API-202B Empirical Methods II

Session #14: Instrumental Variables Case Studies (II)

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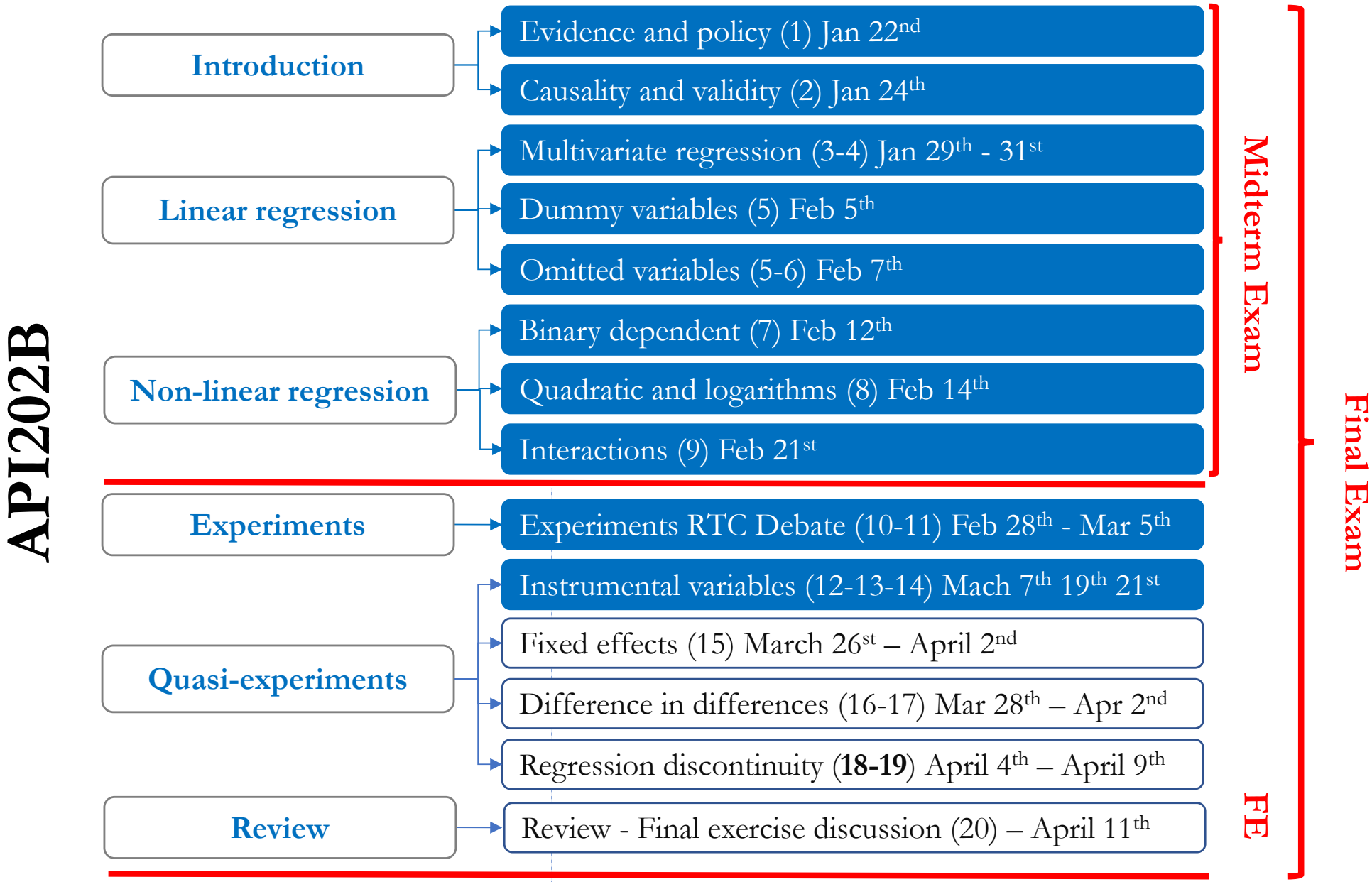
Where we are and what lies ahead in API202B?



