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CENTRO DE SISTEMAS PÚBLICOS

IN4402: Applied statistics for management and economics

Estimating Instrumental Variables

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- To capture this, we can run OLS in two **stages:**

first stage: $$X_i = \pi_0 + \pi_1 Z_i + v_i$$

second stage: $$Y_i = \beta_0 + \beta_1 \widehat{\boldsymbol{X}_i} + u_i$$

- There is a method for estimating both stages using the same variance-covariance matrix: **two-stages least square (2SLS).**

- If we have many instruments ($Z_1, Z_2, \ldots$), we use all in the first stage:
$$X_i = \pi_0 + \pi_1 Z_1 + \pi_2 Z_2 + \pi_3 Z_3 + v_i$$

- We should add covariates (W_i) in the first stage and then control for that effect in the second stage:
$$X_i = \pi_0 + \pi_1 Z_1 + \pi_2 Z_2 + \pi_3 Z_3 + \pi_4 W_i + v_i$$

$$Y_i = \beta_0 + \beta_1 \widehat{\boldsymbol{X_i}} + \beta_2 W_i + u_i$$

INSTRUMENTAL VARIABLES ESTIMATING

CUASI AND NON EXPERIMENTAL METHODS

```
> summary(lm(Y~X+Q))$coefficients #Endogeneous regression -> X is biased
               Estimate Std. Error    t value     Pr(>|t|)
(Intercept) -0.0122637 0.04507074  -0.272099  7.857349e-01
X            5.4670276 0.03247571 168.342041 1.047603e-296
Q            0.4682528 0.05499298   8.514774  8.441462e-16
```

```
> summary(lm(X~Z+Q))$coefficients #First Stage where Z is instrument and Q covariate
               Estimate Std. Error   t value     Pr(>|t|)
(Intercept) -0.04826532 0.05742495 -0.840494 4.013076e-01
Z            1.02455989 0.06032526 16.983929 1.119680e-45
Q            0.99795394 0.05570610 17.914626 3.593973e-49
```

```
> X_hat <- predict.lm(lm(X~Z+Q))
```

```
> summary(lm(Y~X_hat+Q))$coefficients #Second Stage -> Unbiased estimation
               Estimate Std. Error   t value     Pr(>|t|)
(Intercept) -0.01266232  0.3377340 -0.037492 9.701179e-01
X_hat        5.05959752  0.3466945 14.593822 9.672448e-37
Q            0.88619541  0.4837122  1.832072 6.794201e-02
```

- Real 2SLS-IV method (instead of OLS two times) estimates just one variance-covariance matrix so **S.E. are lower**

```
> summary(lm(Y~X_hat+Q))$coefficients #Second Stage -> Unbiased estimation
               Estimate Std. Error   t value     Pr(>|t|)
(Intercept) -0.01266232  0.3377340 -0.037492 9.701179e-01
X_hat        5.05959752  0.3466945 14.593822 9.672448e-37
Q            0.88619541  0.4837122  1.832072 6.794201e-02
```

```
> summary(ivreg(Y~X+Q|Z+Q))$coefficients #Estimation using 2SLS method
               Estimate Std. Error    t value      Pr(>|t|)
(Intercept) -0.01266232 0.05574847 -0.2271332  8.204765e-01
X            5.05959752 0.05722753 88.4119488 2.284416e-215
Q            0.88619541 0.07984452 11.0990136  3.557419e-24
```

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Checking the estimation of Instrumental Variables

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- It’s important to understand the IV method:
  - Avoid **weak** instruments
  - **Interpret** the effect estimate ($\boldsymbol{\beta_1^{2SLS}}$)
  - Have in mind that **standard errors** will be higher

- What happens if the relevance is not strong enough??

$$\widehat{\beta_1^{2SLS}} = \frac{Cov(Y_i, Z_i)}{Cov(X_i, Z_i)} =$$

INSTRUMENTAL VARIABLES: HETEROGENEITY

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- Validity of the effect coefficient
  - The estimation can be interpreted as local effect conditioned on the instrumental variable
    - This means that external validity might be low
    - IV uses a subgroup for the estimation so errors might be larger

- When we have non-compliance, random-assignment can be a good instrument because it's exogenous and relevant
  - The IV effect can be interpreted as CACE (remember CACE= ITT / ITTd)

$$Treated_i = \pi_0 + \pi_1 Assigned_i + v_i$$

$$Result_i = \beta_0 + \underbrace{+\ \beta_1}\widehat{Treated}_i + u_i$$

$$\text{CACE} = \underbrace{E[Y_i(d=1) - Y_i(d=0)}_{\text{Average Treatment Effect}} | \underbrace{d_i(1)=1]}_{\text{Among compliers}}$$

