. Profit = $P \cdot q - C(q)$. This example links to Practice Problem 2.1 in Pepall et al. (p. 25).

- Of course we can easily re-arrange the demand curves above, so as to put the price on the left-hand side. This is known as the **inverse demand function**. For our two demand models:

- Linear inverse demand function:

$$P = A - B \times Q^D,$$

where $A = a/b, B = 1/b$. (What's the interpretation of A ?)

- Inverse demand function with constant price elasticity of demand:

$$P = X^{\frac{1}{\eta}} \times (Q^D)^{-\frac{1}{\eta}},$$

- We need to be clear on the concept of equilibrium. The following will do as a definition: In equilibrium, no consumer and no firm has an incentive to change its decision on how much to buy or produce. Nothing changes - the market is at rest.
- We will now look at market outcomes under perfect competition and monopoly.

2.1. Perfect competition

- We distinguish between short-run (SR) and long-run (LR) outcomes.
 - In the short run, fixed capital (plant & equipment) is fixed - neither the number of firms nor the fixed capital at each firm can be changed in response to changing market conditions.
 - In the long run, in contrast, fixed capital can change.
- Definition of perfect competition: Each firm is a **price taker** - no individual firm can influence the market price. The price is determined by the interaction of all the firms and consumers in the market - more precisely, by aggregate supply and aggregate demand. Assumes that each firm's potential supply of the product is "small" relative to total demand.
- The firm perceives that it can sell as much, or as little, as it wants at the going price.

- Implication: Firm's demand curve is **flat**.
- How can firm's demand curve be flat while the industry demand curve is downward sloping? This follows from the definition above: under perfect competition, no individual firm can affect the price by varying its output level. Hence, by definition, the price is invariant to changes in output made by a single firm. The industry demand curve, however, is determined by consumer preferences - loosely speaking consumer preferences are such that the buyer will demand less of the good if the price increases.
- [Draw the firm's demand curve, the industry demand curve, the industry supply curve]
- Single firm's decision: choose its output volume q so as to maximize profits, given market price P :

$$\max_q Pq - C(q),$$

where $C(q)$ includes costs of intermediate inputs (e.g. raw materials), labour, **and** the rate of return on capital (so zero profits - an implication under perfect competition as we shall see - doesn't imply that owners get nothing; they get the "normal" rate of return on capital). Note that P is not a function of q here - reflecting price taking behaviour, of course.

- Assuming the firm's profit is concave in q , we have the following first-order condition, necessary and sufficient for profit maximization:

$$P - \frac{\partial C(q)}{\partial q} = 0$$

$$P = \frac{\partial C(q)}{\partial q},$$

- Example (draws on Practice Problem 2.1 in Pepall et al): Suppose $P = 30$ and

$$C(q) = 100 + q^2 + 10q$$

Figure 2 then shows how the firm's profit, defined

$$\pi = Pq - C(q),$$

varies with the quantity it supplies. Clearly maximum profits is achieved at $q = 10$. We can easily confirm that this is consistent with the first-order condition above:

$$\begin{aligned} P &= \frac{\partial C(q)}{\partial q} \\ P &= 2q + 10 \\ q &= \frac{P - 10}{2}, \end{aligned}$$

and recall $P = 30$.

- [Figure 2 here] (CAN BE FOUND ON THE PAGE BEFORE p.4)

- We have just derived the optimal supply of an individual firm, given the prevailing price P . But how is this price set in the first place? It's important to remember that the equilibrium price in the market is determined by industry supply and industry demand. It is also important to distinguish between the short run and the long run. Let's take these points in turn.
- Industry supply is simply total supply by all firms in the market. If, as in the example above, individual supply is

$$q = \frac{P - 10}{2},$$

and if there 50 firms in the market, then industry supply is given by

$$Q^S = \frac{50P - 500}{2} = 25P - 250.$$

- Suppose industry demand is as follows:

$$Q^D = \frac{6000 - 50P}{9}.$$

- In market equilibrium, we have $Q^S = Q^D$, hence $P = 30$ (confirm this) is the equilibrium price.
- Each firm will receive profits as follows:

$$\begin{aligned} \pi &= Pq - C(q) \\ \pi &= 30 \times 10 - [100 + 10^2 + 10 \times 10] \\ \pi &= 0, \end{aligned}$$

i.e. there will be zero profits in this particular equilibrium.

- In the **long run** equilibrium all firms will make zero profits. Otherwise it will not be an equilibrium - if firms are making profits (over and above the natural return on capital), then more firms will

enter the market and thus shift the aggregate supply function. Entry into the market will cease exactly when all firms are making zero profits - hence this is the long run equilibrium.

- Notice that in the LR: total costs = total revenue (since zero profits); hence average costs = price = marginal cost.
- However, in the **short run** firms in a competitive market can make profits, since new firms can't enter the market immediately (by assumption).
- To illustrate this point, suppose we start from the long run equilibrium derived above. Now suppose there is a positive demand shock, so that the demand function shifts outward, from

$$Q^D = \frac{6000 - 50P}{9},$$

to

$$Q^D = \frac{8750 - 50P}{9}.$$

How will this affect the 50 existing firms? We know that the supply of each individual firm is

$$q = \frac{P - 10}{2},$$

and so, with 50 firms in the market, the industry supply function is unchanged:

$$Q^S = 25P - 250.$$

The new (short-run) equilibrium implies

$$\begin{aligned} Q^D &= Q^S \\ \frac{8750 - 50P}{9} &= 25P - 250 \\ P &= 40. \end{aligned}$$

Hence the market equilibrium price has increased from 30 to 40. Each individual firm now supplies

$$q = \frac{P - 10}{2} = 15,$$

and so each individual firm receives positive profits:

$$\begin{aligned}\pi &= Pq - C(q) \\ \pi &= 40 \times 15 - [100 + 15^2 + 10 \times 15] \\ \pi &= 125.\end{aligned}$$

The reason this is a short-run, but not long-run, equilibrium, is that these profits will trigger entry of new firms. This will shift the industry supply curve out, until entry stops as there are no supernatural profits to be made in the market.

2.2. Monopoly

- Now suppose all the sellers in the market become consolidated into **one firm** - a monopoly.
- The monopoly's demand curve is the industry's demand curve.
- Hence the monopoly is able to **influence** the price.
- Monopolist's decision: choose output volume q so as to maximize profits, but take into account the effect of q on P :

$$\max_q P(q)q - C(q),$$

where $P(q)$ is the inverse demand curve.