Our class today

- The Minneapolis Domestic Violence Experiment (MDVE)
- Mimicking the MDVE (cooked data)
- Back to the real MDVE
  - Local Average Treatment Effects (LATE)
  - Intention to Treat Effects (ITT)
  - Treatment Effect in the Treated (TOT)
- Takeaways
- Vocabulary

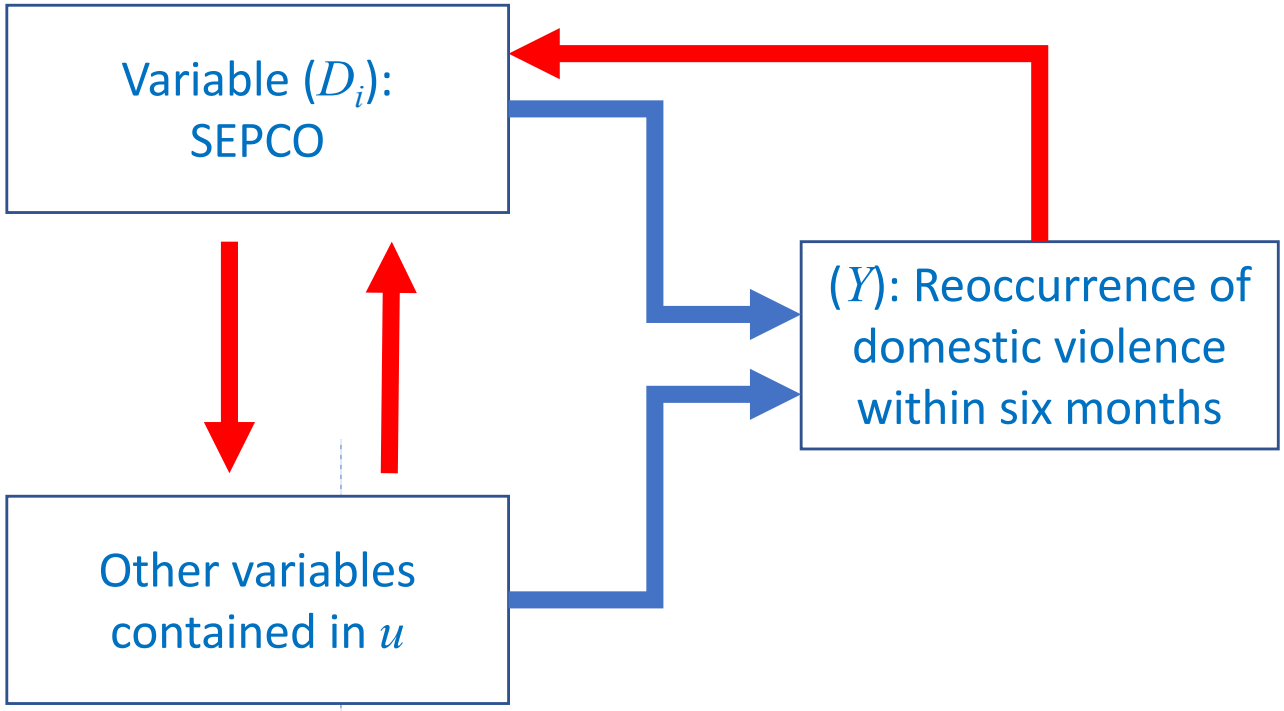
Minneapolis Domestic Violence Experiment (MDVE)

- Instrumental variables can be used to estimate treatment effects in randomized experiments, when we suspect that actual application of treatment is influenced by the intensity of the outcome variable
- MDVE (1984):
  - Study to determine the impact of arresting batterers in the likelihood of reoccurrence of domestic violence within six months
  - Two treatments to suspected offenders:
    - Arrest (usually resulting in a night in jail)
    - Minor punishment (separation from premises for 8 hours and counseling intervention)
  - Treatment randomized by means of color-coded forms in report pads
  - Case of life threatening or severe injuries – felony assaults –excluded

