FOURTH STATA LAB

Randomized Controlled Trials (RCT)

THE PROBLEM OF CAUSAL INFERENCE

In evaluating public policies we are often interested in whether there are cause-and-effect relationships:

-How much does earning a master's degree increase future income?

-Does introducing/increasing the minimum wage affect employment?

-Does a universal basic income have positive/negative effects on employment attachment?

-Does working late in life have positive/negative effects on health?

THE PROBLEM OF CAUSAL INFERENCE

In the press and media it often happens that simple correlations are represented as cause-and-effect relationships:

- “This government has increased economic growth” if GDP figures are positive, “This government has taken us into recession” if GDP figures are negative…

-Correlations cannot be interpreted as cause-and-effect relationships. If we want to prove something empirically, we have to be much more precise!

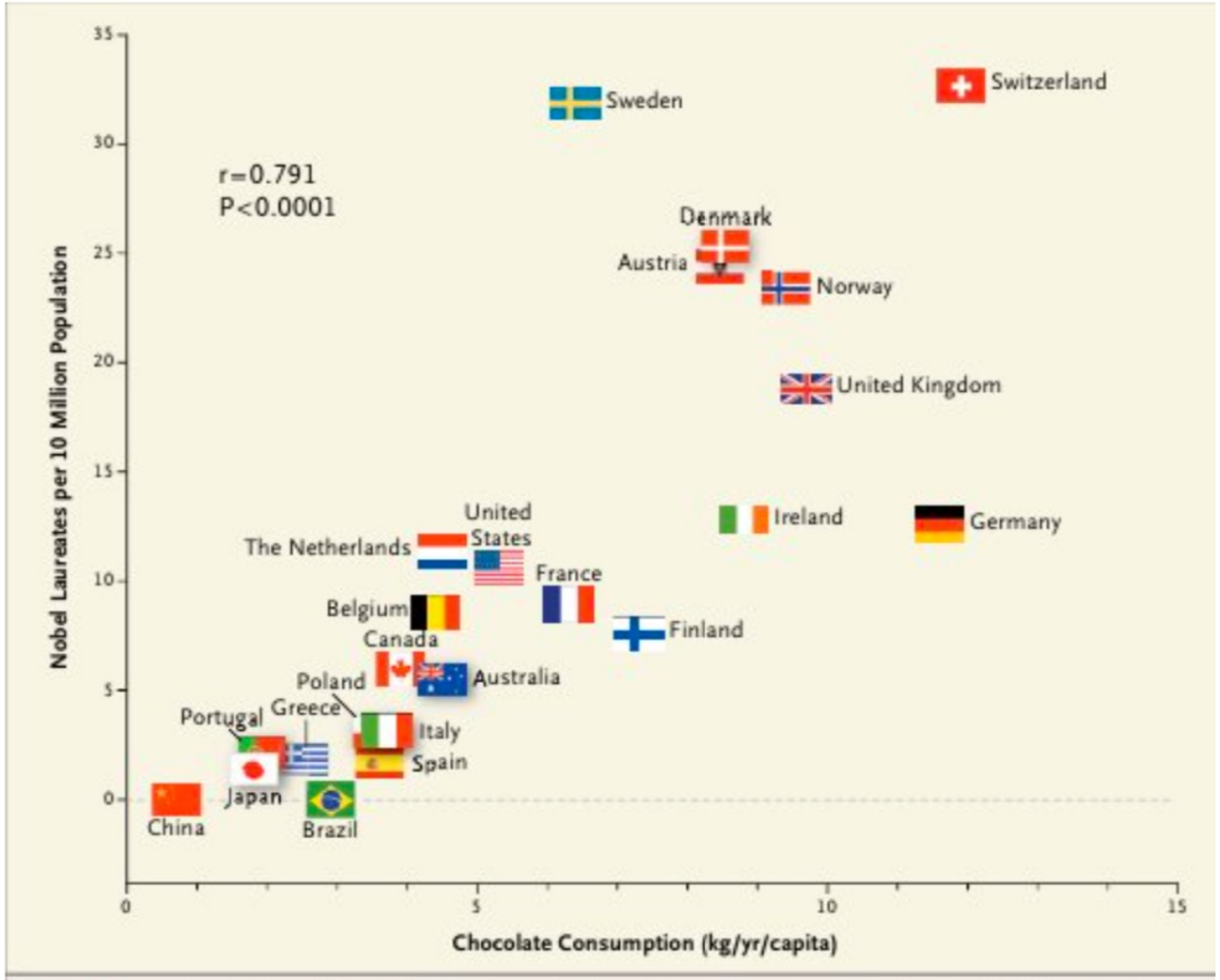

Figure 1. **Correlation between Countries' Annual Per Capita Chocolate Consumption and the Number of Nobel Laureates per 10 Million Population.**

-Can you think of a reason why per capita chocolate consumption is highly correlated with the number of Nobel Prizes won per capita?