- First-order condition:

$$\begin{aligned} \frac{\partial P(q)}{\partial q}q + P(q) - \frac{\partial C(q)}{\partial q} &= 0 \\ \left[\frac{\partial P(q)}{\partial q} \frac{q}{P(q)} + 1 \right] P(q) &= \frac{\partial C(q)}{\partial q} \\ \left[-\frac{1}{\eta} + 1 \right] P(q) &= \frac{\partial C(q)}{\partial q}, \end{aligned}$$

where $\eta > 1$ is the elasticity of demand, measuring how responsive the quantity demanded is to price movements.

- One interpretation of this is that the firm chooses q so as to result in an output price that exceeds the marginal cost:

$$\begin{aligned} P(q) &= \frac{\partial C(q)}{\partial q} \left[-\frac{1}{\eta} + 1 \right]^{-1} \\ &= \frac{\partial C(q)}{\partial q} \left[\frac{\eta}{\eta - 1} \right] > \frac{\partial C(q)}{\partial q} \end{aligned}$$

The steeper the slope of the demand curve, the less elastic is demand, and so the higher is the markup.

- The monopolist makes a profit over and above the normal return on capital
- Because the monopolist is the only firm in this market, and because we assume no other firm can enter the market, this is a long-run equilibrium - i.e. even in the long run there is no tendency for the market price to equal the unit cost of production.

This concludes my brief overview of the perfect competition and monopoly.

- I will not discuss the material in Pepall et al. (2008) on present discounted value (Section 2.2) because I assume you know it already. Please read this section on your own.
- I will also skip Sections 2.3-4 in the book, which contain a discussion of efficiency. Please read on your own.

3. Empirical Analysis of Demand and Supply: Setting the Scene

Reference: Epple and McCallum (2005).

In this section we consider a simple supply-demand model, in which the market price P and the quantity q are jointly determined by demand and supply, and discuss how we can use **data** to estimate parameters of interest. Homogeneous good.

- We continue to take **demand** as a given - i.e. we don't derive explicitly it from consumer preferences (but, of course, we understand that demand is determined by preferences and income). Suppose we write demand in period t in constant elasticity form:

$$q_t = X_t P_t^{-\eta},$$

where $-\eta < -1$ is the price elasticity of demand, and X_t is a demand shift parameter. Thus high values of X_t (could be income - see paper) will be associated with high demand, and vice versa; i.e. changes in X_t will **shift** the demand curve, and thus **influence** the equilibrium price.

- To motivate the **supply** curve, consider the first-order condition for the monopolist:

$$\left[-\frac{1}{\eta} + 1 \right] P(q) = \frac{\partial C(q)}{\partial q},$$

which says that the monopolist will supply the quantity q for which the marginal revenue is equal to the marginal cost. This means we can identify two categories of driving factors of supply:

- The demand: Think of $P(q)$ as the inverse demand curve, hence shocks to demand will influence equilibrium price.
- The firm's technology: Recall that $C(q)$ represents the firm's total cost of producing q . Now modify the cost function so that the production cost explicitly depends on input prices W :

$$C = C(q, W),$$

Given that the cost function is a monotonically increasing function of output produced (seems very reasonable), we can invert the cost function and write quantity supplied as

$$q_t = S(P_t, W_t).$$

- **Supply** in logarithmic form:

$$q_t^s = \alpha_0 + \alpha_1 p_t + \alpha_2 w_t + u_t \quad (3.1)$$

- **Demand** in logarithmic form:

$$q_t^d = \beta_0 + \beta_1 p_t + \beta_2 y_t + v_t \quad (3.2)$$

- Parameters: $\alpha_1 > 0$; $\alpha_2 < 0$; $\beta_1 < 0$; $\beta_2 > 0$.
- Equations (3.1) and (3.2) form a system of equations in **structural form**, in the sense that each equation specifies **causal, theoretical** relationships. The parameter β_1 is interpretable as the price elasticity of demand, for example - a key parameter in our theoretical model.
- Suppose our goal is to estimate the parameters of the model. What type of data do we need?
 - Quantity supplied & demanded
 - Output price
 - Demand shifters - e.g. income y
 - Supply shifters - e.g. input prices w

- Our empirical equations:

$$q_t^s = \alpha_0 + \alpha_1 p_t + \alpha_2 w_t + u_t \quad (\text{Supply})$$

$$q_t^d = \beta_0 + \beta_1 p_t + \beta_2 y_t + v_t \quad (\text{Demand})$$

- Equilibrium:

$$q_t^s = q_t^d$$

- Econometrics: Price is an endogenous variable. To see this, combine the supply and demand equations and solve for price and quantity in reduced form. You will obtain equations of the following form:

$$q = \pi_1 w_t + \pi_2 y_t + v_1(u_t, v_t)$$

$$p = \omega_1 w_t + \omega_2 y_t + v_2(u_t, v_t).$$

Clearly a shock to demand (v_t) will impact on the price - hence price is endogenous.

- **Identification:** Suppose our goal is to estimate the parameter β_1 , which measures the causal effect of a change in the price on quantity demanded. That is, this parameter measures the slope of the demand function.
- In the language of simultaneous equation econometrics, we cannot identify β_1 unless the rank and order conditions are fulfilled (see an econometrics book if you are interested).
- More intuitively, we cannot infer β_1 from the observed relationship in the data between quantity and price, because we can't be sure about whether this relationship in the data reflects movement along the demand curve, the supply curve, or a combination.
- [Illustration of identification problem]
- To identify the demand curve, we need to come up with a way of holding demand **constant** while varying supply.
- Instrumental variables: instrument the price variable using supply side variables - in the model above, this means we need
- $\alpha_2 \neq 0$, or otherwise we cannot identify β_1 . Intuitively, the reason is that, while q depends on p , causation runs in the opposite direction as well. By using an IV approach, we consider how movements in the price that are only attributable to supply side shocks correlate with quantities

produced and consumed. Our theory then tells us we can interpret the results as telling us what the demand curve looks like.