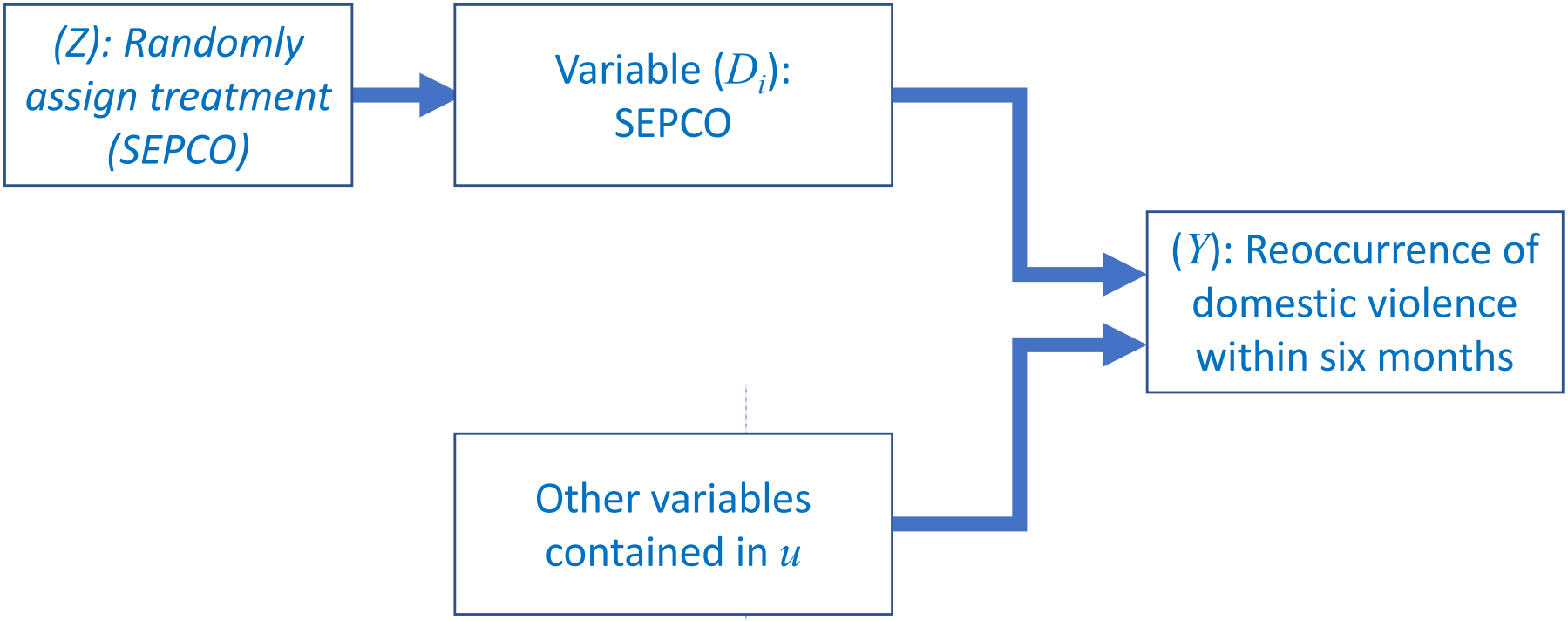
MDVE: What is the problem we are trying to solve?

Simultaneous causality: ***In some cases at police discretion, suspects were arrested even when random assignment called for separation/counseling***

Endogeneity:
Explanatory variable is correlated with the error term



MDVE: What is the problem we are trying to solve?



IV Approach: First stage, reduced form and second stage regressions

First stage regression (regress D on Z):

$$SEPCO = \alpha_0 + \alpha_1 Assigned\ to\ SEPCO + \varepsilon$$

Reduced form (regress Y on Z):

$$Reocurrence = \gamma_0 + \gamma_1 \text{ Assigned to SEPCO} + \text{v}$$

Second stage regression (regress Y on $\widehat{D}$, that is D instrumented by Z)

$$Reocurrence = \beta_0 + \beta_1 \widehat{SEPCO} + \text{u}$$

Before going back to MDVE, let us mimic the experiment with cooked data

Individual	Assigned to SEPCO	SEPCO	Re-ocurrence	Re-ocurrence in Assigned to SEPCO	Re-ocurrence in SEPCO	Re-ocurrence in Assigned to Control	Re-ocurrence in Control
1	1	1	1	1	1	0	0
2	1	1	1	1	1	0	0
3	1	1	0	0	0	0	0
4	1	1	0	0	0	0	0
5	1	1	0	0	0	0	0
6	1	1	0	0	0	0	0
7	1	1	0	0	0	0	0
8	1	1	0	0	0	0	0
9	1	1	0	0	0	0	0
10	1	1	0	0	0	0	0
11	1	1	0	0	0	0	0
12	1	0	1	1	0	0	1
13	1	0	0	0	0	0	0
14	1	0	0	0	0	0	0
15	0	0	1	0	0	1	1
16	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0
18	0	1	0	0	0	0	0
19	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0
Total	**14**	**12**	**4**	**3**	**2**	**1**	**2**
Averages	**70.0%**	**60.0%**	**20.0%**	**21.4%**	**16.7%**	**16.7%**	**25.0%**

First Stage (D on Z)	
Alpha-0	0.1667
Alpha-1	0.6190

MDVE (cooked): First stage and second stage regressions

First stage regression (regress Z on D):

$$SEPCO = \alpha_0 + \alpha_1 Assigned\ to\ SEPCO + \varepsilon$$

$$\widehat{SEPCO} = 0.1667 + 0.6190\ Assigned\ to\ SEPCO$$

Reduced form (regress Y on Z):

$$Reocurrence = \gamma_0 + \gamma_1\ \text{Assigned to SEPCO} + \text{v}$$

Before going back to MDVE, let us mimic the experiment with cooked data

Individual	Assigned to SEPCO	SEPCO	Re-ocurrence	Re-ocurrence in Assigned to SEPCO	Re-ocurrence in SEPCO	Re-ocurrence in Assigned to Control	Re-ocurrence in Control
1	1	1	1	1	1	0	0
2	1	1	1	1	1	0	0
3	1	1	0	0	0	0	0
4	1	1	0	0	0	0	0
5	1	1	0	0	0	0	0
6	1	1	0	0	0	0	0
7	1	1	0	0	0	0	0
8	1	1	0	0	0	0	0
9	1	1	0	0	0	0	0
10	1	1	0	0	0	0	0
11	1	1	0	0	0	0	0
12	1	0	1	1	0	0	1
13	1	0	0	0	0	0	0
14	1	0	0	0	0	0	0
15	0	0	1	0	0	1	1
16	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0
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19	0	0	0	0	0	0	0
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First Stage (D on Z)	
Alpha-0	0.1667
Alpha-1	0.6190

