

ECO 310: Empirical Industrial Organization

Lecture 1: Introduction to the Course

Victor Aguirregabiria (University of Toronto)

September 10, 2018

Introduction / Logistis: Outline

1. Basic information (meetings, tutorials, evaluation, etc)
2. Course topics and objectives.
3. Introduction to Empirical IO.

1. Basic Information: meetings, evaluation, etc

Class meetings and tutorials

- **Class meetings:** Mondays 10am to 12pm in room OI 2214.
- **Tutorials:** Mondays 12pm to 1pm in room OI 2214.
- **Tutorials are a fundamental part of this course.** The main purpose of the tutorials is to provide programming experience and practical experience with actual market data, but also for midterm exam review session.
- **Office hours:** Tuesdays & Thursdays: 2:00-3:00pm. Room: GE 309.

Course prerequisites

- **Microeconomic Theory:** ECO200Y1, or ECO204Y1, or ECO206Y1, or equivalents.
- **Quantitative Methods:** ECO220Y1, or ECO227Y1, or equivalents.
- **Important Note:** It is your responsibility as student to ensure you have met the prerequisites for this course.

Evaluation

- Your final grade will be based on:
 - Problem sets (2 sets): 30%
 - Midterm Exam: 30%
 - Final Exam: 40%

Problem Sets

- Two, each worth 15%. You will have to use STATA software package.
- Your answers to the problem sets should be typed and in electronic version, preferably in PDF format.
- Problem set #1 will be handed out on Monday, October 1st and is due on **Monday, October 15th**.
- Problem set 2 will be handed out on Monday, November 26 and is due on **Thursday, December 6th**.
- **Late assignments will not be accepted and will receive a grade of zero.**

Midterm Exam

- Worth 30% of the course grade.
- On **Monday, October 29** during the Tutorial Class.
- The test will be 60 minutes in duration.
- All the exams are closed-book.
- **Missing the midterm exam implies a zero grade in the exam.**

Final Exam

- Worth 40% of the course grade.
- On December TBA during the Final Exam Period.
- Closed-book.
- The final exam is cumulative.
- **Missing the final exam implies a zero grade in the exam.**

Course Website

- The course web-site is accessible through the University of Toronto Quercus.
- PDF copies of the main references / readings are already available in the course website.
- I will periodically post the lecture slides online, before class.
- I will use the course web-site as a means of communication with the class.
- I recommend you check the announcements regularly.

Course Readings and Software

- The main references of the course are:
 - The chapters of a **book project**.
 - **Four survey papers**, one for each topic in the course.
- Not required but useful econometrics reference: Jeffrey M. Wooldridge (2008). "Introductory Econometrics"
- You are required to have access to the **STATA software package**.
- You can get the student version, inexpensively, from the software licensing office in Robarts library. The six month license of STATA/IC is sufficient for this course.
<https://www.stata.com/order/new/edu/gradplans/student-pricing/>

2. Course Topics & Objectives

Course Topics

- The course covers four models which are **the workhorses in Empirical IO**.
- [1] Measuring Productivity. Estimation of Production Functions.
- [2] Measuring Consumer Preferences. Estimation of Demand of Differentiated Products.
- [3] Firm Competition in Prices and Quantities.
- [4] Empirical Models of Market Entry.

Course Objectives

- Understand the main features of empirical models:
 - demand;
 - production function;
 - price and quantity competition;
 - market entry.
- Learn how to use market real world data to estimate the parameters of these empirical models, and interpret the economic implications of these estimations.
- Acquire enough **programming experience using Stata** and **practical experience using actual data** such that you can work in a research project in empirical IO.

3. Introduction to Empirical IO

Introduction to Empirical IO: Outline

- 1. What is Empirical IO?
- 2. Empirical Questions in IO.
- 3. The Basic Structure of EIO Models.
- 4. An Example.

What is Empirical IO?

- IO studies:
 - how markets work;
 - how firms compete or collude with each other;
 - and how these interactions determine profits and consumer welfare.
- In Empirical IO, **we use data** on consumers' and firms' decisions to:
 - measure consumer demand, firm productivity and profitability;
 - to understand firms' strategies;
 - to analyze how government regulations affect market competition and social welfare.

