Causal Research Design: Experimentation

Concept of Causality

A statement such as "*X* causes *Y*" will have the following meaning to an ordinary person and to a scientist.

Ordinary Meaning	Scientific Meaning
X is the only cause of *Y*.	*X* is only one of a number of possible causes of *Y*.
X must always lead to *Y* (*X* is a deterministic cause of *Y*).	The occurrence of *X* makes the occurrence of *Y* more probable (*X* is a probabilistic cause of *Y*).
It is possible to prove that *X* is a cause of *Y*.	We can never prove that *X* is a cause of *Y*. At best, we can infer that *X* is a cause of *Y*.

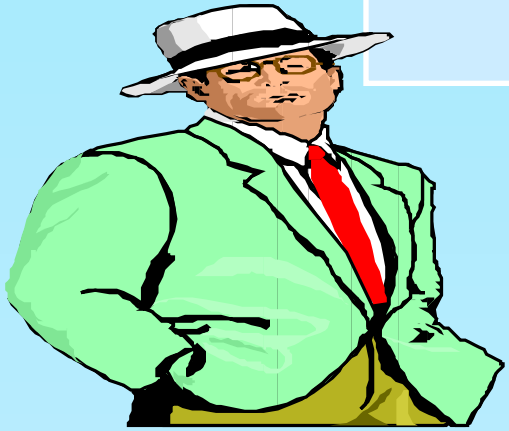
Conditions for Causality

- **Concomitant variation** is the extent to which a cause, *X*, and an effect, *Y*, occur together or vary together in the way predicted by the hypothesis under consideration.
- The **time order of occurrence** condition states that the causing event must occur either before or simultaneously with the effect; it cannot occur afterwards.
- The **absence of other possible causal factors** means that the factor or variable being investigated should be the only possible causal explanation.

between Purchase of Fashion Clothing and Education

Table 7.1

Education, X	Purchase of Fashion Clothing, Y: High	Purchase of Fashion Clothing, Y: Low	
High	363 (73%)	137 (27%)	500 (100%)
Low	322 (64%)	178 (36%)	500 (100%)



Purchase of Fashion Clothing By Income and Education

Low Income Purchase

Education	High	Low	
High	122 (61%)	78 (39%)	200 (100%)
Low	171 (57%)	129 (43%)	300 (100%)

High Income Purchase

Education	High	Low	
High	241 (80%)	59 (20%)	300
Low	151 (76%)	49 (24%)	200

Definitions and Concepts

- **Independent variables** are variables or alternatives that are manipulated and whose effects are measured and compared, e.g., price levels.
- **Test units** are individuals, organizations, or other entities whose response to the independent variables or treatments is being examined, e.g., consumers or stores.
- **Dependent variables** are the variables which measure the effect of the independent variables on the test units, e.g., sales, profits, and market shares.
- **Extraneous variables** are all variables other than the independent variables that affect the response of the test units, e.g., store size, store location, and competitive effort.

Notations of Experimental Design

- O denotes a formal *observation* or measurement
- X denotes *exposure* of test units participating in the study to the experimental manipulation of treatment
- EG denotes an *experimental group* of test units that are exposed to the experimental treatment.
- CG denotes a *control group* of test units participating in the experiment but not exposed to the experimental treatment
- R denotes *random* assignment of test units or groups to experimental treatments . Increases reliability
- M denotes that both the experimental group and the control group are *matched* on the basis of some relevant characteristics

Experimental Design

An **experimental design** is a set of procedures specifying:

- the test units and how these units are to be divided into homogeneous subsamples,
- what independent variables or treatments are to be manipulated,
- what dependent variables are to be measured; and
- how the extraneous variables are to be controlled.

Validity in Experimentation

- **Internal validity** refers to whether the manipulation of the independent variables or treatments **actually** caused the observed effects on the dependent variables. Control of extraneous variables is a necessary condition for establishing internal validity.(draw valid conclusions about the effects of independent variables on the study groups).

- **External validity** refers to whether the cause-and-effect relationships found in the experiment can be generalized. To what populations, settings, times, independent variables and dependent variables can the results be projected?(make valid generalizations to a larger population of interest).