-If we interpreted this correlation as a causal relationship, we would have to conclude that eating chocolate is the best recipe for winning a Nobel Prize!

CAUSAL INFERENCE USING A REGRESSION

In estimating a regression we very often run into the problem of **omitted variable bias…**

Imagine that there is a correct model that describes the relationship between a dependent variable (Y) -- e.g., income -- and an independent variable (X) -- e.g., years of education. Specifically, the "population regression model," that is, the correct model, is as follows:

$$Y = \gamma + \tau X + u$$

We are interested in the parameter τ, which correctly measures the average increase in income Y produced by an increase in education level X.

CAUSAL INFERENCE USING A REGRESSION

When we estimate the model with empirical data, we denote the regression as

$$Y = \beta_0 + \beta_1 X + e$$

Based on the definition of the regression parameters, we have the following identity:

$$\beta_1 = \frac{Cov(Y, X)}{Var(X)} = \frac{Cov(\gamma + \tau X + u\ , X)}{Var(X)}$$

We replaced Y with the definition of Y found in the *population regression function*

CAUSAL INFERENCE USING A REGRESSION

Using the properties of covariance, we can write

$$\beta_1 = \frac{Cov(\tau X\ , X)}{Var(X)} + \frac{Cov(u\ , X)}{Var(X)} = \tau + \frac{Cov(u\ , X)}{Var(X)}$$

$\frac{Cov(u\ , X)}{Var(X)}$ Is what is called *selection bias*. It is a bias, because if different from zero, it implies that our estimate of τ given by β_1 is biased!

We need to assume $Cov(u\ , X) = 0$ to interpret β_1 as a causal effect. In other words, there can be no correlations between X and unobservable variables that have an independent influence on Y.

- Does ability influence both income and educational attainment? Is ability usually observable in the data?

THE SOLUTION OFFERED BY THE RCT

If we **randomly assign X**, for example, if we draw at random who will receive much and little education, we will have $Cov(u\ , X) = 0$

Then

$$\beta_1 = \tau + \frac{Cov(u\ , X)}{Var(X)} = \tau$$

Since X (the "treatment") was randomly assigned, the level of X will not be correlated with other variables that have an influence on Y. Thus, β_1 becomes a correct estimate of τ

- If those who go to a master's program are chosen at random from a population, going to a master's program will not be correlated with individual ability.

A PRACTICAL EXAMPLE: LALONDE (1986)

Lalonde's (1986) paper estimates the effect of participating in the *National Supported Work Demonstration* (NWD) program:

-It is a program of offering temporary jobs for disadvantaged people (ex-convicts, ex-drug addicts, non-college graduates) that occurred around 1975 in the United States.

-The goal is to offer publicly funded short work opportunities in a way that provides experience to participants and improves future employment chances.

-Is it possible to estimate the effectiveness of this program simply by comparing the future incomes of those who participate and those who do not? NO, because enrolling in this program could indicate a greater propensity/motivation to seek employment! Those who voluntarily participate are different from those who do not participate!

-Why is it possible in this case instead? The NWD granted access to the program by drawing participants by lottery from the group of those who had applied and were eligible to participate. In this case, participating is not correlated with individual motivation; it is just a matter of luck!

A PRACTICAL EXAMPLE: LALONDE (1986)

The objective is to estimate whether incomes in 1978 (three years after the NWD) are higher for those who participated in the program than for those who did not participate. Before this estimation, we perform the following test:

Random assignment test: we check whether indeed program participants have the same (observable) characteristics as those who did not participate before the start of the NWD (pre-determined characteristics). To test formally, we can use a t-test or F-test (see do file)

```
. tabstat re75 age education black hispanic married nodegree, by(treat) stat(mean sd n) nototal long col(v)
```

treat	Stats	re75	age	educat~n	black	hispanic	married	nodegree
0	Mean	3026.683	24.44706	10.18824	.8	.1129412	.1576471	.8141176
	SD	5201.25	6.590276	1.618686	.4004714	.3168939	.3648392	.3894702
	N	425	425	425	425	425	425	425
1	Mean	3066.098	24.62626	10.38047	.8013468	.0942761	.1683502	.7306397
	SD	4874.889	6.686391	1.817712	.3996597	.2927056	.3748085	.4443762
	N	297	297	297	297	297	297	297

WHY IS THE RANDOM ASSIGNMENT TEST NEEDED?