4. Causality in Applied Econometrics

- Goal of most empirical studies in economics: investigate if and how a change in an 'explanatory' variable X **causes** a change in another variable Y , the dependent variable - in our context, how a change in the price causes demand to fall.
- In order to find the causal effect, we must hold all other relevant determinants of Y **fixed** - ceteris paribus analysis. In the social sciences, we rarely have access to data generated in a laboratory (where the analyst controls the explanatory variables). We therefore need a technique that enables us to analyze the data and draw inferences about the role played by X **as if** other factors determining y are held fixed.
- Regression analysis is one such approach.
- We may achieve a lot by including control variables in our regressions. But when estimating demand-supply models, you typically suspect you don't observe all relevant determinants of demand and supply. As a result, the theory tells us we will have an endogeneity problem.

4.0.1. Instrumental Variables

Arguably the most important econometric problem for estimation of the demand-supply model is posed by the output price being likely endogenous. Suppose my goal is to estimate the price elasticity of demand. To do this, I consider the demand equation

$$q_t = \beta_0 + \beta_1 p_t + \beta_2 y_t + v_t.$$

My problem is that the output price p_t is determined jointly with quantity demanded. In particular, a shock to demand not captured by income y (like what?) is likely to affect the price. Where in our

demand equation above would such a shock enter?

It would enter the residual v_t . If, as a result, the residual v_t is correlated with the price, we clearly have an endogeneity problem.

Some of you may be very familiar with the instrumental variables approach, others may not. In this subsection, I briefly discuss the following:

- The key **assumptions** that need to hold for the IV approach to work
- **How** the IV estimator works
- Some intuition into **why** it works

My exposition is informal but hopefully sufficient given our current purposes. If you have difficulties, you need to consult a basic econometrics textbook (I'd recommend "Introductory Econometrics" by Jeffrey Wooldridge, or "A Guide to Modern Econometrics" by Marco Verbeek, but there are many others too).

4.0.2. Two key assumptions underlying the IV approach

- We suspect that the residual in our demand equation is correlated with the market price:

$$q_t = \beta_0 + \beta_1 p_t + \beta_2 y_t + v_t.$$

$$\text{cov}(p_t, v_t) \neq 0.$$

This amounts to saying that the price is econometrically endogenous.

- Now, the price varies for many reasons. In our model, the price varies because of shocks to supply and shocks to demand:

$$p_t = \phi_1 \times w_t + \phi_2 \times y_t + e_t,$$

where ϕ_1, ϕ_2 are non-zero coefficients. Price will clearly be correlated with a determinant of supply in this case (i.e. the input price variable w_t). The key point, however, is that if w_t is uncorrelated

with shocks to demand, then there is **some variation** in the price that is **not correlated with demand shocks**. That is, there is some **exogenous** variation in the price.

- The IV estimator uses **only** this source of variation in the price to identify the demand curve. Note the analogy with moving around the supply curve whilst holding demand constant.
- We say that w_t is our instrument (by which we really mean there is an exclusion restriction: w_t does not enter the structural demand equation - it is excluded).
- For the IV estimator to work, the following conditions need to hold:

$$\text{cov}(w_t, v_t) = 0, \tag{4.1}$$

$$\text{cov}(w_t, p_t) \neq 0. \tag{4.2}$$

- The first of the conditions, (4.1), says that the instrument must be uncorrelated with the residual in the demand equation. This is sometimes referred to as **instrument validity**.
- The second condition, (4.2), says that the instrument must be correlated with the endogenous explanatory variable, i.e the price. This is sometimes referred to as **instrument relevance**.
- If these conditions hold, then w_t can be used as an instrument for the price in the demand equation.

4.0.3. *How the IV estimator works*

- We can obtain an instrumental variable estimate by means of a **two-stage procedure**:
1. Run an OLS regression in which price is the dependent variable, and the instrument w_t , and other exogenous variables in the model are the explanatory variables:

$$p_t = \phi_1 \times w_t + \phi_2 \times y_t + e_t$$

Once you've got your results, calculate the **predicted** values of the price based on the regression:

$$\hat{p}_t = \hat{\phi}_1 \times w_t + \hat{\phi}_2 \times y_t$$

You see how this "new" measure of the price will **not** be correlated with the demand residual - since the latter is assumed uncorrelated with w_t (and y_t)

2. In the demand equation, use the **predicted** values of the price (instead of the **actual** values) as the explanatory variable, and run the following regression using OLS:

$$q_t = \beta_0 + \beta_1 \hat{p}_t + \beta_2 y_t + v_t.$$

The resulting estimate of β_1 is the instrumental variable estimate, denoted b_1^{IV} .

If your sample is large and/or w_t is a very important explanatory variable for price for supply-related reasons, the IV estimate b_1^{IV} is likely to be much closer to the true value β_1 than the biased OLS estimate b_1^{OLS} . (To say what I have just said "properly" would require a lot of statistical jargon - consult an econometrics book if you are interested). This is the basic reasons for using the IV estimator in applied research.

4.0.4. Intuition

- I find it easiest to think of the IV estimator as a way of "purging" the price of endogeneity. That is, we **remove** from the price variable the part that co-varies with the residual in the demand equation, but **keep** the part that is not correlated with residual in the demand equation. This is what the prediction after the first-stage regression achieves. Predicted price is then "exogenous" and there will therefore be no endogeneity bias.

5. Market Structure & Market Power

Recall the following from Lecture 1:

- The SCP paradigm starts with a given market structure and investigates how firms behave & perform in that type of market.
- The "New theoretical IO" investigates how the firms' strategic behaviour affects the structure of the market.
- Both approaches agree the market structure **matters** for what happens in the market.
- In the previous section we went through the basic microeconomics of perfect competition and monopoly. As you know, monopoly is often thought to be bad from an efficiency point of view, because of the "deadweight loss". This arises because the monopolist has market power.
- In contrast, if there are many small firms in the market (key here is that they are "small" in the sense that their production decisions do not affect the output price - they have no market power) no individual firm will have market power. Consequently, at least in the long run, perfect competition ensures that output is produced at minimum average cost, that price is equal to minimum average cost, and that supernormal profit is competed away. There is no deadweight loss in this case, and so we would characterize the market outcome as efficient.
- In this section we first discuss ways of characterizing the market structure using simple, quantitative techniques. We then discuss the Lerner index, which is a popular quantitative measure of market power.

5.1. Measuring Market Structure

Concentration curves

- Concentration curves show how the cumulative fraction of total output in the market changes as we go from the largest to the smallest firms in the market. Lorenz curves.