Types of Experiments

- ***Two broad classes:***
  - Laboratory experiments: *those in which the independent variable is manipulated and measures of the dependent variable are taken in a contrived, artificial setting for the purpose of controlling the many possible extraneous variables that may affect the dependent variable*
  - Field experiments: *those in which the independent variables are manipulated and measurements of the dependent variable are made on test units in their natural setting*

Trade-offs Between Internal and External Validity

- ***Laboratory:*** Setting where researchers can run experiments at a reasonable cost and have considerable control over the research environment.
- ***Field Setting:*** Real-world setting where numerous uncontrollable variables may exist.
- Internal validity tends to be higher in controlled environments, such as laboratory settings.
- Internal validity tends to be lower in less-controlled environments, such as field settings.
- External validity may be higher with field experiments.
- External validity may be lower in laboratory settings.

Experimental Research Used to Test

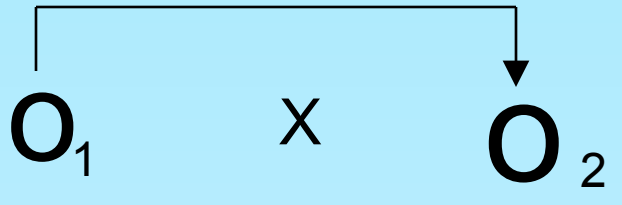
- Effectiveness of new advertising or competitor's advertising
- Effect of various prices on sales of a product
- Consumer acceptance of new products in trial and repeat-purchase levels
- Effect of different package designs on sales
- Whether event A causes event B

7 Extraneous Factors that Can Confound Our Cause-effect Relation

- History- Specific events, external to the experiment, but happening at the same time which affect the dependent variable.
  - Q1 X1 Q2
  - Qn- sales X1- new promotional campaign
- Maturation- Similar to history effects. Refers to **change within test units** that are not due to impact of experimental treatments. Change occurs because of passage of time.
  - This happens in experiments with consumer panels when participants change consumption of a brand to seek variety or taste preferences change.
  - In an experiment involving people, maturation takes place as people become older, more experienced, tired, bored, or uninterested.

7 Extraneous Factors that Can Confound Our Cause-effect Relation

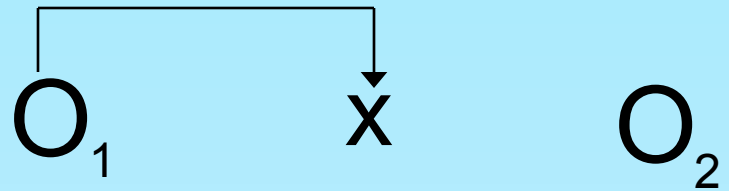
- Testing- Process of experimentation itself may affect the observed relation(effect of measuring the dependent variable before and after the presentation of treatment).
  - **Main testing effect**- effect of a prior observation on a latter observation. First measurement is responsible for change often and does not have anything to do with the manipulation of an experimental variable.
  - Panel members want to appear consistent and will rate a brand the same even if they change their attitude. Post treatment attitude is influenced more by pre-treatment attitude than by the treatment itself.



Hurts Internal Validity

7 Extraneous Factors that Can Confound Our Cause-effect Relation

- Testing- Process of experimentation itself may affect the observed relation.
  - **Interactive testing effect**- prior measurement affects test unit's response to independant variable.
  - People asked to indicate attitudes towards Chevrolet will start to notice Chevrolet advertisements more than people who do not participate in the study.
  - The measured effects are not generalizable to the population.



Hurts external validity

7 Extraneous Factors that Can Confound Our Cause-effect Relation

- **Instrumentation**- changes in the measuring instrument, in the observers, etc.
- **Statistical Regression-** Tendency for extreme cases of marketing phenomenon to move closer to the average during the course of an experiment.
  - Heavy product users often modify their consumption during the study to be more like the average user.
  - Heavy brand users regress their consumer behavior more towards the mean of the group.

