# INTRODUCTORY ECONOMETRICS

## *Lesson 1*

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# 1 Introduction



# 1.1 Definitions. Elements of Econometrics



## Introduction: Definitions

ECONOMETRICS

- (plz, do not confuse with economic + tricks !!!)
- etymological:
  οίκος [oíkos], 'household',
  and νόμος [nómos], 'rules'
  hence economics ⇝ household management,
  + μετρώ [metró], 'measure'.
  Economy + Measurement
- additive:
  Social science which applies
  Economic theory, Mathematics and Statistical inference
  to the analysis of economic phenomena (Goldberger(1964)).
- utilitarian: The art of the econometrician = define appropriate model + find optimal statistical procedure
  ⇝ econometrician ≠ statistician;
  ···+ sound training in economics (Malinvaud(1963)).



## Introduction: Definitions

- plain: application of statistical methods to economic data (Maddala(1977)).
- concise: empirical determination of economic laws (Theil(1971)).
- AFG(2004): Econometrics deals with
  - formulation (or specification),
  - quantification (or estimation),
  - validation (or testing),
    of relationships among economic variables.

## Introduction: 3 Elements:

- **ECONOMIC THEORY:**
  in charge of
  - (general:) analysis of the economy
  - (specific:) relationships among economic variables
- **DATA:**
  to quantify is NOT one of the objectives of Economic Theory
- **STATISTICS:**
  provides basic structure of data processing methods for:
  - (estimation:)
    quantify relationships among variables in an appropriate way.
  - (testing:)
    validate results in agreement with certain established standards.



## 1.2 Concept and example of model: From the economic model to the econometric model.



## Element 1: Economic Th: basic model

- **Case:** company manager or sales director,
- **Interest:** to know relationship between their sales and their price.
- **basic economic logic:** sales as a function of price $\rightsquigarrow$ basic economic model:

$$V_{sales} = f(\underset{\substack{price \\ (-)}}{p})$$

$f(\bullet)$ is a generic function
(Ec Th : $f(\bullet)$ = inverse fn $\rightsquigarrow$ sales $\uparrow$ if price $\downarrow$.)



## Element 1: Economic Th: additional vars

- **additional economic logic:**
  sales depend on
  - conditions of rival firms (e.g. competition price)
  - market conditions (e.g. economic cycle)
- **complete Model:**

$$V_{\text{sales}} = f(\underset{\substack{\text{price} \\ (-)}}{p}, \underset{\substack{\text{competition price} \\ (+)}}{pc}, \underset{\substack{\text{cycle} \\ (+)}}{c})$$

- NOTE:
  proposed economic model $\equiv$ summary of ideas,
  but nothing new for manager;
  they need specific model for their company
  $\rightsquigarrow$ how their sales **respond** to **their** price.

## Element 2: Data:

- specific Information:
  manager has **information** about:
- - their sales and their prices **(quantitative data)**
  - prices of the competition **(quantitative data)**
  - cyclical moment **(qualitative data)**
- *e.g.*:

| dates | Sales | price | comp.p. | cycle |
|---|---|---|---|---|
| jan 80 | 1725 | 12.37 | 11.23 | high |
| feb 80 | 1314 | 11.25 | 10.75 | high |
| apr 95 | 1234 | 13.57 | 14.5 | low |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |

and all this month after month until December of 2004.



## Element 2: Data: specific model

- specific model for available data:

$$V_t = f(p_t, pc_t, c_t), \qquad t = 1980.1, \ldots, 2004.12$$

  where subindex $t$ indicates period or moment of relationship.

- up to now:
  - economic model: summary of general ideas about relationship
  - data: or specific information on the different variables

  - **How to put together both elements?. . . ????**



## E2: (generic) model + (specific) data?:

- **A:** assumptions about $f(\bullet)$; *e.g.*: linear relationship.
  The model will then be:

$$V_t = \beta_0 + \beta_1 p_t + \beta_2 pc_t + \beta_3 c_t, \qquad t = 1980.1, \ldots, 2004.12$$

- $\beta$'s = parameters or coefficients :
  *e.g.* $\beta_1$ answers the question:
  *how much sales change if price changes in one monetary unit?*
  $\rightsquigarrow$ price policies, production decisions etc. for the company.

- **B:** indicators:
  allocate quantitative values to qualitative variables (like Cycle): *e.g.* substitute with indicator such as Industrial Production Index.



## E2: Model +data?: random disturbances

- After this the model expresses a quantitative relationship among variables:

$$\begin{aligned} 1725 &= \beta_0 + 12.37\beta_1 + 11.23\beta_2 + 101.7\beta_3 \quad (1980.\text{Jan}) \\ 1314 &= \beta_0 + 11.25\beta_1 + 10.75\beta_2 + 97.3\beta_3 \quad (1980.\text{Feb}) \\ \vdots &= \vdots \end{aligned}$$

- **NOTE:** . . . different relationship for each month??? . . .
- **C:** disturbance term;

- back to the generic *economic* model:
  $\Rightarrow$ stable behaviour among variables
  $\Rightarrow$ "average" behaviour reflected in data
  $\Rightarrow$ add term $u_t$ to cover up for small discrepancies. . .

