7) Two-Stage Least Squares (2SLS)

Vitor Kamada

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Reference

Tables, Graphics, and Figures from

Mastering 'Metrics: The Path from Cause to Effect

Angrist & Pischke (2014): Chapter 3.3

Instrumental Variables Estimation

$$y = \beta_0 + \beta_1 x + u$$

$$\text{I) } Cov(z, u) = 0$$

$$\text{II) } Cov(z, x) \neq 0$$

$$Cov(z, y) = \beta_1 Cov(z, x) + Cov(z, u)$$

$$\hat{\beta}_1 = \frac{Cov(z,y)}{Cov(z,x)}$$

Instrument Relevance

$$x = \pi_0 + \pi_1 z + v$$

$$\pi_1 = \frac{Cov(z,x)}{Var(z)}$$

$$H_0 : \pi_1 = 0$$

Does High Fertility Rate Perpetuate Poverty?

Population Grows Faster than Food (Malthus)

Quantity-Quality Tradeoff (Gary Becker)

Negative correlation between average family size and development indicators like education

China One Child Policy in 1979

Angrist, Lavy, and Schlosser (2010)

Second Birth	Children per Family
Singleton	3.6
Twin	3.92

1% of mothers have twins

Second-Born Sibling	Children per Family
Opposite Sex	3.6
Same Sex	3.68

Half of families have either two boys or two girls

Two-Stage Least Squares (2SLS)

$$y_1 = \beta_0 + \beta_1 y_2 + \beta_2 z_1 + u_1$$

$$y_2 = \pi_0 + \pi_1 z_1 + \pi_2 z_2 + \pi_3 z_3 + v_2$$

$$Cov(z_i, v_2) = 0, \quad i = 1, 2, 3$$

$$\pi_2 \neq 0 \text{ or } \pi_3 \neq 0$$

$$y_1 \text{ on } \hat{y}_2 \text{ and } z_1$$

Quantity-Quality First Stages

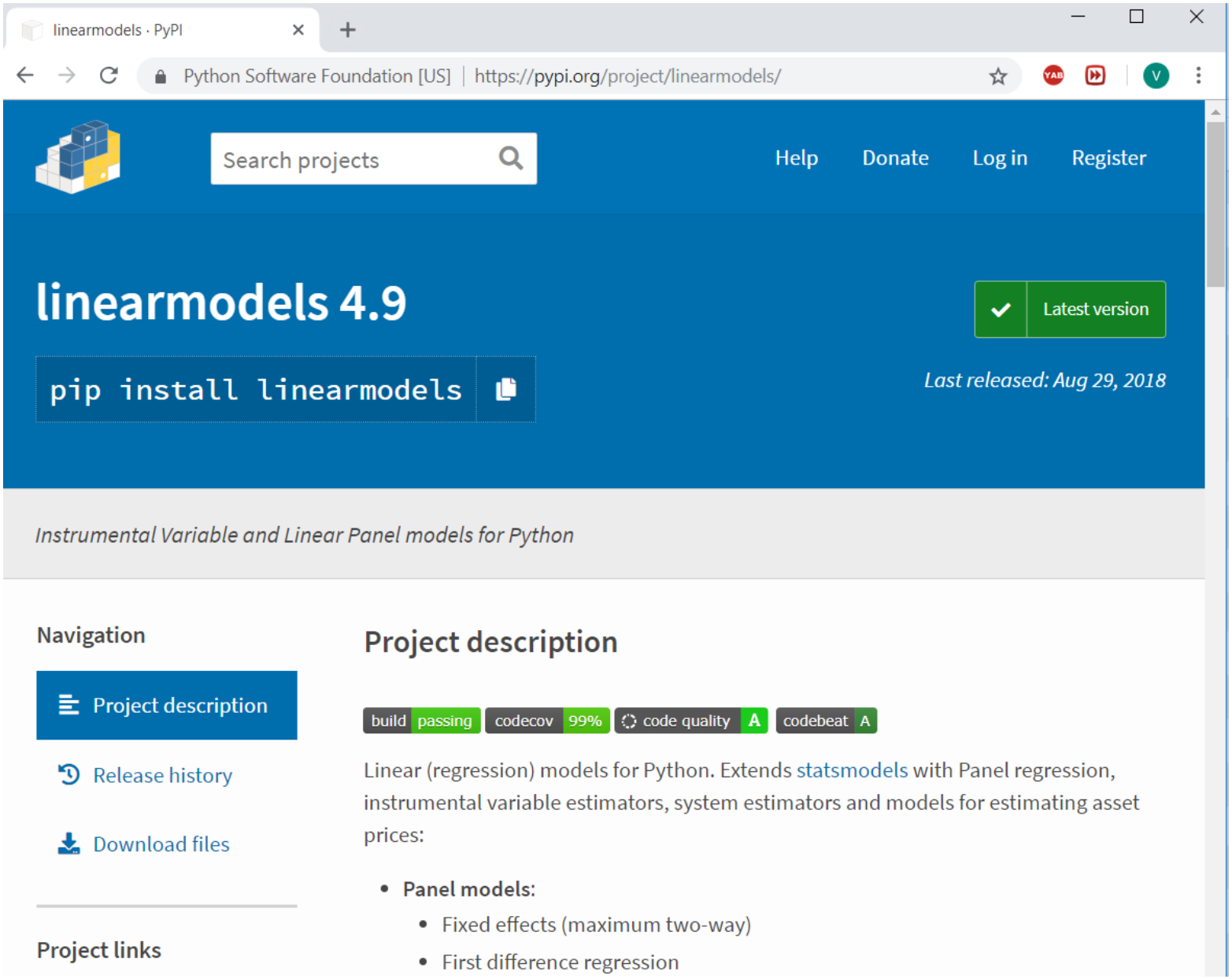
	Twins instruments		Same-sex instruments		Twins and same-sex instruments
	(1)	(2)	(3)	(4)	(5)
Second-born twins	.320	.437			.449
	(.052)	(.050)			(.050)
Same-sex sibships			.079	.073	.076
			(.012)	(.010)	(.010)
Male		−.018		−.020	−.020
		(.010)		(.010)	(.010)
Controls	No	Yes	No	Yes	Yes