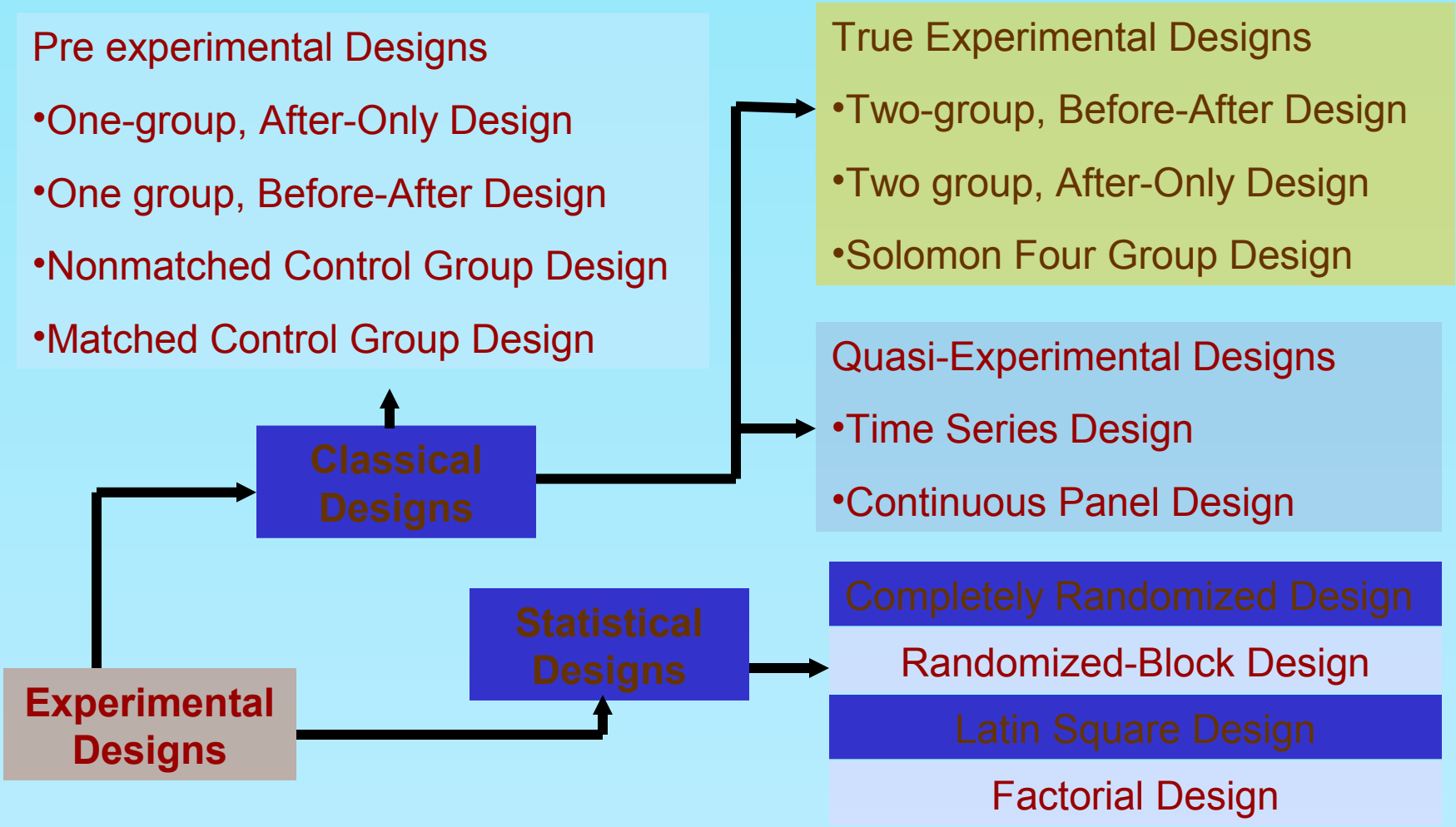
7 Extraneous Factors that Can Confound Our Cause-effect Relation

- **Selection Bias-** Improper assignment of test units to treatment conditions. Unequal experimental and control groups, when we fail to assign a sufficiently large number of test units randomly to conditions, and when we cannot validate that groups of test units are equal prior to being tested.
  - Consumers who have a favorable brand attitude tend to watch more of that brand's advertisements.
  - Merchandizing displays(old and new) assigned to deptt stores that differ in size.
  - Select test units randomly, assign test units randomly, and assign treatments randomly to overcome selection bias.
- **Experimental Mortality-** loss of test units during an experiment.