Reduced Form (Y on Z)	
Gamma-0	0.1667
Gamma-1	0.0476

MDVE (cooked): First stage and second stage regressions

First stage regression (regress Z on D):

$$SEPCO = \alpha_0 + \alpha_1 Assigned\ to\ SEPCO + \varepsilon$$

$$\widehat{SEPCO} = 0.1667 + 0.6190\ Assigned\ to\ SEPCO$$

Reduced form (regress Y on Z):

$$Reocurrence = \gamma_0 + \gamma_1\ \text{Assigned to SEPCO} + \text{v}$$

$$\widehat{Reoccurrence} = 0.1667 + 0.0476\ \text{Assigned to SEPCO}$$

Second stage regression (regress Y on $\hat{D}$, that is D instrument by Z)

$$Reocurrence = \beta_0 + \beta_1\ \widehat{SEPCO} + \text{u}$$

Before going back to MDVE, let us mimic the experiment with cooked data

Individual	Assigned to SEPCO	SEPCO	Re-ocurrence	Re-ocurrence in Assigned to SEPCO	Re-ocurrence in SEPCO	Re-ocurrence in Assigned to Control	Re-ocurrence in Control	Forecast of Treatment (X or D) based on (Z)
1	1	1	1	1	1	0	0	0.7857
2	1	1	1	1	1	0	0	0.7857
3	1	1	0	0	0	0	0	0.7857
4	1	1	0	0	0	0	0	0.7857
5	1	1	0	0	0	0	0	0.7857
6	1	1	0	0	0	0	0	0.7857
7	1	1	0	0	0	0	0	0.7857
8	1	1	0	0	0	0	0	0.7857
9	1	1	0	0	0	0	0	0.7857
10	1	1	0	0	0	0	0	0.7857
11	1	1	0	0	0	0	0	0.7857
12	1	0	1	1	0	0	1	0.7857
13	1	0	0	0	0	0	0	0.7857
14	1	0	0	0	0	0	0	0.7857
15	0	0	1	0	0	1	1	0.1667
16	0	0	0	0	0	0	0	0.1667
17	0	0	0	0	0	0	0	0.1667
18	0	1	0	0	0	0	0	0.1667
19	0	0	0	0	0	0	0	0.1667
20	0	0	0	0	0	0	0	0.1667
Total	**14**	**12**	**4**	**3**	**2**	**1**	**2**	
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First Stage (D on Z)	
Alpha-0	0.1667
Alpha-1	0.6190

Reduced Form (Y on Z)	
Gamma-0	0.1667
Gamma-1	0.0476

Second-Stage (Y on $\widehat{D}$)	
Beta-0	0.1538
Beta-1	0.0769

MDVE (cooked): First stage and second stage regressions

First stage regression (regress Z on D):

$$SEPCO = \alpha_0 + \alpha_1 Assigned\ to\ SEPCO + \varepsilon$$

$$\widehat{SEPCO} = 0.1667 + 0.6190\ Assigned\ to\ SEPCO$$

Reduced form (regress Y on Z):

$$Reocurrence = \gamma_0 + \gamma_1\ \text{Assigned to SEPCO} + \text{v}$$

$$\widehat{Reoccurrence} = 0.1667 + 0.0476\ \text{Assigned to SEPCO}$$

Second stage regression (regress Y on $\hat{D}$, that is D instrument by Z)