Empirical Questions in IO

- Why firms producing the same product have different productivities?
What do firms do to improve their productivities?
- Why determines the different prices and market shares of firms in an industry?
- What is consumers valuation of a new product?
- What are the main strategies variables of firms in an industry, e.g., prices, capacity, innovation, advertising, ...?
- What is the value of a merger between two firms and its implications on competition and consumer welfare?
- What are the effects on competition and welfare of government policies such as taxes/subsidies, barriers to entry, pricing restrictions, licenses, etc?

Econometrics and Empirical IO

- Econometrics and data analysis are **fundamental tools for the modern economist** of the 21st century.
- In this course, we will review and apply some basic econometric models and methods:
 - linear regression model;
 - instrumental variables estimation;
 - discrete choice models.
- You will gain practical experience working with economic data, and making use of STATA.

Basic Structure of EIO Models

- **Models:** To study competition in an industry, EIO researchers propose and estimate **models of demand and supply**.
- **Behavior:** Models of consumer and firm behavior where consumers are utility maximizers and firms are profit maximizers.
- **Unobservables:** The model recognizes that we as researchers have less information about demand and costs than firms in the industry. Some variables in the model observable to firms are unobservable to us.
- **Parameters:** The parameters of the model have a clear economic interpretation in terms of **consumer preferences, production technology, or institutional constraints**.

Principle of Revealed Preference

- We observe consumers' and firms' choices.
- We assume that they make these decisions to maximize a payoff or utility.
- Under this condition, their **observed choices reveal information to us about their payoff functions.**
- Examples: consumer purchase of particular model of car; firm opening a store in a particular location; firm choice of price; etc.

Typical Structure of IO Models

1. Model of consumer behavior (Demand)

- Product differentiation?

2. Model for firms' costs

- Economies of scale; Economies of scope? Entry costs? Investment costs?

3. Equilibrium model of static competition

- Price (Bertrand), Quantity (Cournot).

4. Equilibrium model of market entry.

5. Equilibrium model of dynamic competition

- Investment, advertising, quality, product characteristics, stores, etc.

Typical Structure of IO Models [2]

- The researcher's choice of model depends on the specific empirical question of interest.
- For some empirical questions it would be sufficient to consider the part of the model related to consumer demand (e.g., value of a new product), or to the production function (e.g., measure firms' productivity).
- For other questions, we will need to estimate models of price/quantity competition or even entry.

An Example: (1) Empirical Question

- **We always start with an empirical question.**
- US cement industry. Evaluation of the effects in this industry of the 1990 Amendments to the Air Clean Act.
- The new law restricts the amount of emissions a cement plant can make.
- It requires the adoption of a "new" technology that implies lower marginal costs but larger fixed costs than the "old" technology.
- **What has been the effect of this new policy on prices, quantities, number of plants, profits, and consumer welfare?**



An Example: (2) Key characteristics of the industry

1. Homogeneous product. (We abstract from spatial differentiation).
2. Substantial fixed costs from operating a plant (cement furnace).
3. Variable costs increase in a convex way when output approaches full capacity.
4. Capacity investment is an important strategic variable.
5. Industry is very local (due to high transportation costs per dollar value). It can be characterized as a set of many "isolated" local markets.
6. Oligopolist industry. Small number of firms at a local market.

An Example: (3) Data

- The specification of the model depends crucially on the **data** that is available for the researcher.
- M local markets (e.g., towns) observed over T consecutive quarters.
- We index markets by m and quarters by t .
- For every market-quarter observation, the dataset contains information on: the number of plants operating in the market (N_{mt}), aggregate amount of output produced by all the plants (Q_{mt}), market price (P_{mt}), and some market characteristics that may affect demand or/and costs, e.g., population, average income, input prices (X_{mt}).

$$Data = \{ P_{mt} , Q_{mt} , N_{mt} , \mathbf{X}_{mt} : m = 1, 2, \dots, M; t = 1, 2, \dots, T \}$$

An Example: (4) Descriptive analysis

- Given this data and our empirical question, we can obtain the following descriptive statistics.
- Mean market output, price, and number of plants** before and after the policy change:

$$\bar{Q}_{Before} = \frac{1}{T_{Before}} \sum_{t < 1990} \sum_{m=1}^M Q_{mt}$$

$$\bar{Q}_{After} = \frac{1}{T_{After}} \sum_{t > 1990} \sum_{m=1}^M Q_{mt}$$

Similarly, for price and for number of plants.