Controlling Extraneous Variables

- **Randomization** refers to the random assignment of test units to experimental groups by using random numbers. Treatment conditions are also randomly assigned to experimental groups.
- **Matching** involves comparing test units on a set of key background variables before assigning them to the treatment conditions.
- **Statistical control** involves measuring the extraneous variables and adjusting for their effects through statistical analysis.
- **Design control** involves the use of experiments designed to control specific extraneous variables.

Types of Experimental Designs



A Classification of Experimental Designs

- **Pre-experimental designs** do not employ randomization procedures to control for extraneous factors: the one-shot case study, the one-group pretest-posttest design, and the static-group.
- In **true experimental designs**, the researcher can randomly assign test units to experimental groups and treatments to experimental groups: the pretest-posttest control group design, the posttest-only control group design, and the Solomon four-group design.

A Classification of Experimental Designs

- **Quasi-experimental designs** result when the researcher is unable to achieve full manipulation of scheduling or allocation of treatments to test units but can still apply part of the apparatus of true experimentation: time series and multiple time series designs.

- A **statistical design** is a series of basic experiments that allows for statistical control and analysis of external variables: randomized block design, Latin square design, and factorial designs.

Classical Designs - Pre-experimental Designs(absence of randomization)

One Group, After-only Design/one-shot case study

- Apply the experimental treatment to a subject or group and measure the results

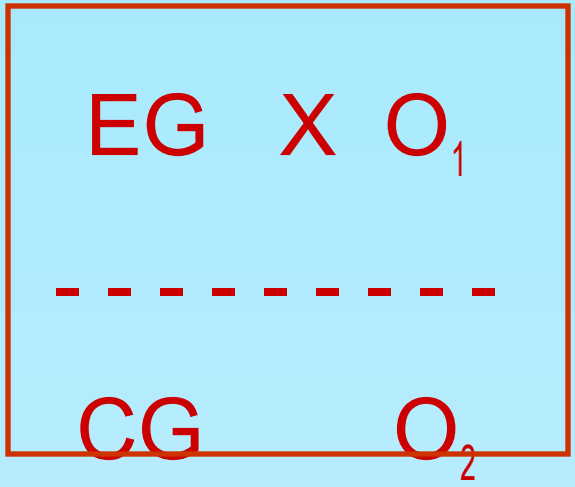
EG X O

Leaves open the possibility that the results could be explained by events external to the design

Pre-experimental Designs (Contd.)

Static group design(unmatched ctrl grp)

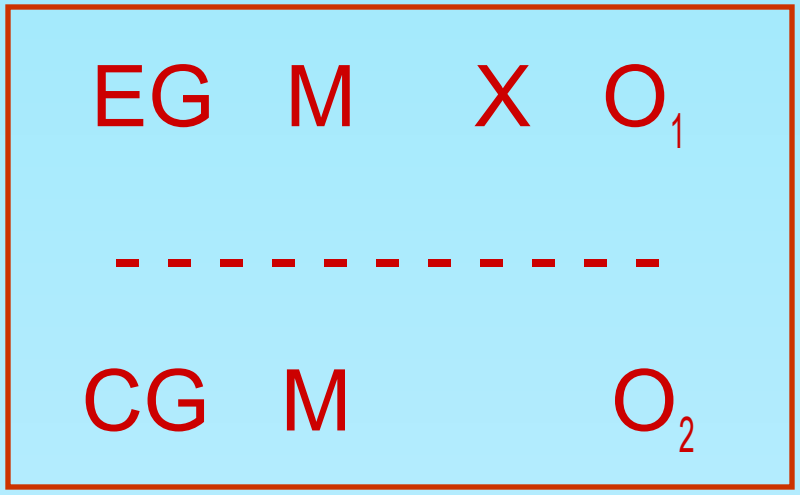
- Introduce a control group to control for history and maturation



Pre-experimental Designs (Contd.)