INSTRUMENTAL VARIABLES: BIAS AND ERRORS
CUASI AND NON EXPERIMENTAL METHODS

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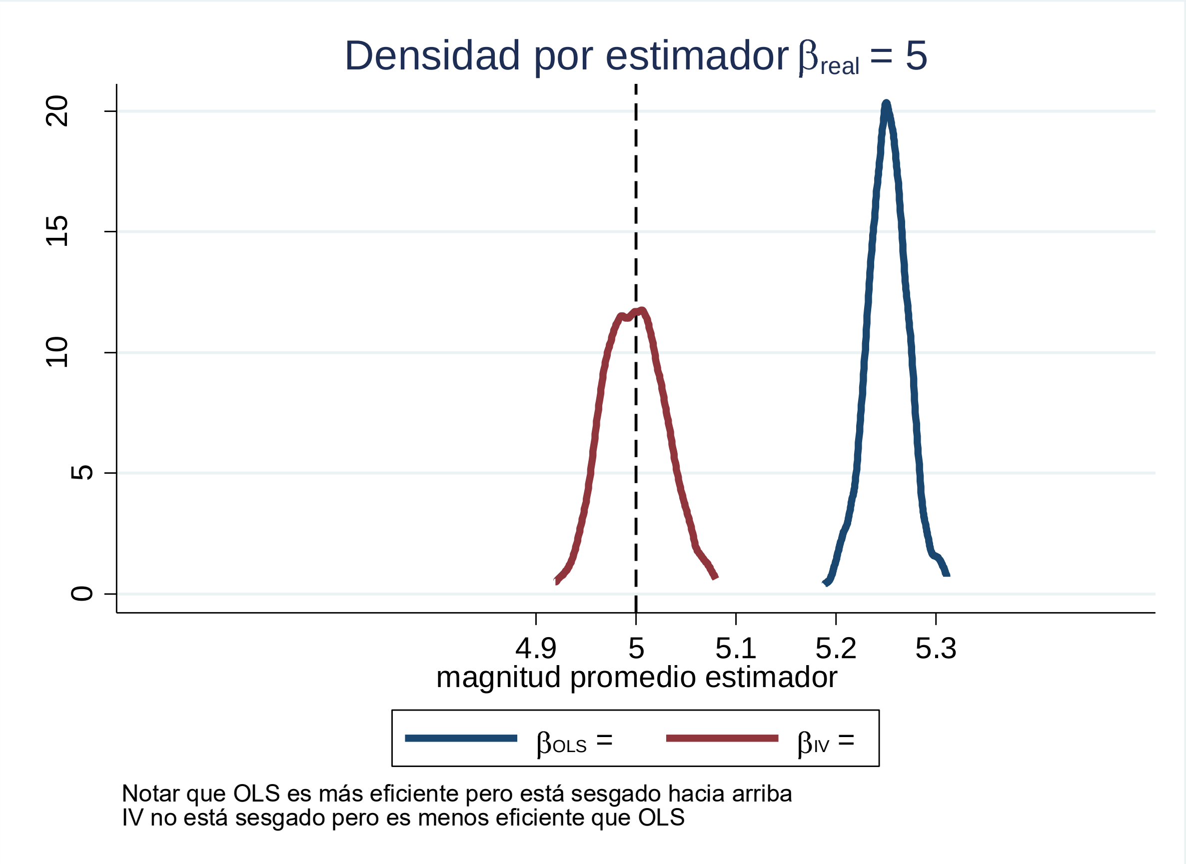
- Under endogeneity:
  - OLS is biased and inconsistent
  - IV is unbiased
    - less efficient than OLS



- Let’s see a comparison on the effect of **Job trainings:**

TABLE 4.4.1
Results from the JTPA experiment: OLS and IV estimates of training impacts

	Comparisons by Training Status (OLS)		Comparisons by Assignment Status (ITT)		Instrumental Variable Estimates (IV)	
	Without Covariates (1)	With Covariates (2)	Without Covariates (3)	With Covariates (4)	Without Covariates (5)	With Covariates (6)
A. Men	3,970	3,754	1,117	970	1,825	1,593
	(555)	(536)	(569)	(546)	(928)	(895)
B. Women	2,133	2,215	1,243	1,139	1,942	1,780
	(345)	(334)	(359)	(341)	(560)	(532)

Notes: Authors’ tabulation of JTPA study data. The table reports OLS, ITT, and IV estimates of the effect of subsidized training on earnings in the JTPA experiment. Columns 1

- Summary:
  - Discuss whether is a strong or **weak** instrument
    - Bias might be larger than before
  - Discuss **heterogeneity** assumptions
    - The estimate has a local effect interpretation
  - Discuss **error estimation**
    - Discuss standard error estimation (higher for IV)

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Instrumental Variables Application II

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INSTRUMENTAL VARIABLES APPLICATION
CUASI AND NON EXPERIMENTAL METHODS

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AMÉRICA LATINA

Alarma en Chile por el aumento de la violencia narco: muertes, peleas y disparos en funerales

Decenas de muertes en un fin de semana y cuatro tiroteos en 48 horas. Según los expertos está relacionada con el aumento del tráfico de drogas

- Can prisons and encarceration be a good option?

