The Economics of European Regions: Theory, Empirics, and Policy

Dipartimento di Economia e Management

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- The two most important are:
  - the introduction of potential outcomes in randomized experiments by Neyman (1923)
  - the introduction of randomization as the "reasoned basis" for inference by Fisher (1935).

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- The potential yields **are not equal** to the actual or observed yield because i indexes all varieties and k indexes all plots, and each plot is exposed to only one variety.
- Then goes on to describe an urn model for determining which variety each plot receives
- This model is stochastically identical to the *completely randomized experiment* with $n = m/v$ plots exposed to each variety.

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2. implicit consideration of something like the stability assumption;
3. implicit consideration of a model for the assignment of treatments to units that corresponds to the completely randomized experiment.

However, "implicit is not explicit; randomization as a physical act, and later as a basis for analysis, was yet to be introduced by Fisher " (Neyman, 1923)

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- He proposed the physical randomization of units and furthermore developed a distinct method of inference based for this special class of assignment mechanisms, that is, randomized experiments.
- The "Fisher's exact P-values" are the accepted rigorous standard for the analysis of randomized clinical trials.
- In such a way, the concept of potential outcomes was used in the context of randomized experiments.

Potential Outcomes Approach: a brief history (cont.)

- Despite the almost immediate acceptance of randomized experiments, Fisher's p-values, and Neyman's notation for potential outcomes, these same elements were not used for causal inference in *observational studies*.

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  2. Rubin (1975, 1978) discuss the assignment mechanism in terms of the potential outcomes.

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Rubin, 1974, p. 639

. . . define the causal effect of the E versus C treatment on Y for a particular trial (i.e., a particular unit . . .) as follows: Let $y(E)$ be the value of Y measured at t_2 on the unit, given that the unit received the experimental Treatment E initiated at t_1; Let $y(C)$ be the value of Y measured at t_2 on the unit given that the unit received the control Treatment C initiated at t_1. Then $y(E) - y(C)$ is the causal effect of the E versus C treatment on Y . . . for that particular unit.

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$\Rightarrow$ For these reasons, the modern approach to causal inference and program evaluation is based on the "**Rubin Causal Model** (RCM)".

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- The same thing is true for the females.
- Females started and ended the year lighter on average than the males.

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There is no evidence of any interesting effect of diet (or of anything else) on student weight. In particular, there is no evidence of any differential effect on the two sexes, since neither group shows any systematic change.

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Statistician 1

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Statistician 2

After "controlling for" initial weight, the diet has a differential positive effect on males relative to females because for males and females with the same initial weight, on average the males gain more than the females.

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- For causal inference, both are wrong!

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- The potential outcomes are June weight under the university diet $Y_i(1)$ and under the "control" diet $Y_i(0)$.
- The covariates are sex of students, male versus female, and September weight.
- But the assignment mechanism has **assigned everyone to the new treatment**! There is **no one**, male or female, who is **assigned to the control** treatment.

$\Rightarrow$ there is absolutely no purely empirical basis on which to compare the effects, either raw or differential, of the university diet with the control diet!

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   • Such definition do not require to take a stand on whether the effect is constant or varies across the population.
   • Moreover, does not require to assume endogeneity or exogeneity of the assignment mechanism.
   • Allows researcher to first define the causal effect of interest without considering probabilistic properties of the outcome.

Advantages of POA (cont.)

2. The POA **links** the analysis of causal effects to *explicit manipulations*: considering two potential outcomes forces the researcher to think about scenarios under which each outcome could be observable, that is to consider the kind of experiment that could reveal the causal effects.

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• The clear manipulation is the name change!

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• Similarly, the outcome, earnings, given enrolment in the program can be modelled again conditional on individual characteristics and labour market histories.
• The probability of enrolling in the program given the earnings in both treatments can be modelled conditional on individual characteristics.
• This *sequential* modelling will lead to a model for realized outcome in a easier way with respect to directly specifying a model for the realized outcomes.

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   • In this approach many of the critical assumption will be formulated as (conditional) independence assumptions involving the potential outcomes.
   • Assessing their validity requires the researcher to consider the dependence structure if all potential outcomes were observed.
   • By contrast, models in terms of realized outcomes often formulate the critical assumptions in terms of errors regression functions.
   • In the regression function $Y_i = \alpha + \tau W_i + \epsilon_i$ the independence assumption between W_i and ϵ_i implicitly bundle also functional-form assumptions.

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   • If we observe the *entire population* (increasingly common with the growing availability of administrative dataset) we would be able to estimate population averages with no uncertainty.
   • However, causal effect will be *uncertain* because for each unit at most one of the two potential outcomes is observed.

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- The supply and demand functions play the same role as the potential outcome in Rubin's approach, with the equilibrium price similar to the realized outcome.

Econometric literature (cont.)

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- Potential outcome are also used explicitly in labour market setting by Roy (1951).
- Roy models individuals choosing from a set of occupations.
- Individuals know what their earning would be in each of these occupations and choose the occupation (treatment) that maximizes their earnings.
- In Roy's model there is:
    - an explicit use of the potential outcomes;
    - a specific selection/assignment mechanism, i.e. choosing the treatment with the highest potential outcome.

Econometric literature (cont.)

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- The focus in the econometric literature is traditionally on *endogeneity* or *self-selection*, etc.
- Individual who choose to enrol in a training program are by definition different from those who choose not to enrol.
- These differences, if they influence the response, may invalidate causal comparison of outcomes by treatment status.

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• In *general stratified experiment* the randomization takes place within a finite number of strata.

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- The use of formal randomization has become more widespread in the social science in recent years.
- In randomized experiments estimators for the average effect of the treatment are usually given by the difference in means by treatment status.

2. Unconfounded assignments

The **unconfounded assignments** mechanisms maintains the restrictions that the assignment probability **does not depend** on potential outcomes:

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The unconfounded assumption (Rosembaum and Rubin 1983) is not tied to functional form or distributional assumption.

2. Unconfounded assignments (cont.)

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Various methods have been proposed for special cases.

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- **Sensitivity analysis**: where robustness of estimates to specific limited departures from unconfoundedness are investigated (Rosenbaum and Runin, 1983; Rosenbaum, 1995).
- **Bounds on estimands**: where ranges of estimands consistent with the data and the limited assumptions the researcher is willing to make, are derived and estimated (Manski, 1990; 2003; 2007).

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- **Instrumental variables**: it relies on the presence of additional treatments, the so-called instruments, that satisfy specific exogeneity and exclusion restrictions (Imbens and Angrist, 1994; Angrist, Imbens and Rubin, 1996).