Matched Control Group Design

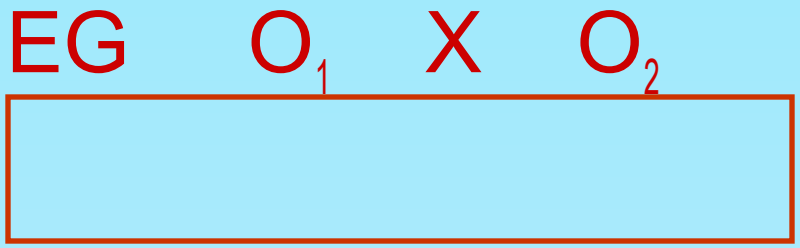
- Matches experimental and control groups to reduce selection bias



Pre-experimental Designs (Contd.)

One-group, Before - After Design

- Improve control by adding before measure



- Treatment effect = O2 – O1.
- Validity is questionable because the extraneous variables are largely uncontrolled.

Pre-experimental Designs (Contd.)

Threats to Experiment Validity in One-group, Before - Afte
Design

Before Measure Effect

- May alert respondents to the fact that they are being studied
- Results in more socially desirable behavior

- Mortality Effect
  - Some subjects may stop participating in the experiment
- Instrumentation Effect
  - Results from a change in the measuring instrument

Classical Designs – True Experimental Designs

True experimental designs adopt random assignment procedure and use one or more control groups

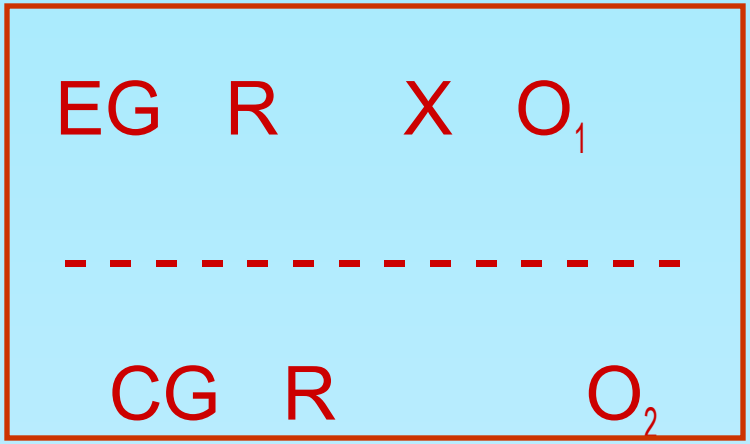
Random Assignment

- For any given assignment of a treatment ,test units to EG, every member of the universe has an equal probability of being chosen .

True Experimental Designs (Contd.)

Two Group, After-only Design

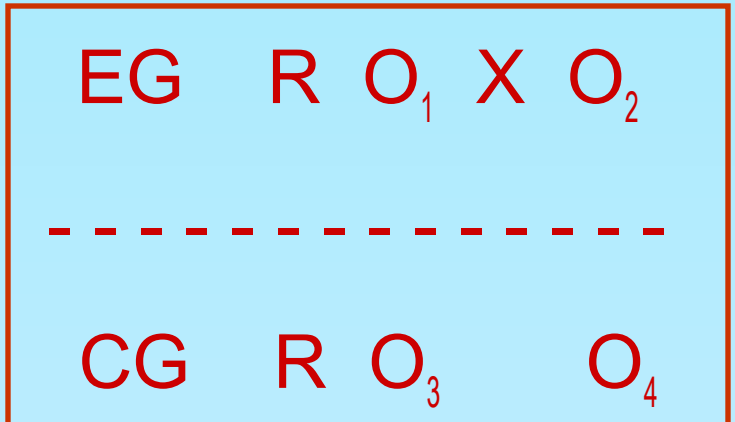
- Randomization can *match* test and control groups on all dimensions simultaneously, given a sufficient sample size



True Experimental Designs (Contd.)

Two-group, Before-after Design/pretest-posttest control group design

- Adds a control group to one-group, before - after design
- TE=(O2-01)-(O4-O3)
- Helps control for selection bias.