- Sort the data by output, from highest to lowest. Construct a rank variable $1, 2, \dots, N$ where 1 is the largest firm.
 - Calculate each firm's market share: $\text{output}(i)/\text{output}(\text{market})$
 - Compute the cumulative market share
 - Plot cumulative market share against size rank.
- [Figure 3.1 in Pepall et al.]

Replicating Figure 3.1 in Pepall et al. (2008)

Data:

	rank	msA	msB	msC
1.	1	.1	.55	.25
2.	2	.1	.0225	.25
3.	3	.1	.0225	.25
4.	4	.1	.0225	.05
5.	5	.1	.0225	.05
6.	6	.1	.0225	.05
7.	7	.1	.0225	.05
8.	8	.1	.0225	.05
9.	9	.1	.0225	.
10.	10	.1	.0225	.
11.	11	.	.0225	.
12.	12	.	.0225	.
13.	13	.	.0225	.
14.	14	.	.0225	.
15.	15	.	.0225	.
16.	16	.	.0225	.
17.	17	.	.0225	.
18.	18	.	.0225	.
19.	19	.	.0225	.
20.	20	.	.0225	.
21.	21	.	.0225	.

where rank is the rank from the highest to the lowest market share, and msX shows the market share of each firm in industry X.

To obtain the concentration curve for these industries, all I need to do now is to compute the cumulative market share, and then produce a scatter plot with the cumulative market share on the vertical axis and rank on the horizontal axis.

In Stata, I can do this very easily:

```
ge cum_msA=sum(msA)
ge cum_msB=sum(msB)
ge cum_msC=sum(msC)

list rank msA cum_msA msB cum_msB msC cum_msC
```

	rank	msA	cum_msA	msB	cum_msB	msC	cum_msC
1.	1	.1	.1	.55	.55	.25	.25
2.	2	.1	.2	.0225	.5725	.25	.5
3.	3	.1	.3	.0225	.595	.25	.75
4.	4	.1	.4	.0225	.6175	.05	.8
5.	5	.1	.5	.0225	.64	.05	.85
6.	6	.1	.6	.0225	.6625	.05	.9
7.	7	.1	.7	.0225	.685	.05	.95
8.	8	.1	.8	.0225	.7075	.05	1
9.	9	.1	.9	.0225	.73	.	1
10.	10	.1	1	.0225	.7525	.	1
11.	11	.	1	.0225	.775	.	1
12.	12	.	1	.0225	.7975	.	1
13.	13	.	1	.0225	.8200001	.	1
14.	14	.	1	.0225	.8425	.	1
15.	15	.	1	.0225	.865	.	1
16.	16	.	1	.0225	.8875	.	1
17.	17	.	1	.0225	.91	.	1
18.	18	.	1	.0225	.9325	.	1
19.	19	.	1	.0225	.955	.	1
20.	20	.	1	.0225	.9775	.	1
21.	21	.	1	.0225	1	.	1

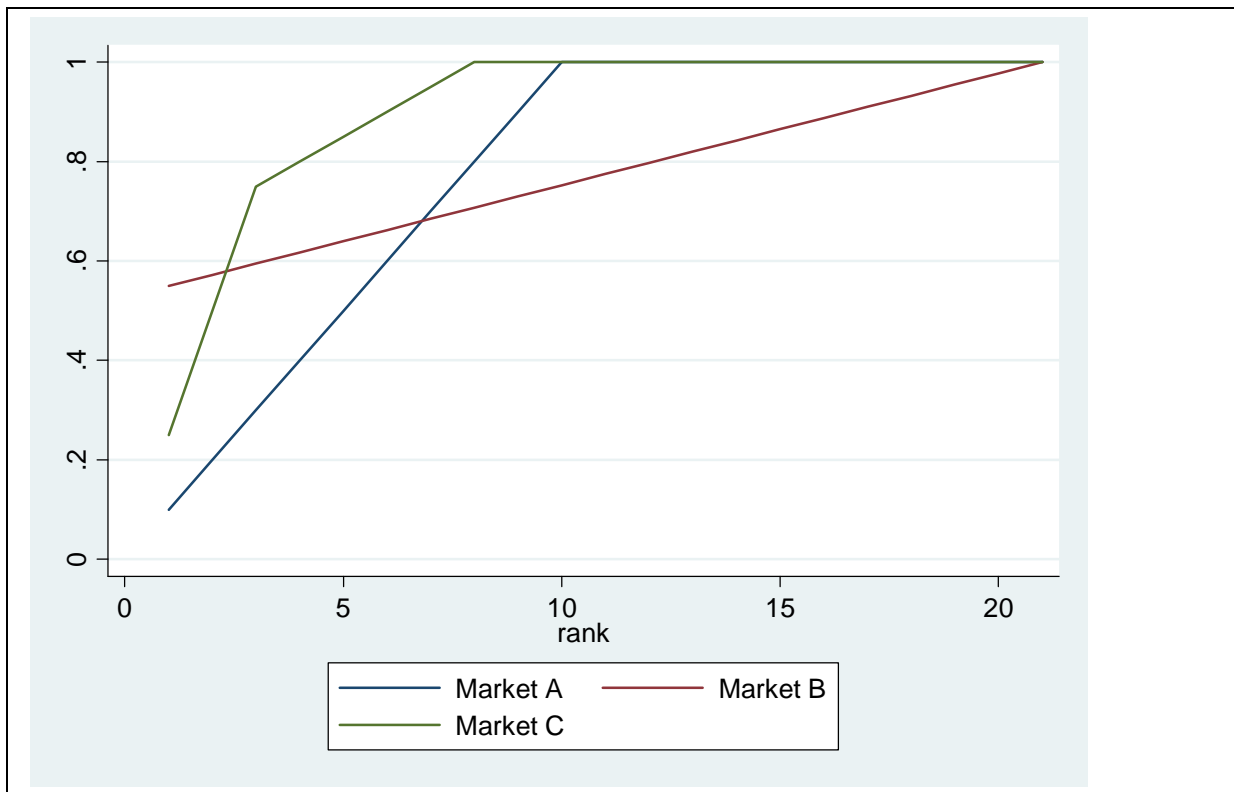
To get the graph, I tell Stata the following:

```
label var cum_msA "Market A"
label var cum_msB "Market B"
label var cum_msC "Market C"

scatter cum_msA cum_msB cum_msC rank, s(i i i) c(1 1 1)
```

Result:

Replicating Figure 3.1 in Pepall et al. Concentration Curves



How interpret the graph?