$$Reocurrence = \beta_0 + \beta_1\ \widehat{SEPCO} + \text{u}$$

$$\widehat{Reoccurrence} = 0.1538 + 0.0769\ \widehat{SEPCO}$$

Before going back to MDVE, let us mimic the experiment with cooked data

Individual	Assigned to SEPCO	SEPCO	Re-ocurrence	Re-ocurrence in Assigned to SEPCO	Re-ocurrence in SEPCO	Re-ocurrence in Assigned to Control	Re-ocurrence in Control	Forecast of Treatment (X or D) based on (Z)
1	1	1	1	1	1	0	0	0.7857
2	1	1	1	1	1	0	0	0.7857
3	1	1	0	0	0	0	0	0.7857
4	1	1	0	0	0	0	0	0.7857
5	1	1	0	0	0	0	0	0.7857
6	1	1	0	0	0	0	0	0.7857
7	1	1	0	0	0	0	0	0.7857
8	1	1	0	0	0	0	0	0.7857
9	1	1	0	0	0	0	0	0.7857
10	1	1	0	0	0	0	0	0.7857
11	1	1	0	0	0	0	0	0.7857
12	1	0	1	1	0	0	1	0.7857
13	1	0	0	0	0	0	0	0.7857
14	1	0	0	0	0	0	0	0.7857
15	0	0	1	0	0	1	1	0.1667
16	0	0	0	0	0	0	0	0.1667
17	0	0	0	0	0	0	0	0.1667
18	0	1	0	0	0	0	0	0.1667
19	0	0	0	0	0	0	0	0.1667
20	0	0	0	0	0	0	0	0.1667
Total	**14**	**12**	**4**	**3**	**2**	**1**	**2**	
Averages	**70.0%**	**60.0%**	**20.0%**	**21.4%**	**16.7%**	**16.7%**	**25.0%**	

Impact on Intended to Treat (ITT): 4.76 pp

Treatment Effect on Treated (TOT): **-8.83% pp**

ITT, TOT and LATE (cooked data)

- Why do you think are these three indicators of the impact of sending reported batterers to separation and counseling on the probability of reoccurrence is **SO** different (in words)?

- ITT: 4.76 pp
  - ITT does not take into account that some subjects randomly assigned to treatment (SEPCO) were not treated. In our example, individual 12 was assigned to SEPCO, was not SEPCO but rather arrested, and incurred in domestic violence again. As there is no correlation between violence and assignment to treatment, it is hard to make the case for a bias ex-ante.
- TOT: -8.83 pp
  - TOT does not take into account that there is some causality linking the outcome (probability of reoccurrence) and the treatment (if too violent, I decide not to SEPCO).
- **LATE: 7.69 pp**

MDVE (cooked data): Treatment and results by group

# of cases	Delivered treatment		
Assigned treatment	Arrest	Separation / Counseling	Total
Arrest	5	1	6
Separation-Counseling	3	11	14
Total	8	12	20

% of cases	Delivered treatment		
Assigned treatment	Arrest	Separation / Counseling	Total
Arrest	83.33%	16.67%	30.00%
Separation-Counseling	21.43%	78.57%	70.00%
Total	40.00%	60.00%	100.00%