Posttest only control group design

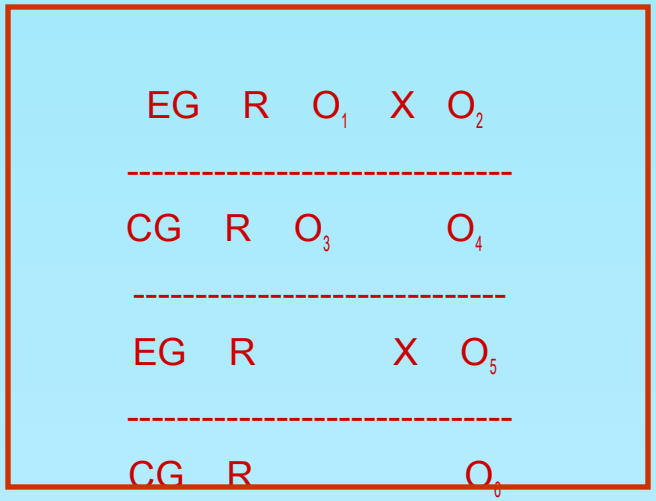
- Does not involve any premeasurement.

EG: R	X	O1
CG: R		O2

True Experimental Designs (Contd.)

Solomon Four - Group Design

- This design is often prohibitively expensive
- Provides power to control for before measure effect of O_1 on both X and O_2



Quasi-Experimental Designs

- Offer some degree of control but there is no random assignment of variables
- Provide more measurements and more information than pre-experimental design

Time Series Designs

- Series of measurements are employed during which an experimental treatment occurs

EG O_1 O_2 O_3 O_4 X O_5 O_6 O_7 O_8

Quasi-experimental Designs (Contd.)

Trend Studies

- Measures over time come from succession of separate random samples from the same population

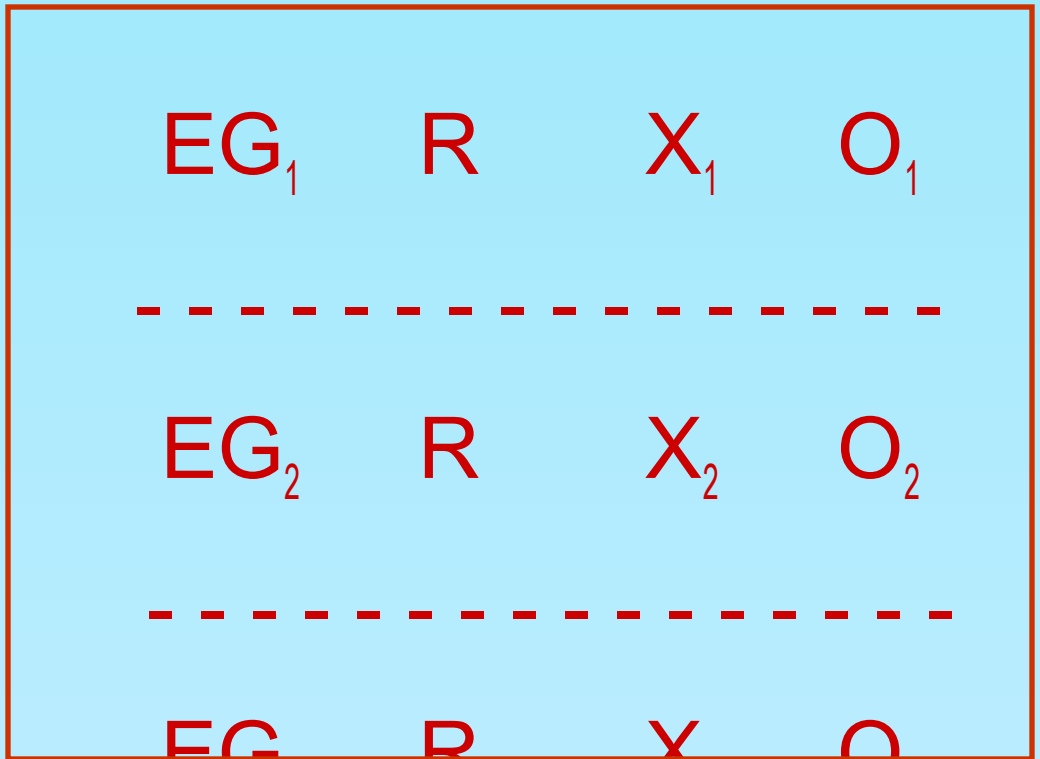
Continuous Panel Studies

- Collect a series of measurements on the same sample of test units over an extended period of time

