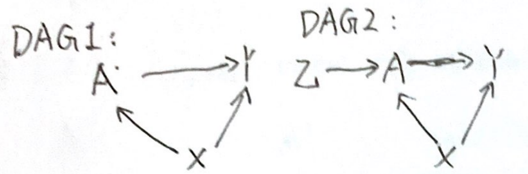
§ 5. Instrumental variables methods

§ 5.1 Introduction



$E(Y^{A=1}) - E(Y^{A=0})$ ⇓ A的causal Effect

$E(Y^{Z=1}) - E(Y^{Z=0})$ ⇓ Z的Causal Effect

① Z直接影响A(处理),并通过A间接影响Y.

② Z与X无关.

Z通常是一种encouragement.

比如鼓励少试者吸烟,喝酒.

③ Z是randomized trial.

- IV is randomly assigned.
- IV is believed to be randomized in the nature.

? 那么使用工具变量如何求得处理A的causal Effect.

§5.2 Randomized trials with noncompliance

Difference
- assigned treatment (as an instrument)
- treatment received (observed treatment in a randomized trial.)

§ 5.2.1

Z — treatment assigned

Z: ask sb. to take the treatment? (是否接受鼓励去take the treatment?)

(randomization to treatment) 可以把Z看成是treatment的分配.

A: treatment received (实际上是否接受treatment)

Y: outcome.

(不完全服从)

Non-compliance: Not everyone assigned treatment ($Z=1$) will acctually receive the treatment (A不一定为1)

(happens in randomized trial)

Z: treatment assignment

A: actual treatment

Hypothesis:

☆ Z treatment assignment does not directly affect Y.

§ 5.2.2 Potential treatment

Observed data: (Z, A, Y) ? Z怎么观察到.

Z可能与A不同,意味着对于某些subject $Z = 1-A$, $A = 1-Z$.

• 类比potential outcome,可以定义potential treatment:

(i) $A^{Z=1} = A^1$, 如果randomized to $Z=1$ (处理的分配为1), 真实的treatment为A^1 (其值可能为0,也可能为1)

(ii) $A^{Z=0} = A^0$, 如果randomized to $Z=0$ (处理的分配为0), 真实的treatment为A^0.

一旦assign完成,就只能观察到A^1或者A^0.其实它们都是潜在的.

§ 5.2.3 Causal effect of Z on A

Think of average causal effect of treatment assignment on actual treatment: $E(A^1 - A^0)$ [proportation treated]

如果whole population都assigned to treatment ($Z=1$), ~~它们所对应的~~ received treatment (A^1) 减去如果whole population都assigned to control ($Z=0$) 的received treatment, (A^0) 再取期望.

绝对服从

In perfect compliance, 每个人都按照assignment去做

$A^1=1$, $A^0=0$ (for everyone), 那么 $E(A^1-A^0)=1$.

☆ Estimable from observed data (需要的条件 {Randomization, consistency)

Consistency: $A^1 = A$ (A的值) if $Z=1 \Rightarrow A^1 = A|Z=1$

(类比 $Y^1 = Y|Z=1$)

Randomization: Z是随机分配的.

$E(A^1) = E(A|Z=1)$

$E(A^0) = E(A|Z=0)$

在assign to treatment的这部分subpopulation中, A的均值就等于whole population都assign to treatment中A的均值. 因为Z是随机的,所以部分与总体的某些特征是一致的.

Take the subpopulation $Z=1$ and take their sample mean of A

§ 5.2.4 Causal effect of Z on outcome

Think of average causal effect of treatment assignment on outcome: $E(Y^{Z=1} - Y^{Z=0})$ [average value of Y]

If everyone assigned to received treatment, their average outcome minus the average outcome if no one had been assigned to receive the treatment.

In perfect compliance, average causal effect of treatment assignment on outcome will be equal to the causal effect of treatment on outcome.

☆ Estimable from observed data (同样两个条件 {Randomization, consistency)

$E(Y^{Z=1}) = E(Y|Z=1)$, $E(Y^{Z=0}) = E(Y|Z=0)$

§ 5.2.5 Causal effect of A on outcome.

☆ 重点关注的Causal effect

把Z看作一种strong encouragement that most people will do what they have been told to receive the treatment. (Z is an IV)

5.1, 5.2