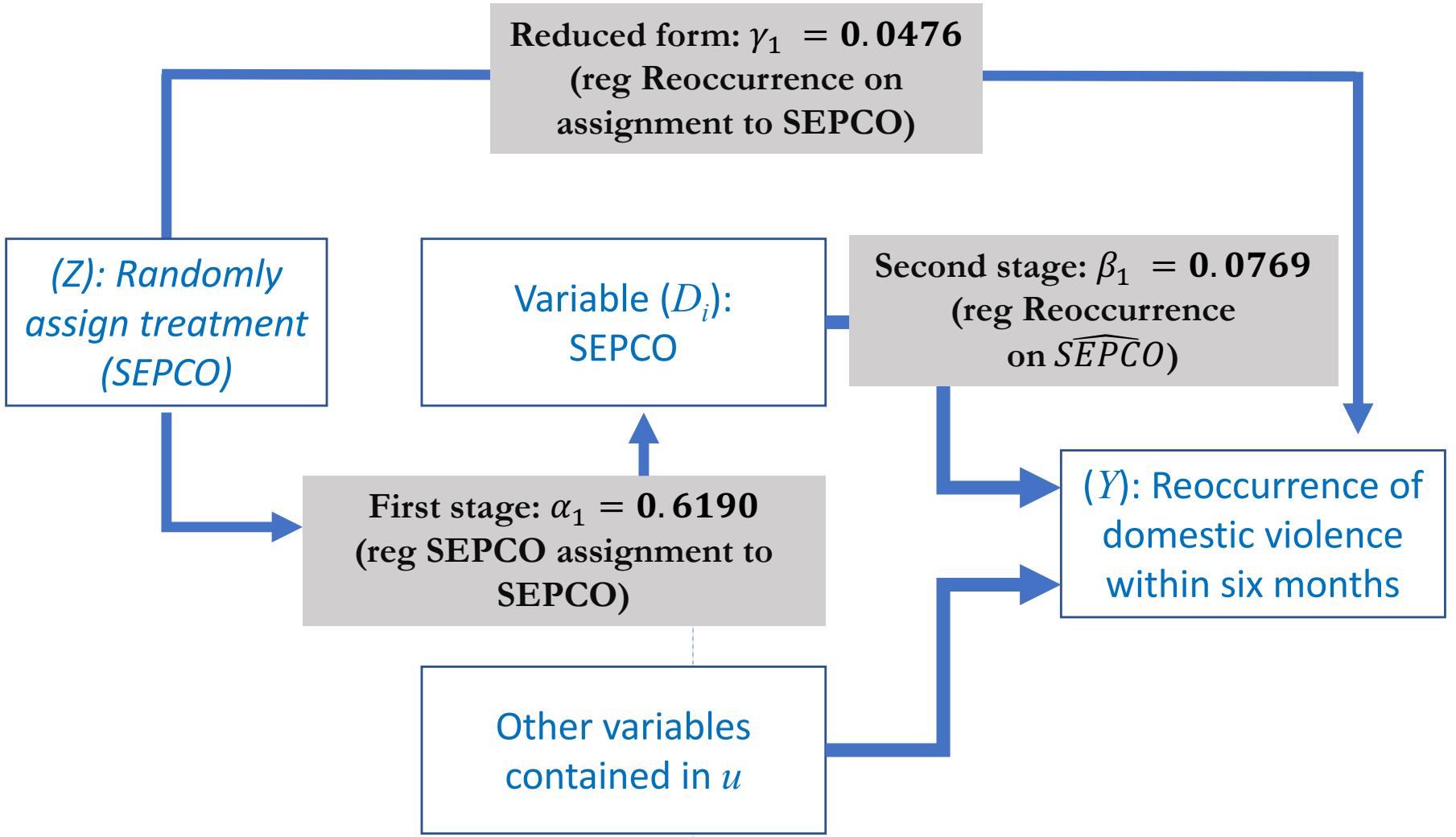
First Stage 61.9%

Reoccurrence: 20.00%
Reoccurrence in cases **assigned to** Separation/Counseling: 21.4%
Reoccurrence in cases **assigned to** where Arrest: 16.7%
Reoccurrence in cases **where** Separation/Counseling **was delivered**: 16.7%
Reoccurrence in cases **where** Arrest **was delivered**: 25.0%

4.76pp — Reduced form (ITT)

TOT -8.33pp

MDVE (cooked data): Both ITT and TOT are significantly lower than LATE



β_1 is called LATE estimate
Local Average Treatment Effect

Now let us move on to the real Minneapolis Domestic Violence Experiment (MDVE) statistics

MDVE: Treatment and results by group

# of cases	Delivered treatment		
Assigned treatment	Arrest	Separation / Counseling	Total
Arrest	91	1	92
Separation-Counseling	45	177	222
Total	136	178	314

% of cases	Delivered treatment		
Assigned treatment	Arrest	Separation / Counseling	Total
Arrest	98.9%	1.1%	29.3%
Separation-Counseling	20.3%	79.7%	70.7%
Total	43.4%	56.6%	100.0%

Reoccurrence: 17.8%
Reoccurrence in cases **assigned to** Separation/Counseling: 21.1%
Reoccurrence in cases **assigned to** where Arrest: 9.7%
Reoccurrence in cases **where** Separation/Counseling **was delivered**: 21.6%
Reoccurrence in cases **where** Arrest **was delivered**: 12.9%

MDVE: First stage and second stage regressions

First stage regression (regress Z on D):

$$SEPCO = \alpha_0 + \alpha_1 Assigned\ to\ SEPCO + \varepsilon$$

$$\widehat{SEPCO} = \underline{0.011} + \underline{0.786}\ Assigned\ to\ SEPCO$$

Reduced form (regress Y on Z):