Statistical Designs

Completely Randomized Design

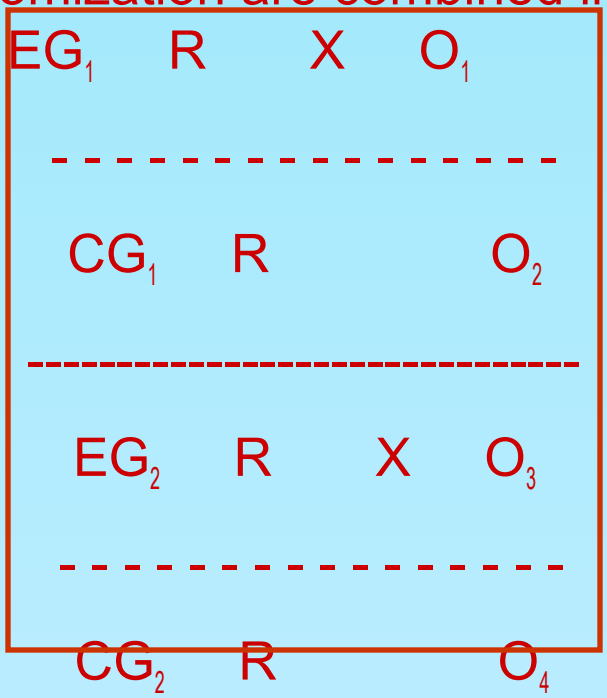
- Any number of treatments can be assigned to test units on a random basis



Statistical Designs (Contd.)

Randomized Block Design

- Employs the randomization process for all variables
- Matching ensures that there are no differences between test samples on matched variables
- Matching and randomization are combined in randomized block design



Statistical Designs (Contd.)

Latin Square Design

- Reduces number of groups involved when interaction between the treatment levels and control variables are unimportant
- Requires same number of rows, columns, and treatment levels
- Cannot be used to determine interaction effects

Latin Square Design - Example

	Stores			
	1	2	3	4
Private Brand A 21 cents	III	IV	I	II
Private Brand B 22 cents	II	III	IV	I
Major Brand A 25 cents	I	II	III	IV
Major Brand B 26 cents	IV	I	II	III

Statistical Designs (Contd.)

Factorial Designs

- Two or more experimental variables are considered simultaneously
- Each combination of the experimental treatment levels applies to randomly selected groups

EG1 R X1 (Hi Adv, Hi Price) O1 n 6

EG2 R X2 (Hi Adv, Low Price) O2 n 6

EG3 R X3 (Low Adv, Hi Price) O3 n 6

EG4 R X4 (Low Adv, Low Price) O4 n 6

EG5 R X5 (No Adv, Hi Price) O5 n 6

EG6 R X6 (No Adv, Low Price) O3 n 6

Limitations of Experimentation

- Experiments can be time consuming, particularly if the researcher is interested in measuring the long-term effects.
- Experiments are often expensive. The requirements of experimental group, control group, and multiple measurements significantly add to the cost of research.
- Experiments can be difficult to administer. It may be impossible to control for the effects of the extraneous variables, particularly in a field environment.
- Competitors may deliberately contaminate the results of a field experiment.

Test Marketing

- A controlled experiment conducted on a small segment of the target market.
  - **To test the sales potential for a new product or service**
  - **To test variations in the marketing mix for a product or service**

- Value of the Test Market is Based on
  - Number of locations used for the experiment
  - Representativeness of the locations selected for the experiment
  - Duration of the experiment
  - Extent market conditions remain “normal”
  - Cost of the experiment versus the quality of information gathered from it

Test Marketing

- ***Standard Test Marketing:*** Companies use their regular distribution channels to sell their products to a small segment of the market.
- ***Controlled Test Marketing:*** Outside research firm is hired to choose a retailer that will be responsible to warehouse, shelve, stock, distribute, and price the product that is apprpriate for the target market.
- ***Electronic Test Marketing:*** Uses scanner-based systems in supermarkets and highly sophisticated broadcasting systems to examine the relationship between what consumers purchase and different advertising messages they watch on television.
- ***Simulated Test Marketing:*** Done in a laboratory, where prospective customers are exposed to a new product, competitive products, and marketing stimuli. Money given to customers by the research firm to purchase products in the artificial setting.

Selecting a Test-Marketing Strategy