Testing that there are no differences in pre-determined characteristics between treatment and control group is important because of two potential problems I might have if the test fails:

- In practice, the random assignment of the program may have failed due to organizational/planning problems

=> Consequences: the results of my RCT cannot be considered reliable.

A similar but less serious problem is the following:

- I observe who has the "chance/right to access," where this right is randomly assigned. In this case, the random assignment test does not fail, but there is a problem related to the fact that not everyone who is eligible for treatment might decide to access the program.

=> Consequences: the RCT results are valid, but should be interpreted with caution. Problems: 1) the treatment effect I estimate could be different from the average treatment effect in the population (e.g., only those who expect to have benefits from the program participate and contribute to the effect estimate); 2) the fact that only a portion of the treatment actually receives treatment could bias the estimates toward zero.

=> When there is this partial take-up problem, we say that the RCT identifies an *intention-to-treat* parameter. If I observe both, the random assignment of the right to access the program, and the actual take-up of the program, I can use a 2sls estimation approach to recover a LATE (local average treatment effect)

HAS NSW IMPROVED THE INCOME OF PARTICIPANTS?

Once the random assignment is verified, we can interpret the difference in income in 1978 between participants and nonparticipants as the average effect of NWD parteciaption!

We can also simply calculate a t-test for the difference in income averages in 1978 between participants and nonparticipants

Do we need to add pre-determined controls? They can be included to increase the precision of the estimated treatment effect by reducing its standard error.

```
. reg re78 treat
```

Source	SS	df	MS	Number of obs	=	722
				F(1, 720)	=	3.52
Model	137332501	1	137332501	Prob > F	=	0.0609
Residual	2.8053e+10	720	38962866.3	R-squared	=	0.0049
				Adj R-squared	=	0.0035
Total	2.8191e+10	721	39099301.3	Root MSE	=	6242

re78	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
treat	886.3037	472.0863	1.88	0.061	-40.52635	1813.134
_cons	5090.048	302.7826	16.81	0.000	4495.606	5684.491

LATE ESTIMATION WITH A RCT: BAICKER ET AL. 2014

Baicker et al. 2014 use a lottery that gave access to Medicaid to Oregon residents. Not all winners of the lottery actually applied to Medicaid. They estimate two models:

$$Y = b_{ITT} \text{ winning lottery} + b2\ X + e$$

$$Y = b_{LATE} \text{ predicted(Medicaid coverage)} + b2\ X + e$$

where predicted(Medicaid coverage) is derived from the following first stage regression:

$$\text{Medicaid coverage} = b1 \text{ winning lottery} + b2\ X + e$$

An additional assumption of the 2sls (LATE) model is that winning the lottery affects Y only through its effect on the likelihood of being covered by Medicaid.

b_{LATE} is the effect of Medicaid on the compliers (the subset of individuals who obtain Medicaid on winning the lottery and who would not without winning the lottery)

TABLE 1—2009 EARNINGS

	Control mean (1)	Intent-to-treat (2)	Local average treatment effect (3)	*p*-values (4)
Employment (any earnings)	0.5470	−0.0042 (0.0037)	−0.0156 (0.014)	0.266
Amount of earnings	6,513.02 (10,227.30)	−51.74 (76.80)	−194.93 (289.00)	0.500
Earnings above FPL	0.1314	−0.0032 (0.0026)	−0.0122 (0.0099)	0.219

THE ADVANTAGES OF THE RTC

- Simplicity: if a treatment is randomly assigned, we can interpret a simple difference between groups as a causal effect of the intervention!
- Credibility: the hypothesis that participating in treatment is not related to other factors affecting the dependent variable is very credible
- Lalonde (1986) shows that if we use as a “control group” not those who applied for NWD and were randomly selected, but a comparison group drawn from a U.S. labor market sample survey, the results on the effects of the NSW program are not reliable!

PROBLEMS WITH THE RTC

- To perform an RTC is usually very expensive.
- We cannot answer many “hard questions” with this approach, because certain experiments cannot be performed (e.g., we cannot force a random group to stay in school an extra year!).
- External validity: can the results we get on the small group that participated in our experiment be extended to the general population?
- Ethical issues: for example, is it fair to allocate public resources on the basis of a random draw instead of to those who need them most?