$$Reocurrence = \gamma_0 + \gamma_1\ \text{Assigned to SEPCO} + \text{v}$$

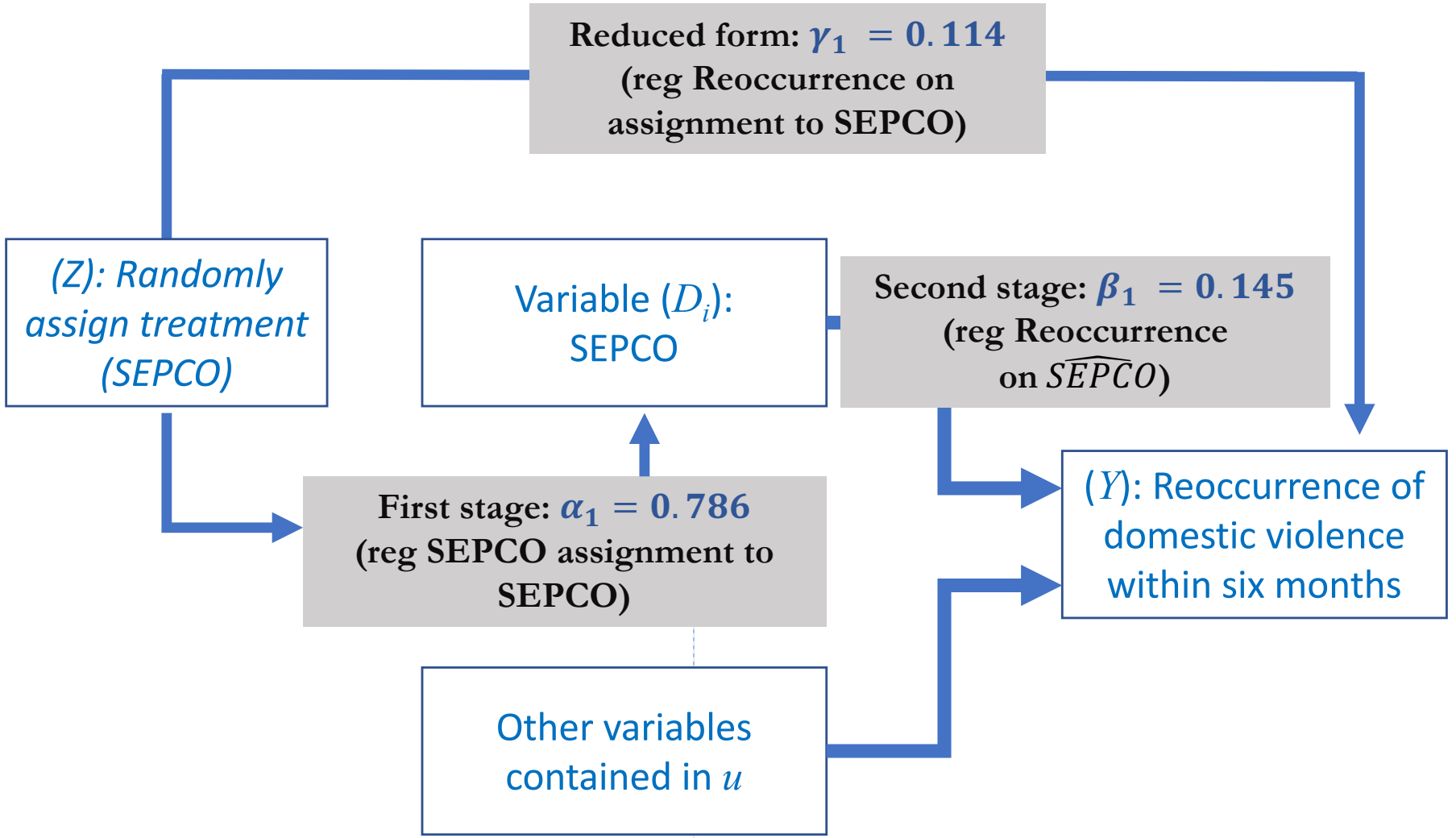
$$\widehat{Reoccurrence} = \underline{0.097} + \underline{0.114}\ \text{Assigned to SEPCO}$$

Second stage regression (regress Y on $\hat{D}$, that is D instrument by Z)

$$Reocurrence = \beta_0 + \beta_1\ \widehat{SEPCO} + \text{u}$$

- How can we know β_1 if we don't have the actual data behind the table? **Dividing the reduced form estimate (0.114) by the First-stage estimate (0.786) = 0.145 or 14.5 pp**