An Example: (4) Descriptive analysis

- One might be tempted to claim that the causal effect of the policy change on output, prices, and number of plants is simply the differences in means before and after:

$$\text{Policy Effects} = \bar{Q}_{After} - \bar{Q}_{Before}, \bar{P}_{After} - \bar{P}_{Before}, \\ \bar{N}_{After} - \bar{N}_{Before} \text{ ?????}$$

- However, this estimate of the effect is not taking into account that other things in the industry (e.g., demand, costs) could be different before and after 1990.
- This difference in means evaluation could be capturing spuriously the effects of these other changes.

An Example: (5) Structural analysis

- Also, these differences in means do not give us the effects of the policy change on costs, profits, and consumer welfare.
- To deal with these limitations of this descriptive approach, we:
 - propose a model of demand, costs, and competition;
 - estimate the parameters of this model separately before and after 1990;
 - attribute to the policy change those changes in parameters associated to changes in costs (not demand).
 - use the model to obtain values of the endogenous variables (P , Q , N) that had occurred if the policy change had not occurred (counterfactuals).

An Example: (6) Specification of demand

- For instance: linear in prices and in parameters.

$$P_{mt} = \beta_0 + \beta_X \mathbf{X}_{mt}^D - \beta_1 Q_{mt} + \varepsilon_{mt}^D$$

- Or log-linear (isoelastic)

$$\ln P_{mt} = \beta_0 + \beta_X \ln \mathbf{X}_{mt}^D - \beta_1 \ln Q_{mt} + \varepsilon_{mt}^D$$

- β'_0 s are parameters.
- \mathbf{X}_{mt}^D are observable variables affecting demand, e.g., population, average income.
- ε_{mt}^D is a random variable with zero mean that is unobservable to us as researchers and affects demand.

An Example: (7) Specification of costs

- The cost of a firm in this industry is:

$$C(q_{imt}) = VC_{mt}(q) + FC_{mt}$$

- The **Variable Cost** is quadratic:

$$VC_{mt}(q) = (\gamma_1^{MC} + \gamma_X^{MC} \mathbf{X}_{mt}^{MC} + \varepsilon_{mt}^{MC}) q + \frac{\gamma_2^{MC}}{2} q^2$$

where γ_1^{MC} , γ_X^{MC} , and $\gamma_2^{MC} \geq 0$ are parameters.

- The **marginal cost** is:

$$MC_{mt}(q) = \gamma_1^{MC} + \gamma_X^{MC} \mathbf{X}_{mt}^{MC} + \gamma_2^{MC} q + \varepsilon_{mt}^{MC}$$

- The **Fixed Cost** is:

$$FC_{mt} = \gamma_1^{FC} + \gamma_X^{FC} \mathbf{X}_{mt}^{FC} + \varepsilon_{mt}^{FC}$$

- ε_{mt}^{MC} and ε_{mt}^{FC} are unobservable to the researcher.

An Example: (8) Cournot Competition

- Suppose that there are N_{mt} plants active in local market m at quarter. We assume that firms active in a local market compete with each other ala Cournot.
- The profit function of a firm is (q = own output; \tilde{Q} = output of competitors):

$$\Pi_{mt}(q, \tilde{Q}) = P_{mt}(q, \tilde{Q}) q - VC_{mt}(q) - FC_{mt}$$

- This best response output is characterized by the following condition of optimality:

$$P_{mt} + \frac{\partial P_{mt}(q + \tilde{Q})}{\partial q} q = MC_{mt}(q)$$

- An given our linear specification of demand and costs, this condition implies:

An Example: (9) Model of Market Entry

- Let $\Pi_{mt}^*(N)$ be the Cournot equilibrium profit per-firm with N active plants. It is a strictly decreasing function.
- The equilibrium entry condition establishes that every active firm and every potential entrant is maximizing profits.
- Active firms should be making non-negative profits: $\Pi_{mt}^*(N_{mt}) \geq 0$.
- Potential entrants are not leaving positive profits on the table:
 $\Pi_{mt}^*(N_{mt} + 1) < 0$.
- There is a unique value of N that satisfies the equilibrium conditions:

$$\Pi_{mt}^*(N) \geq 0 \quad \text{and} \quad \Pi_{mt}^*(N + 1) < 0$$

An Example: (9) Model of Market Entry

- Suppose that we approximate these two inequalities with the condition the condition $\Pi_{mt}^*(N) = 0$, or what is equivalent, $P_{mt} q_{mt} - VC(q_{mt}) = FC_{mt}$.
- Let's derive this expression for the model with linear demand equation and the quadratic variable cost function.
- Remember that F.O.C. for Cournot equilibrium is:
 $P_{mt} - \beta_1 q_{mt} - MC_{mt} = 0$, or equivalently $P_{mt} = \beta_1 q_{mt} + MC_{mt} = 0$.
 Therefore, $P_{mt} q_{mt} - VC(q_{mt}) = (\beta_1 q_{mt} + MC_{mt}) q_{mt} - VC(q_{mt})$.
- And given that $VC(q_{mt}) = \gamma_1 q_{mt} + (\gamma_2/2) q_{mt}^2$, we have that $P_{mt} q_{mt} - VC(q_{mt}) = FC_{mt}$ can be written as:

$$\left(\beta_1 + \frac{\gamma_2^{MC}}{2} \right) q_{mt}^2 = F_{mt}$$

An Example: (10) Structural equations

- For every market-year (m, t) , the model can be described as a system of three equations with three endogenous variables, N , P , and Q ,

$$\text{Demand} \quad P_{mt} = \beta_X \mathbf{X}_{mt}^D - \beta_1 Q_{mt} + \varepsilon_{mt}^D$$

$$\text{Cournot} \quad P_{mt} - \beta_1 \frac{Q_{mt}}{N_{mt}} = \gamma_X^{MC} \mathbf{X}_{mt}^{MC} + \gamma_2^{MC} \frac{Q_{mt}}{N_{mt}} + \varepsilon_{mt}^{MC}$$

$$\text{Entry} \quad \left(\beta_1 + \frac{\gamma_2^{MC}}{2} \right) \left(\frac{Q_{mt}}{N_{mt}} \right)^2 = \gamma_X^{FC} \mathbf{X}_{mt}^{FC} + \varepsilon_{mt}^{FC}$$

- This system of equations is denoted as the **structural equations** of the model.

An Example: (11) Market equilibrium

- For any value of the exogenous values of the parameters, this model has an equilibrium and it is unique.
- The proof is simple:
 - The Entry equation determines output per firm, $\frac{Q_{mt}}{N_{mt}}$;
 - Then, given output-per-firm, the Cournot equation determines price, P_{mt} .
 - Finally, given price, the demand equation determines total output, Q_{mt} , and then number of plants, N_{mt} .
- The solution of this system, that relates each endogenous variable with only exogenous variables is call the **reduced form equations**.

An Example: (12) Estimation

- As researchers, we are interested in using the model and data to estimate the model parameters β' s, γ^{MC} 's, and γ^{FC} 's.
- Econometric model:

$$P_{mt} = \beta_X \mathbf{X}_{mt}^D - \beta_1 Q_{mt} + \varepsilon_{mt}^D$$

$$P_{mt} - \beta_1 \frac{Q_{mt}}{N_{mt}} = \gamma_X^{MC} \mathbf{X}_{mt}^{MC} + \gamma_2^{MC} \frac{Q_{mt}}{N_{mt}} + \varepsilon_{mt}^{MC}$$

$$\left(\beta_1 + \frac{\gamma_2^{MC}}{2} \right) \left(\frac{Q_{mt}}{N_{mt}} \right)^2 = \gamma_X^{FC} \mathbf{X}_{mt}^{FC} + \varepsilon_{mt}^{FC}$$

- Note that each of these equations is linear in parameters, and it can be estimated as a Linear Regression Model.

An Example: (13) Endogeneity

- **Endogeneity problem.** A key econometric problem that we will have to deal with in the estimation of these equations is that some of the regressors (i.e., price, output, or number of plants) are correlated with the error term of the regression (i.e., the unobservables ε 's).
- Ignoring this endogeneity problem and estimating the parameters by OLS can generate serious bias in our estimates and in the answers to our empirical questions.
- A possible approach to deal with this problem is Instrumental Variables (IV) estimation.

An Example: (14) Answer to Empirical Question

- Once we have estimated the parameters of the model, separately before and the policy change in 1990, we are in the position to answer our empirical question.
- Changes in output, price, plants, costs, profits, and consumer surplus associated to the new policy.
- **Counterfactual:** What are the equilibrium values of these variables in every market-year (m, t) after 1990 if the cost parameters were the same as before 1990?