What does the curve look like for a highly concentrated market?

Calculation of HHI

```
. ge msAsq=(msA*100)^2  
(11 missing values generated)  
  
. ge msBsq=(msB*100)^2  
  
. ge msCsq=(msC*100)^2  
(13 missing values generated)  
  
. tabstat msAsq msBsq msCsq, stat(sum)
```

Results:

stats	msAsq	msBsq	msCsq
sum	1000	3126.25	2000

Concentration indices

- Concentration curves are useful but sometimes it is easier to interpret "a number" than eyeballing lots of graphs.
- A common concentration index is the **concentration ratio**, CR_n , defined as the total market share of the top n firms. The most common choice is to set $n = 4$.
- Note that the CR_4 is easy to read off the concentration curve (revisit Fig. 3.1 in Pepall et al.)
- Clearly CR_n contains less information than the concentration curve, but arguably it is easier to "use".
- An alternative to CR_n that attempts to reflect more fully the information in the concentration curve is the **Herfindahl-Hirschman Index** (HHI). For a market (or industry) with N firms, this is defined as follows:

$$HHI = \sum_{i=1}^N s_i^2,$$

where s_i is the market share of the i th firm.

- What's the HHI for a monopolist?
- What's the HHI for a firm in a perfectly competitive market?
- [Compute HHI for "data" underlying Fig 3.1]
- Implementation: What is a market? See lecture 2. Rarely clear-cut answer. If the definition of the market is ambiguous, then clearly our measures of concentration will be open to criticism as well.
- Economic/statistical view: Products that are "closely substitutable" arguably should belong to the same market. A useful statistical measure of the degree of substitutability is provided by the **cross-price elasticity of demand**:

$$\eta_{ij} = \frac{\partial q_i}{\partial p_j} \frac{p_j}{q_i},$$

measuring the response in demand for product i resulting from a change in the price of product j .

In practice, however, other criteria are often used - see Section 3.1.1 in Pepall et al.

5.2. Measuring market power

- We have seen how summary statistics such as the concentration ratio or the HHI index can be used to describe the structure of a market. However, it is important to realize that a particular structure does not necessarily imply a particular market outcome.
- For example, suppose there are only 2 or 3 firms in the market. The HHI will indicate concentration in the market is high. But can we be sure that market outcomes are inefficient as a result? The answer is not straightforward - as we shall see later in the course, markets with just 2 or 3 firms **may** come quite close to duplicating the competitive (efficient) outcome.
- The implication is that if we want to say something about market outcomes, we had better look at more direct measures of market outcomes.
- We are often interested in learning whether firms in a particular market actually exercise market power. One common summary statistic that can be used to this end is the Lerner index, defined as follows:

$$LI = \frac{P - MC}{P},$$

where P, MC denote price and marginal cost. Thus the Lerner index measures the discrepancy between price and marginal cost. We saw above that, for a monopolist, the following first-order condition applies:

$$\begin{aligned} \frac{\partial P(q)}{\partial q} q + P(q) - \frac{\partial C(q)}{\partial q} &= 0 \\ \left[\frac{\partial P(q)}{\partial q} \frac{q}{P(q)} + 1 \right] P(q) &= \frac{\partial C(q)}{\partial q} \\ \left[-\frac{1}{\eta} + 1 \right] P(q) &= \frac{\partial C(q)}{\partial q} \\ \left[\frac{\eta - 1}{\eta} \right] P(q) &= \frac{\partial C(q)}{\partial q}, \end{aligned}$$

hence

$$P = MC \frac{\eta}{\eta - 1},$$

and

$$\begin{aligned} P - MC &= MC \left(\frac{\eta}{\eta - 1} - 1 \right) \\ P - MC &= MC \left(\frac{1}{\eta - 1} \right), \end{aligned}$$

and so

$$\begin{aligned} LI &\equiv \frac{P - MC}{P} = \frac{MC \left(\frac{1}{\eta - 1} \right)}{MC \frac{\eta}{\eta - 1}} \\ LI &= \frac{1}{\eta}. \end{aligned}$$

Recall that η is the price elasticity of demand: a very high value of η implies a very elastic demand curve, i.e. a very flat demand curve, and thus a low Lerner index. As $\eta \rightarrow \infty$, as will be the case under perfect competition, $LI \rightarrow 0$ (recall the demand curve from the point of view of the firm is flat under perfect competition).

- The greater is the Lerner Index, the farther the market outcome lies from the competitive case - and the more market power is being exploited. In this sense, the Lerner Index is a direct indication of the extent of market competition.
- Practical problems:
 - How define your market?
 - Averaging over several firms in the market - e.g.

$$LI = LI = \frac{P - \sum_{i=1}^N s_i MC_i}{P},$$

where s_i is the market share of the i th firm and N is the total number of firms in the market (note that the price is common across firms).

- Not straightforward to measure marginal costs. One popular solution is to multiply both the numerator and the denominator by output:

$$LI = \frac{PQ - MC \times Q}{PQ} = \frac{\text{profit}}{\text{sales}}.$$

6. Empirical Application: The Staples Case

- Reference: Ashenfelter et al. (2005). "Econometric Methods in Staples".
- The methods reviewed in the previous section are often used to **describe** the structure of the market.
- Equipped with summary measures of the market structure (e.g. degree of concentration; number of competitors etc.), we can ask how these variables **correlate with outcomes of interest**. There are many possible reasons why such an analysis might be of interest. In this section we look in detail how empirical analysis of the relationship between **market power** and **pricing** was used in a court case concerning a proposed merger between Staples and Office Depot, in the U.S. in the 1990s.
- Two sides: The Federal Trade Commission (FTC) and the defendants. Econometric analysis played an important role in the investigation and litigation of the case. The FTC argued that Staples systematically charged its customers the least in cities in which its two main competitors were present, and the most in cities where the competitors were not present.
- Consequently, it was argued, because the proposed merger would reduce competition, prices would likely rise, harming consumers.