IV Example 1: Institutions and economic performance



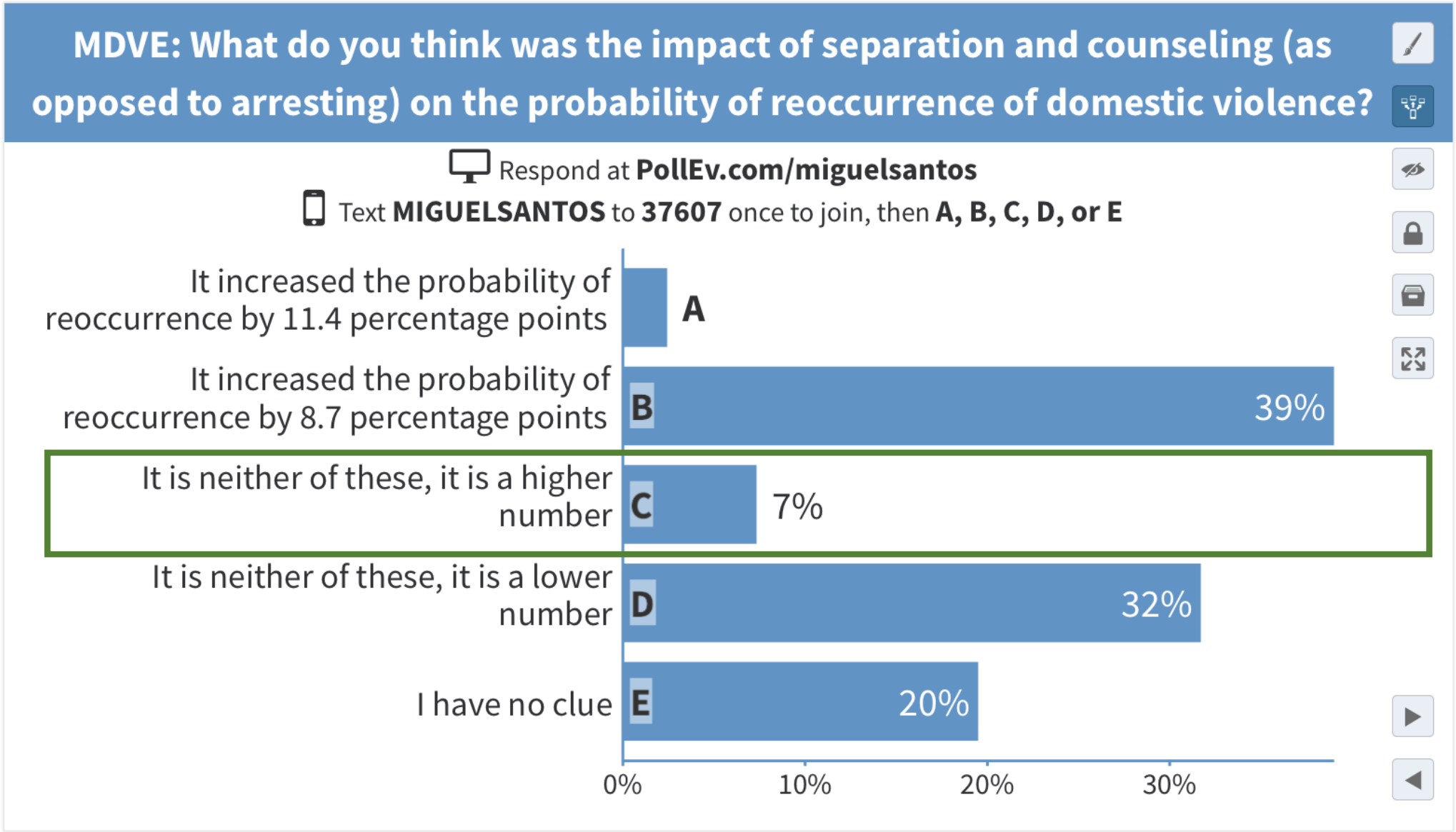
β_1 is called LATE estimate
Local Average Treatment Effect

ITT, TOT and LATE

- What is the Intention to Treat Effects (ITT)?
- **21.1 – 9.7 = 11.4 pp**

- What is the Treatment Effect on the Treated (TOT)?
- **21.6 – 12.9 = 8.7 pp**

- What is the Local Average Treatment Effects?
- **14.5 pp: resulting from dividing the reduced form estimate (0.114) by the First-stage estimate (0.786) = 0.145**
- What can we say about these three effects in the MDVE?
- **LATE is an unbiased estimator of the impact of treatment (SEPCO). It exploits the variation derived from randomization to extract the "good variation" in treatment.**


MDVE: What do you think was the impact of separation and counseling (as opposed to arresting) on the probability of reoccurrence of domestic violence?
Respond at PollEv.com/miguelsantos
Text MIGUELSANTOS to 37607 once to join, then A, B, C, D, or E
It increased the probability of reoccurrence by 11.4 percentage points
A
It increased the probability of reoccurrence by 8.7 percentage points
B
39%
It is neither of these, it is a higher number
C
7%
It is neither of these, it is a lower number
D
32%
I have no clue
E
20%
0%
10%
20%
30%

Takeaways

- Instrumental variables (IV) are useful when we do not have a randomized experiment, but nature or public policy has caused two similar groups of individuals to be treated differently
- IV can be used to adjust for imperfect compliance to treatment in randomized experiments (resulting in Local Average Treatment Effects of LATE estimators)
- As an estimator of the impact of treatment in presence of imperfect treatment compliance, LATE is superior (unbiased) to ITT and TOT
- The key in the IV approach is the disentangle the "good variation" in the variable of interest from the "bad variation", and exploit the good variation to estimate causal treatment effects
- Finding a good instrument is hard!
    - Has to be a true source of exogenous variation
    - Needs to be correlated with regressor of interest (relevance)
    - It is not related to the outcome variable other than its relationship-influence to the regressor

Vocabulary

- Instrumental variable
- Quasi experiments or natural experiment
- Instrument relevance
- Instrument exogeneity / Exclusion restriction
- First stage regression
- Reduced form regression
- Second stage regression
- Local Average Treatment Effects (LATE)
- Intention to Treat Effects (ITT)
- Treatment Effect in the Treated (TOT)