Sample Size is 89,445

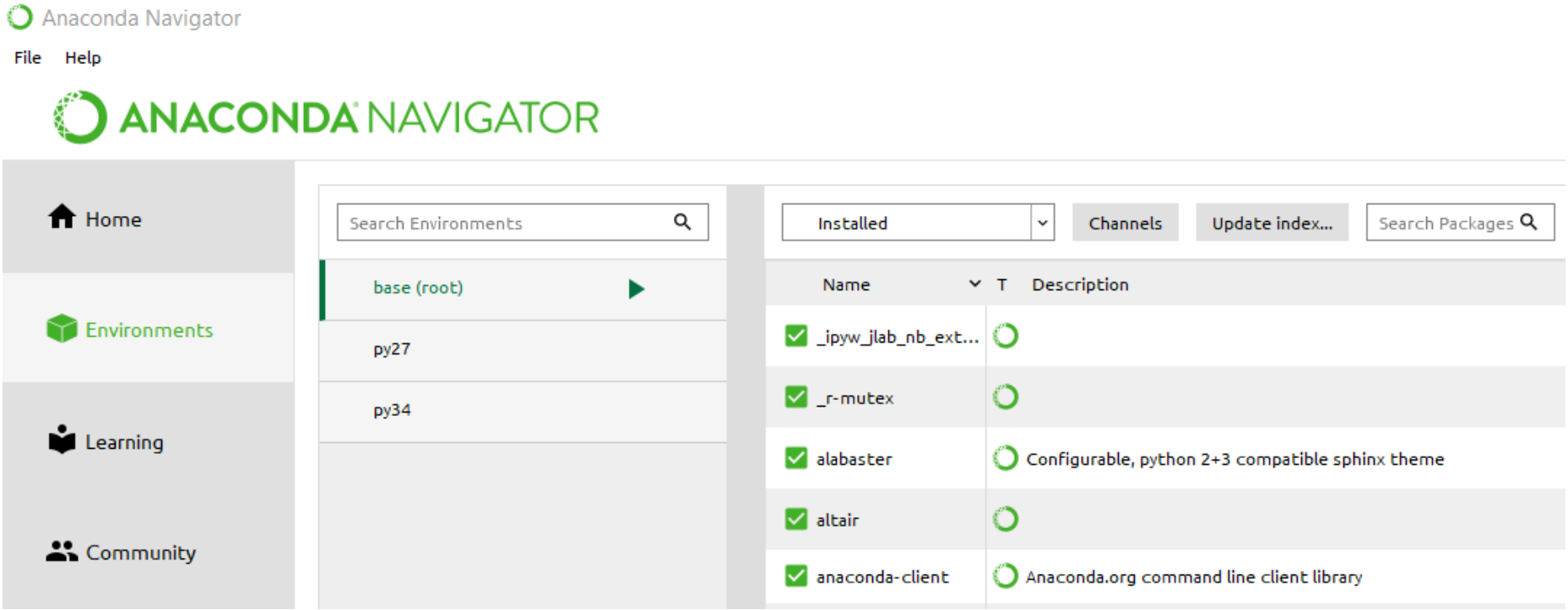
Estimates of the Quantity-Quality Trade-off