6.1. Background

- Prior to 1986, office supplies in the U.S. were primarily bought from small independent stationers, warehouse clubs and mail order firms.
- In 1986, two office supplies superstores (OSS) were set up in the country - **Staples**, located in the Northeast; and **Office Depot**, in Florida. These superstores offered a very wide range of office supplies to customers, known as "one-stop shopping".
- By the end of 1996, there were 3 strong OSS competitors in the U.S. market: Staples, Office Depot; and OfficeMax. They had strong regional positions, and were beginning to expand into each other's territories.
- Staples and Depot competed directly in 40+ cities.
- In September 1996, Staples and Depot announced they were planning to **merge**.
- In April 1997, the FTC voted to oppose the transaction, on the grounds that consumer welfare would be harmed as a result of the merger.
- The FTC won a preliminary injunction (court order) against the merger in U.S. District Court in June 1997, which resulted in Staples and Depot abandoning the transaction.

6.2. The Evidence

6.2.1. Non-econometric evidence

- A lot of the evidence used in Court revolved around pricing decisions. One report described the result of comparison-shopping a bundle of goods at office supplies superstores in different locations, and it was found that prices tended to be higher in locations in which there were fewer competitors.
- The price difference was thus **attributed** to different levels of competition.
- Figure 1: Staples prices were highest in regions where it faced no competition, and lowest in markets where the three major players were all present.

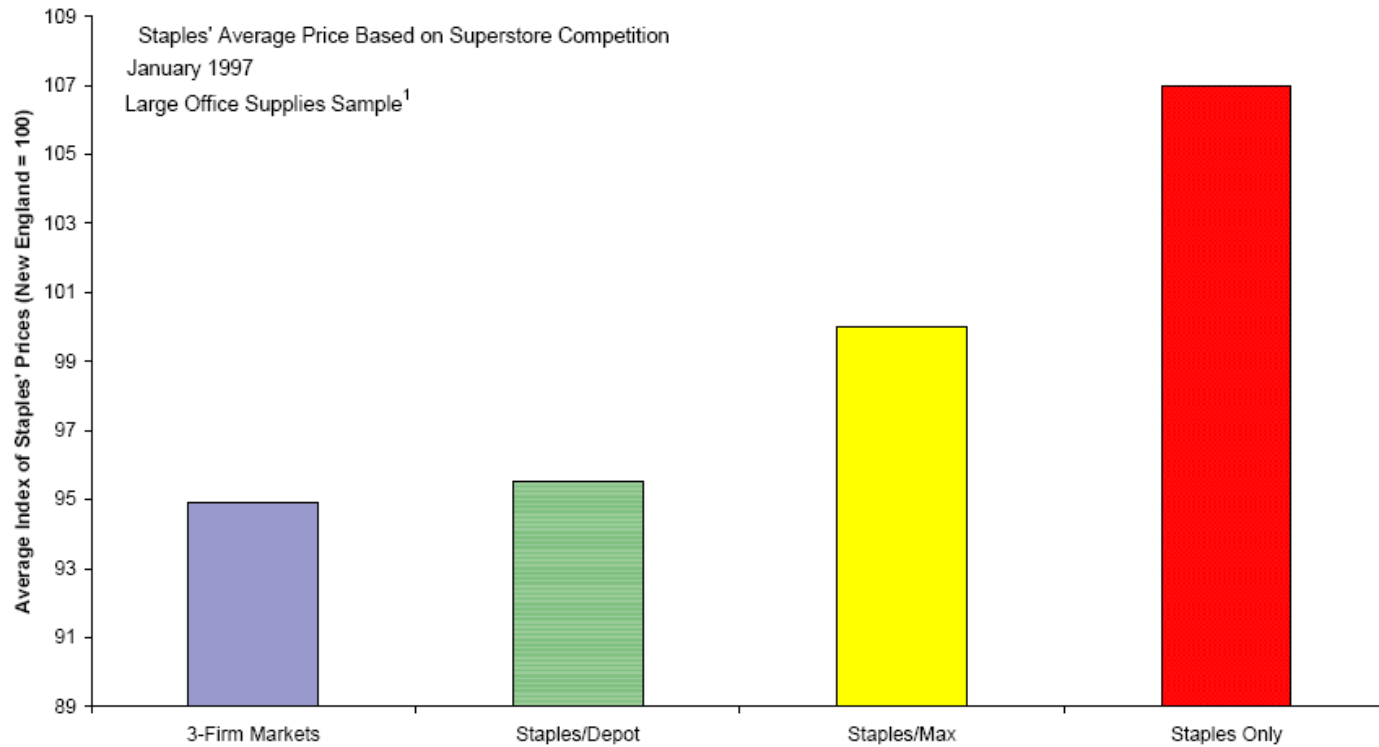
- There was also some documentary evidence presented by the FTC indicating that Staples considered the presence of Office Depot in its price setting decisions.

[Ashenfelter et al. Figure 1 here]

Figure 1



STAPLES' PRICES ARE HIGHER WITH LESS SUPERSTORE COMPETITION



¹ Based on an office supply sample accounting for 90% of Staples' sales
Data source: PX 117

Source: Ashenfelter et al. (2005)

6.2.2. Econometric issues

The econometric analysis focused on the impact of competition on price. One very important issue refers to how best to **estimate** the impact of competition on price. The Staples case highlighted the relative merits of:

- **cross-sectional** studies (which examine differences in prices across a number of regions at a point in time); and
- **panel-data studies** (which examine differences in prices over time across the regions).

Cross sectional data. Suppose we have constructed a price index measuring the the price of some standardized product, sold in different locations i at price p_i . To investigate the effect of competition on the price, we might run a regression of the following form

$$\ln p_i = \alpha_0 + \beta_1 \times competition_i + X_i \gamma + e_i,$$

where β_1 is the effect of competition on price; X_i is a vector of other variables determining price (with associated parameter vector γ), α_0 is the intercept, and e_i is a residual.

- Clearly, to identify β_1 we need a dataset in which prices as well as levels of competition differ across locations.
- If we use OLS to estimate the model, we are faced with the usual problem posed by **omitted variables**: maybe there are variables that we don't observe that determine prices as well as competition. For example, the following unobserved influences may be correlated with both prices and entry (note: entry affects competition):
 - Differences in marginal costs
 - Differences in market demand (e.g. due to high/low population)
- This might lead to omitted variables bias in the estimated coefficients.

Panel data.