- Can prisons and incarceration be a good option?

$$ProbCrime_i = \beta_0 + \beta_1 Incarcerated_i + \varepsilon_i$$

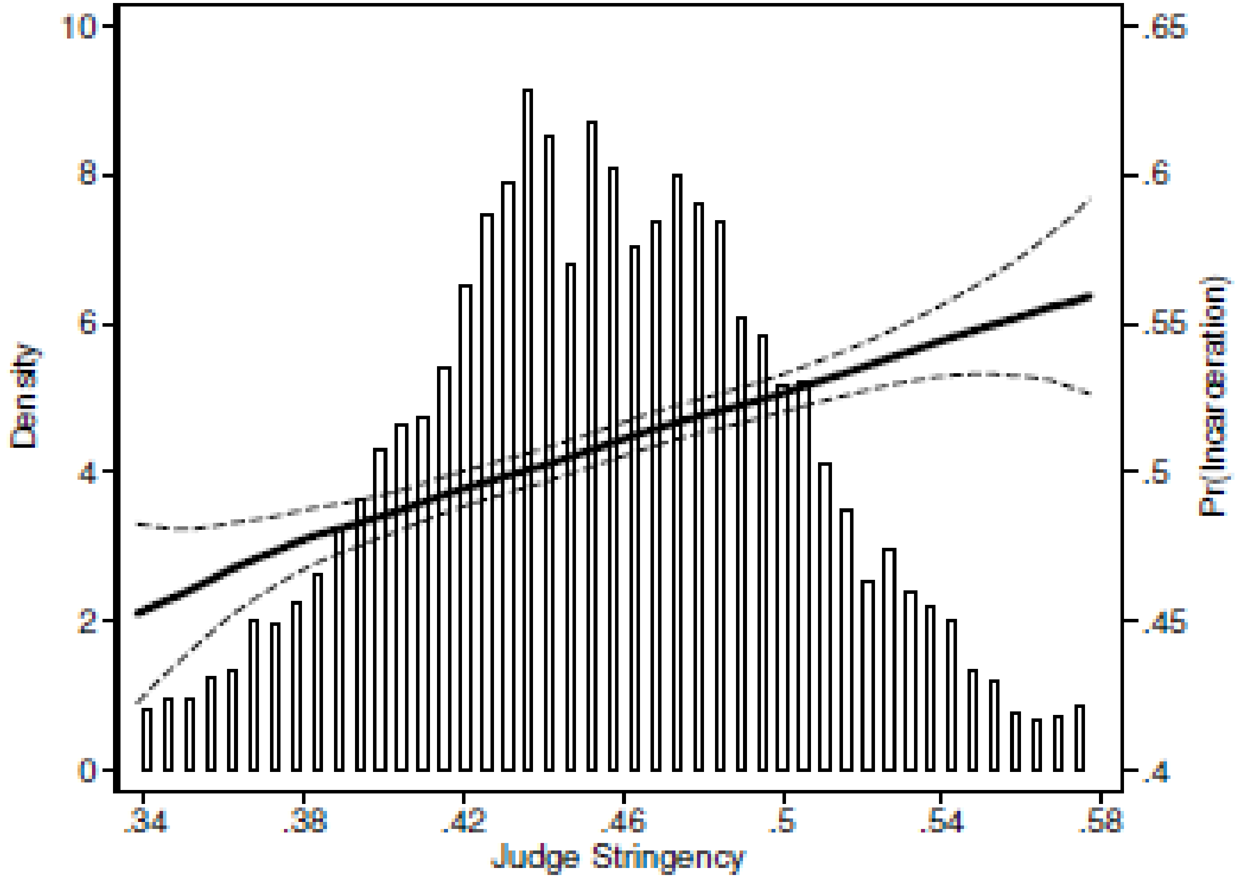
INSTRUMENTAL VARIABLES APPLICATION
CUASI AND NON EXPERIMENTAL METHODS

- Bhuller and others (2020) use that
  - judges stringency (how frequent a judge sends to prison) is *distribuyed near as random*
  - judges are *randomly assigned* to cases in Norway

- Could it be a good instrument?