		2SLS estimates		
Dependent variable	OLS estimates (1)	Twins instruments (2)	Same-sex instruments (3)	Twins and same-sex instruments (4)
Years of schooling	−.145	.174	.318	.237
	(.005)	(.166)	(.210)	(.128)
High school graduate	−.029	.030	.001	.017
	(.001)	(.028)	(.033)	(.021)
Some college	−.023	.017	.078	.048
(for age ≥ 24)	(.001)	(.052)	(.054)	(.037)
College graduate	−.015	−.021	.125	.052
(for age ≥ 24)	(.001)	(.045)	(.053)	(.032)

How to Install Packages in Anaconda?



Go to Anaconda Environments



1) Click in the green arrow of “base (root)” to “Open Terminal”

2) Then, type: “pip install linearmodels”

Mroz (1987)

"The Sensitiviy of an Empirical Model of Married Women's Hours of Work to Economic and Statistical Assumptions", Econometrica, 55, 765-799.

```
import pandas as pd

import numpy as np

from linearmodels.iv import IV2SLS

df = pd.read_stata('C:\\Users\\Vitor\\Desktop\\ECO 6100 Introduction to Econometrics (Fall 2018)\\Lectures\\7) Two-Stage Least Squares (2SLS)\\MROZ.dta')
```

df[['wage','educ','exper','motheduc','fatheduc']].describe()

	wage	educ	exper	motheduc	fatheduc
count	428.000000	753.000000	753.00000	753.000000	753.000000
mean	4.177680	12.286853	10.63081	9.250996	8.808765
std	3.310283	2.280246	8.06913	3.367468	3.572290
min	0.128200	5.000000	0.00000	0.000000	0.000000
25%	2.262600	12.000000	4.00000	7.000000	7.000000
50%	3.481900	12.000000	9.00000	10.000000	7.000000
75%	4.970750	13.000000	15.00000	12.000000	12.000000
max	25.000000	17.000000	45.00000	17.000000	17.000000

mod1 = 'np.log(wage) ~ 1 + exper + expersq + educ'

```
reg1 = IV2SLS.from_formula(mod1, df).fit(cov_type='robust')
print(reg1)
```

	Parameter	Std. Err.	T-stat	P-value
Intercept	-0.5220	0.2007	-2.6010	0.0093
exper	0.0416	0.0152	2.7344	0.0063
expersq	-0.0008	0.0004	-1.9402	0.0524
educ	0.1075	0.0132	8.1697	0.0000

mod2 = 'np.log(wage) ~ 1 + exper + expersq + [educ ~ motheduc + fatheduc]'

reg2 = IV2SLS.from_formula(mod2, df).fit(cov_type='robust')

print(reg2)

```
                             Parameter  Std. Err.     T-stat    P-value    Lower CI    Upper CI
--------------------------------------------------------------------------------------------
Intercept                       0.0481     0.4278     0.1124     0.9105     -0.7903      0.8865
exper                           0.0442     0.0155     2.8546     0.0043      0.0138      0.0745
expersq                        -0.0009     0.0004    -2.1001     0.0357     -0.0017  -5.997e-05
educ                            0.0614     0.0332     1.8503     0.0643     -0.0036      0.1264
============================================================================================

Endogenous: educ
Instruments: motheduc, fatheduc
Robust Covariance (Heteroskedastic)
```

print(reg2.first_stage)

	educ
R-squared	0.2115
Partial R-squared	0.2076
Shea's R-squared	0.2076
Partial F-statistic	100.22
P-value (Partial F-stat)	0.0000
Partial F-stat Distn	chi2(2)
Intercept	9.1026
	(21.588)
exper	0.0452
	(1.0854)
expersq	-0.0010
	(-0.7671)
motheduc	0.1576
	(4.4718)
fatheduc	0.1895
	(5.8771)

T-stats reported in parentheses