- Panel datasets exhibit a time series dimension as well as a cross-section dimension. Furthermore, panel data contains information on the **same** cross section units - e.g. stores - over time. The structure of a panel data set is as follows:

id	year	yr92	yr93	yr94	x1	x2
1	1992	1	0	0	8	1
1	1993	0	1	0	12	1
1	1994	0	0	1	10	1
2	1992	1	0	0	7	0
2	1993	0	1	0	5	0
2	1994	0	0	1	3	0
(...)	(...)	(...)	(...)	(...)	(...)	(...)

where id is the variable identifying the individual store that we follow over time; yr92, yr93 and yr94 are time dummies, constructed from the year variable; x1 is an example of a **time varying variable** and x2 is an example of a **time invariant variable**.

- The main advantage of panel data is that it solves an **omitted variables problem**. Suppose our general model is

$$y_{it} = \mathbf{x}_{it}\boldsymbol{\beta} + (\alpha_i + u_{it}),$$

$t = 1, 2, \dots, T$, where we observe y_{it} and \mathbf{x}_{it} , and α_i, u_{it} are not observed. Our goal is to estimate the parameter vector $\boldsymbol{\beta}$. \mathbf{x}_{it} is a $1 \times K$ vector of regressors, and $\boldsymbol{\beta}$ is a $K \times 1$ vector of parameters to be estimated.

- Our problem is that we **do not observe** α_i , which is constant over time for each individual store (hence no t subscript) but varies across stores. Hence if we estimate the model in levels using OLS then α_i will go into the error term:

$$v_{it}^{OLS} = \alpha_i + u_{it}.$$

Consequently, if α_i is correlated with our explanatory variables, the OLS estimates will be biased.

- There are several different panel data estimators available to applied researchers. The most common one is known as the **Fixed Effects** (FE) estimator (or **Within Estimator**).
- Our general model:

$$y_{it} = \mathbf{x}_{it}\boldsymbol{\beta} + (\alpha_i + u_{it}), \quad t = 1, 2, \dots, T; i = 1, 2, \dots, N, \quad (6.1)$$

where I have put $\alpha_i + u_{it}$ within parentheses to emphasise that these terms are unobserved.

- Assumptions about unobserved terms:
 - Assumption 1.1: α_i freely correlated with \mathbf{x}_{it}
 - Assumption 1.2: $E(\mathbf{x}_{it}u_{is}) = \mathbf{0}$ for $s = 1, 2, \dots, T$ (strict exogeneity)
- Note that strict exogeneity rules out feedback from past u_{is} shocks to current \mathbf{x}_{it} . One implication is that FE will not yield consistent estimates if \mathbf{x}_{it} contains lagged dependent variables ($y_{i,t-1}, y_{i,t-2}, \dots$).
- When N is large and T is small, the assumption of strict exogeneity is crucial for the FE estimator to be consistent. In contrast, if $T \rightarrow \infty$, strict exogeneity is not crucial. Usually in empirical IO, we have large N small T .
- If the assumption that $E(\mathbf{x}_{it}u_{is}) = \mathbf{0}$ for $s = 1, 2, \dots, T$, does **not** hold, we may be able to use instruments to get consistent estimates.

To see how the FE estimator solves the endogeneity problem that would contaminate the OLS estimates, begin by taking the average of (6.1) for **each individual** - this gives

$$\bar{y}_i = \bar{\mathbf{x}}_i\boldsymbol{\beta} + (\alpha_i + \bar{u}_i), \quad i = 1, 2, \dots, N, \quad (6.2)$$

where $\bar{y}_i = \left(\sum_{t=1}^T y_{it} \right) / T$, and so on.¹ Now subtract (6.2) from (6.1):

$$\begin{aligned} y_{it} - \bar{y}_i &= (\mathbf{x}_{it} - \bar{\mathbf{x}}_i) \boldsymbol{\beta} + (\alpha_i - \alpha_i + u_{it} - \bar{u}_i), \\ y_{it} - \bar{y}_i &= (\mathbf{x}_{it} - \bar{\mathbf{x}}_i) \boldsymbol{\beta} + (u_{it} - \bar{u}_i), \end{aligned}$$

which we write as

$$\ddot{y}_{it} = \ddot{\mathbf{x}}_{it} \boldsymbol{\beta} + \ddot{u}_{it}, \quad t = 1, 2, \dots, T; i = 1, 2, \dots, N, \quad (6.3)$$

where \ddot{y}_{it} is the **time-demeaned data** (and similarly for $\ddot{\mathbf{x}}_{it}$ and \ddot{u}_{it}).

*This transformation of the original equation, known as the **within transformation**, has eliminated α_i from the equation.*

- Hence, we can estimate $\boldsymbol{\beta}$ consistently by using OLS on (6.3). This is called the **Within estimator** or the **Fixed Effects estimator**.
- You now see why this estimator requires strict exogeneity: the equation residual in (6.3) contains all realized residuals $u_{i1}, u_{i2}, \dots, u_{iT}$ (since these enter \ddot{u}_{it}) whereas the vector of transformed explanatory variables contains all realized values of the explanatory variables $x_{i1}, x_{i2}, \dots, x_{iT}$ (since these enter $\bar{\mathbf{x}}_i$). Hence we need $E(\mathbf{x}_{it} u_{is}) = \mathbf{0}$ for $s = 1, 2, \dots, T$, or there will be endogeneity bias if we estimate (6.3) using OLS.
- In Stata, we obtain FE estimates from the 'xtreg' command if we use the option 'fe', e.g.
- `xtreg yvar xvar, i(firm) fe`
- Rather than time demeaning the data, couldn't we just estimate (6.1) by including one dummy variable for each store? Indeed we could, and it turns out that this is **exactly** the same estimator as the within estimator. If your N is large, so that you have a large number of dummy variables, this may not be a very practical approach however.

¹Without loss of generality, the exposition here assumes that T is constant across individuals, i.e. that the panel is balanced.

- The panel data model used by Ashenfelter et al. is written

$$\ln p_{it} = \alpha_i + \beta_1 \times \text{competition}_{it} + X_{it}\gamma + e_{it},$$

where α_i is the store fixed effect. To obtain FE estimates, we can either do the within transformation described above, or include N dummy variables - both procedures give the same results.