## E2: Model+data?: interpretation

- The econometric model will finally be:

$$V_t = \underbrace{\beta_0 + \beta_1 p_t + \beta_2 pc_t + \beta_3 c_t}_{\text{(important \& systematic "influences")}} + \underbrace{u_t}_{\text{(random disturbance term)}}$$

- Interpretation of $u_t$:
  - $\Rightarrow$ effects that affect sales slightly in every period
    but not explicitly picked up by the model.
  - $\Rightarrow$ small data discrepancies.
  - $\Rightarrow$ non systematic effects $\equiv$ more erratic.
  - $\Rightarrow$ **random variable** with certain probability law
    (*e.g.*: Normal dn).



## Element 3: Statistics:

- Model contains a random variable
  $\rightsquigarrow$ **statistical** procedures that guarantee good results:

$\Rightarrow$ to estimate numeric value of the coefficients,
$\Rightarrow$ to test the validity of the relationship,

- the estimated model
  - won't be a generic model
  - but a specific model for the company
- it will offer the manager
  specific information to make decisions.



## 1.3 The Econometric Model. The Disturbance or Error term.



## Basic Characteristics: data notation

More general econometric model with $K$ variables:

- for time series data:

$$Y_t = \beta_0 + \beta_1 X_{1t} + \cdots + \beta_K X_{Kt} + u_t, \quad t = 1, 2, \ldots, T.$$

- or, for cross-section data:

$$Y_i = \beta_0 + \beta_1 X_{1i} + \cdots + \beta_K X_{Ki} + u_i, \quad i = 1, 2, \ldots, N.$$

- or, for panel data:

$$Y_{it} = \beta_0 + \beta_1 X_{1it} + \cdots + \beta_K X_{Kit} + u_{it}, \quad \begin{cases} i = 1, 2, \ldots, N; \\ t = 1, 2, \ldots, T. \end{cases}$$

## Basic Characteristics: vars notation

- $Y$: the variable we want *to explain*:
  **dependent v, explained v, endogenous v or regressand.**
- $X_1, X_2 \dots X_K$: variables that *explain* the variable $Y$:
  **explanatory v, independent v, exogenous v or regressors.**
- $\beta_k, (k = 1 \dots K)$: *unknown constants* that determine relationship among variables:
  **parameters or intercept & coefficients**.
  $\widehat{\beta}_k$ is the *estimated* coefficient.
- $u$: variable that picks up *other non-important effects* present in data: **random disturbance or error term.**



## Basic Differences with economic model

Presence of a random disturbance that

- picks up erratic behaviour:

$$Y_t = \underbrace{\beta_0 + \beta_1 X_{1t} + \cdots + \beta_K X_{Kt}}_{\text{systematic part}} + \underbrace{u_t}_{\text{non-systematic or random part}} \qquad t = 1, 2 \dots T.$$

- has zero mean:

$$E(Y_t) = E(\beta_0 + \beta_1 X_{1t} + \cdots + \beta_K X_{Kt}) + \underbrace{E(u_t)}_{=0} \quad t = 1, 2 \dots T.$$

- hence systematic part $\equiv$ average behaviour of $Y$.
- other assumptions on $u$ (basic hypothesis, etc.)
  $\rightsquigarrow$ probabilistic behaviour in different cases
  $\rightsquigarrow$ statistical tools $\rightsquigarrow$ Econometric Methods.



## Classification of econometric models

Different approaches:

- looking at type of data:
  - Time series model.
  - Cross-section model.
- looking at period of observation:
  - **static M.:** Vars measured in same moment.
  - **dynamic M.:** Vars referred to different periods:
    *e.g.* $Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{1,t-1} + \beta_3 X_{2,t-1} + u_t$
- looking at number of relationships:
  - **Single-equation models:** a single relationship or equation.
  - **Simultaneous or Multiple-equation models:** more than one equation.

etc.



## 1.4 Stages in the elaboration of the model. Uses of the model.

## Stages in the elaboration of the model

0. **Selection.** Outline the theory of interest:
   - select the variable to explain: $Y$.
   - select the overall relationship: $Y = f(X)$.
1. **Specification.** Outline econometric model coherent with theory:
   - choose the explanatory variables: $X_1 \dots X_K$.
   - choose the functional form: *e.g.* $f(\cdot) \equiv$ lineal.
   - choose the probabilistic behaviour (distribution) of the random disturbance: $u$, *e.g.* $u_t \sim$ iid$\mathcal{N}(0, \sigma^2)$.

$$Y = \beta_0 + \beta_1 X_1 + \cdots + \beta_K X_K + u.$$



## Stages in the elaboration of the model

2. **Estimation.** Quantify unknown parameters according to the available information:
   - find data for variables: $Y_t, X_{1t}, \dots, \dots, X_{Kt}$ for $t = 1, \dots, T$.
   - choose the appropriate statistical method, *e.g.* OLS:

$$Y_t = \widehat{\beta}_0 + \widehat{\beta}_1 X_{1t} + \cdots + \widehat{\beta}_K X_{Kt} + \widehat{u}_t, \quad t = 1, 2 \dots T.$$

3. **Validation.** Evaluate whether the model represents the initial problem correctly:
   - statistical inference on hypotheses.
   - model not adequate $\rightsquigarrow$ back to specification phase.



## Using the econometric model

The model that has gone thru all the previous stages can then be used for:

- **economic analysis:**
  - interpretation of coefficients,
  - hypothesis testing,
  - etc.
- **prediction:**
  - **time series forecasting:**
    to forecast (predict) future values of $Y$.
  - **in general:**
    to respond to questions of the type,
    what would happen if...?