- Bhuller, M., Dahl, G. B., Løken, K. V., & Mogstad, M. (2020). Incarceration, recidivism, and employment. *Journal of Political Economy*, *128*(4), 1269-1324.

$$Incarcerated_i = \pi_0 + \pi_1 JudgesStringency_i + v_i$$



For example, a judge at the 90th percentile incarcerates about 54% of cases as compared to approximately 37% for a judge at the 10th percentile (p. 17)

- Bhuller, M., Dahl, G. B., Løken, K. V., & Mogstad, M. (2020). Incarceration, recidivism, and employment. *Journal of Political Economy*, *128*(4), 1269-1324.

$$Incarcerated_i = \pi_0 + \pi_1 JudgesStringency_i + v_i$$

	(1)	(2)	(3)	(4)	(5)	(6)
Estimation Sample:	Time of Decision	Month 12 after Decision	Month 24 after Decision	Month 36 after Decision	Month 48 after Decision	Month 60 after Decision
Dependent Variable:	**Pr(Incarcerated)**					
Judge Stringency	0.4897***	0.4922***	0.4887***	0.4818***	0.4795***	0.4699***
	(0.0665)	(0.0661)	(0.0662)	(0.0659)	(0.0661)	(0.0669)
F-stat. (Instrument)	53.56	54.67	53.69	52.79	51.89	48.61
Dependent mean	0.5083	0.5077	0.5066	0.5055	0.5047	0.5045
Number of cases	33,548	33,275	32,786	32,341	31,870	31,428

- Bhuller, M., Dahl, G. B., Løken, K. V., & Mogstad, M. (2020). Incarceration, recidivism, and employment. *Journal of Political Economy*, *128*(4), 1269-1324.

	(1)	(2)	(3)	(4)	(5)	(6)
Estimation Sample:	Time of Decision	Month 12 after Decision	Month 24 after Decision	Month 36 after Decision	Month 48 after Decision	Month 60 after Decision
Dependent Variable:	Pr(Incarcerated)					
C. Add Controls for Demographics, Type of Crime, Past Work and Criminal History						
Judge Stringency	0.4705***	0.4723***	0.4667***	0.4622***	0.4606***	0.4525***
	(0.0632)	(0.0627)	(0.0624)	(0.0622)	(0.0627)	(0.0634)
F-stat. (Instrument)	54.67	55.95	55.09	54.38	53.18	50.24
Dependent mean	0.5083	0.5077	0.5066	0.5055	0.5047	0.5045
Number of cases	33,548	33,275	32,786	32,341	31,870	31,428

- Bhuller, M., Dahl, G. B., Løken, K. V., & Mogstad, M. (2020). Incarceration, recidivism, and employment. *Journal of Political Economy*, *128*(4), 1269-1324.

INSTRUMENTAL VARIABLES APPLICATION

CUASI AND NON EXPERIMENTAL METHODS

Dependent Variable:	Pr(Ever Charged)			Number of Charges
	Months 1-24 after Decision	*Months 25-60 after Decision*	*Months 1-60 after Decision*	*Months 1-60 after Decision*
	(1)	(2)	(3)	(4)
OLS: Incarcerated	0.130***	0.115***	0.113***	5.275***
No controls	(0.007)	(0.007)	(0.006)	(0.321)
OLS: Incarcerated	0.126***	0.109***	0.105***	5.369***
Demographics & Type of Crime	(0.007)	(0.007)	(0.006)	(0.310)
OLS: Incarcerated	0.068***	0.050***	0.052***	2.917***
All controls	(0.006)	(0.007)	(0.006)	(0.278)
Dependent mean	0.57	0.57	0.70	10.21
Complier mean if not incarcerated	0.56	0.57	0.73	13.62
Number of cases		31,428		

- Bhuller, M., Dahl, G. B., Løken, K. V., & Mogstad, M. (2020). Incarceration, recidivism, and employment. *Journal of Political Economy*, *128*(4), 1269-1324.

INSTRUMENTAL VARIABLES APPLICATION
CUASI AND NON EXPERIMENTAL METHODS

Dependent Variable:	Pr(Ever Charged)			Number of Charges
	Months 1-24 after Decision	*Months 25-60 after Decision*	*Months 1-60 after Decision*	*Months 1-60 after Decision*
	(1)	(2)	(3)	(4)
IV: Incarcerated	-0.239**	-0.245**	-0.293***	-11.482**
All controls	(0.113)	(0.113)	(0.106)	(5.705)
Dependent mean	0.57	0.57	0.70	10.21
Complier mean if not incarcerated	0.56	0.57	0.73	13.62
Number of cases	31,428			

- Bhuller, M., Dahl, G. B., Løken, K. V., & Mogstad, M. (2020). Incarceration, recidivism, and employment. *Journal of Political Economy*, *128*(4), 1269-1324.

- Summary: according to Bhuller et al. (2020):
  - The instrument of judges stringency is relevant and exogeneous
  - OLS was biasing results
  - IV shows that incarcerating people reduces probability of repeating crimes and number of crimes
    - At least in people with strict judges that get sent to prison