- If the omitted variables that we worried about when discussing the cross-sectional approach are captured by α_i then the FE approach solves the omitted variables problem.
- Note: You must have **time series variation** in prices and in the competition variable, otherwise you cannot identify β_1 by means of the FE approach. To see this, suppose your model is

$$\ln p_{it} = \alpha_i + \beta_1 \times \text{competition}_i + X_{it}\gamma + e_{it},$$

i.e. competition now doesn't have a time subscript, indicating that it does not change over time - similar to the variable x2 in my little example above of the structure of a panel dataset. Now do the within transformation:

$$\begin{aligned} \ln p_{it} - \overline{\ln p_i} &= (\alpha_i - \alpha_i) + \beta_1 \\ &\quad \times (\text{competition}_i - \text{competition}_i) \\ &\quad + (X_{it} - \overline{X_i})\gamma + \check{e}_{it} \\ \ln p_{it} - \overline{\ln p_i} &= (X_{it} - \overline{X_i})\gamma + \check{e}_{it}, \end{aligned}$$

and you see that the competition term has vanished. Hence you can't identify β_1 using this approach.

- This can be a problem in applications such as this one, if entry and exit are rare events (implying that competition stays the same in most cases).

Cross-Section vs. Panel Data: Use cross-section approach if

- – you don't have panel data; or
- you have panel data but there is little entry or exit (so that your competition variable is approximately constant over time)

Otherwise always consider the results from panel data estimators.

6.2.3. Econometric Analysis: Staples

- Economists on both sides tried to determine: how much would Staples price increase in markets where Staples and Office Depot currently compete, if all Office Depot stores were converted to Staples stores?
- You have already seen preliminary evidence in Figure 1 that prices are higher with less superstore competition.
- The FTC computed a price increase of 8.6%
- The defendants computed a price increase of 1.1%
- Why did the two sides come up with such different estimates? To this question we now turn.

Data.

- The **price variable** was an indexed constructed from prices of products in individual OSS outlets over time:

$$\ln p_{it} = \sum_k \omega_k \ln p_{itk},$$

where ω_k is a revenue weight, $k = 1, \dots, 4$ denotes four types of products of varying price sensitivity, and

$$\ln p_{itk} = \sum_{j \in k} w_j p_{itj},$$

where w_j is a quantity weight and p_{itj} is the price of the j :th item at the i :th store at time t . About 7,000 different products were considered. Both sides used this price variable.

- The competition variable measured the local presence of rival OSS. Here the two sides **differed**.
- **Defendants**: Effect of store i 's competitor depends on its **distance** from i :

$$\begin{aligned} \ln p_{it} = & \alpha_i + \sum_t \gamma_t + \sum [\theta_{1z} D5_{it} + \theta_{2z} D10_{it} + \theta_{3z} D20_{it}] \\ & + \sum [\theta_{4z} \ln store5_{it} + \theta_{5z} \ln store10_{it} \\ & + \theta_{6z} \ln store20_{it}] + e_{it}, \end{aligned}$$

where:

- $storeX_{it}$ is the number of stores of retailer z within X miles of store i , at time t
- DX_{it} is a dummy variable = 1 if retailer z does not have a store within X miles of store i , at time t
- Parameters differ by z (different effects for different retailers); includes retailer of store i in the z 's in order to allow for market power effects.

- **FTC**: Each rival store within a city had the same effect regardless of distance:

$$\ln p_{it} = \alpha_i + \sum_t \gamma_t + \sum \beta_{1z} D_{zit} + \sum \beta_{2z} \ln store_{zit} + e_{it}$$

where

- D_{zit} is a dummy variable = 1 if at time t retailer z does not have a store in the city where store i is located
- $\ln store_{zit}$ is the number retailer z 's stores in the city at time t .

Which side is correct? Depends on how the retailers see the local market.

- If retailers see the whole city as a single market then the FTC model is better. If distance matter, then clearly the defendants' model is better.
- Both sides use a **fixed effects** approach, in which each individual store is tracked over time (i.e. there are $i = 1, 2, \dots, N$ stores in the dataset). They chose this approach because they were concerned a cross-sectional approach could lead to serious omitted variable problems.
- Results: The estimated price effects from the two models are very different. The FTC model gives much higher price effects - compare Model 5 (FTC) and Model 2 (defendants) in Table 1.

[Insert Table 1 here]

California included

TABLE 1

PX-400: SIMULATED IMPACT ON STAPLES OFFICE PRODUCTS PRICES OF ELIMINATING OFFICE DEPOT:

Staples Stores with Some Office Depot Competition

	Model 1	Model 2	Model 3*	Model 4*	Model 5	Model 6	Model 7
Simulated Price Change	1.1%	0.8%	2.9%	3.7%	4.0%	3.7%	8.6%
t-Statistic	11.19	4.79	8.88	9.16	10.33	9.12	14.99
Observations in Simulation	6,896	1,685	1,817	1,315	1,465	1,395	3,038
Sample is:							
Parties Sample	Yes	Yes	Yes	Yes	Yes	Yes	
Complete Sample							Yes
Unit of Observation:							
Weekly/Stores	Yes						
Monthly/Stores		Yes	Yes	Yes	Yes	Yes	Yes
Dependent variable is:							
Parties Price Index	Yes	Yes	Yes	Yes	Yes		
Recalculated Price Index						Yes	Yes
Competitor Variables:							
Circle-based**	Yes	Yes	Yes	Yes			
MSA-based***			Yes	Yes	Yes	Yes	Yes

*Models 3 and 4 are based on the same regression model. Model 3 reports the simulated impact of eliminating Office Depot in markets where either the MSA-based competition data or the Circle-based competition data indicate that a Staples store faces Office Depot competition. Model 4 reports the simulated impact of eliminating Office Depot in markets where both the MSA-based competition data and the Circle-based competition data indicate that a Staples Store faces Office Depot Completion.

**Variables which control for the number of Office Depot, OfficeMax, computer superstores and warehouse clubs within 5 miles, 5-10 miles, and 10-20 miles of the Staples store.

***Variables which control for the number of Staples, Office Depot, OfficeMax, Wal-mart, Sam's Club, Computer City, BestBuy, Office1Superstore, Costco, BJ's, CompUSA, Kmart and Target stores in the MSA.

Defendants

Include both

FTC

Further comments.

- The results are sensitive to whether or not California is included in the sample. If California is included, the price effect is much greater than if it is not. Column 7.
- Recall we discussed briefly the assumption underlying the FE estimator that the explanatory variables must be **strictly exogenous** (assumption 1.2 above). Thus, we have to believe that entry and exit decisions are exogenous. However, these decisions may well be depend on Staples' price setting, in which case competition is an endogenous variable. This problem can be addressed by using an IV approach.
- There may be competition effects on non-price variables, e.g. service levels. A more complete analysis of competition would take such effects into account.