DISCRETIZE: Command to Convert a Continuous Instrument into a Dummy Variable for Instrumental Variable Estimation

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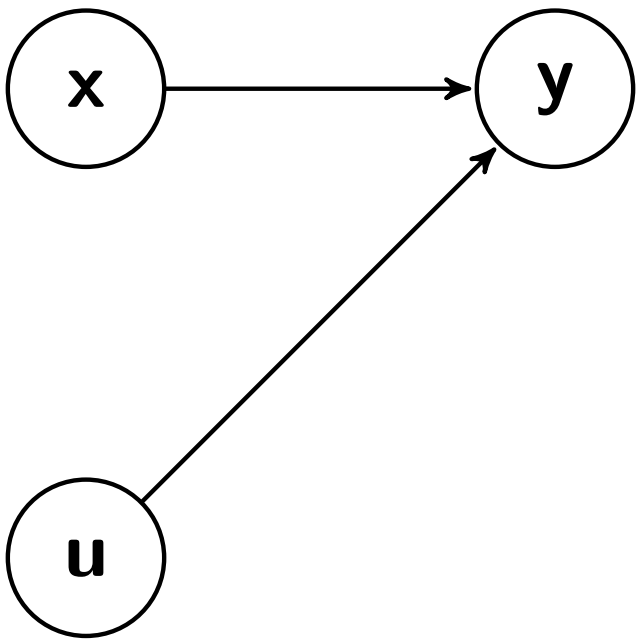
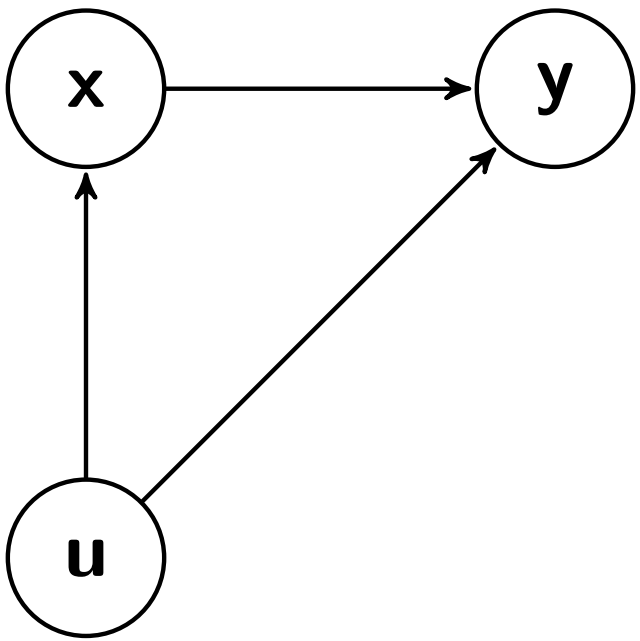
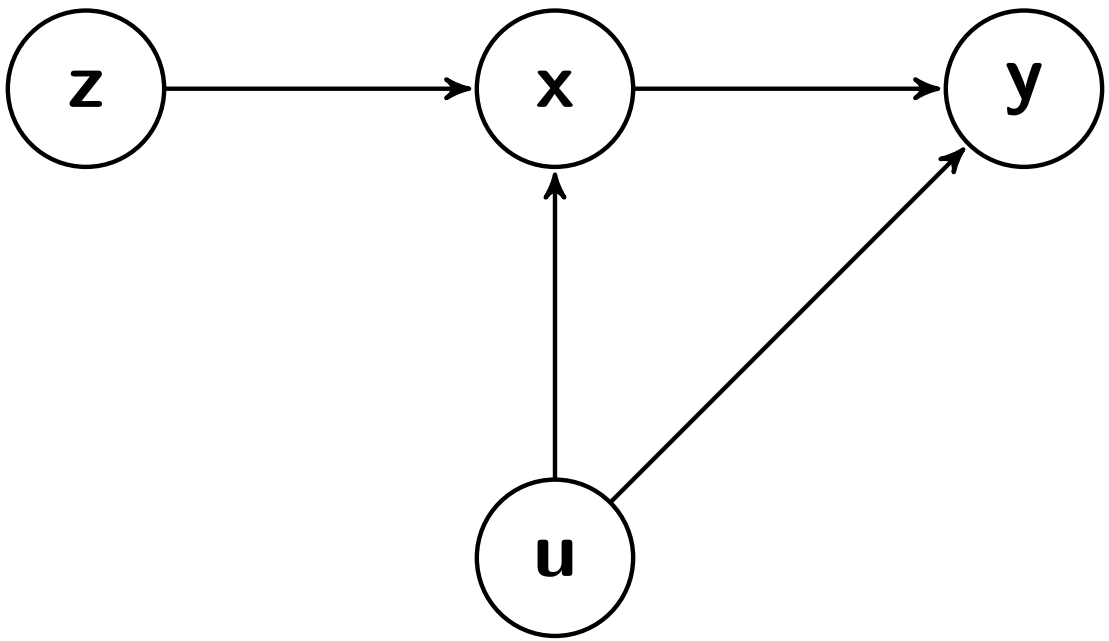
Simple regression model assumes X is uncorrelated with the errors U



If there is an association between X and U: **endogeneity bias**
$\rightarrow$ omitted variable, measurement error or simultaneity



Instrumental Variable (IV): instrument Z excluded from outcome equation (second stage), but determinant of endogenous X (first stage)



Motivation

$\Rightarrow$ Researchers often have no *a priori* knowledge or theoretical understanding regarding the relation between Z and X

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First Solution: Estimate **(complex) non-linear model** between Z and X

- Advantages:
  - Strong first stage
  - Data-driven procedure
- Risks:
  - Overfitting $\rightarrow$ including variation of U that we wanted to eliminate

Motivation

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Second Solution: Estimate **linear model** between Z and X

- Advantages:
  - No overfitting
- Risks:
  - If relationship is non-linear, often leads to a weak instrument problem

Motivation

$\Rightarrow$ Researchers often have no *a priori* knowledge or theoretical understanding regarding the relation between Z and X

Third Solution: **Convert continuous Z into binary instrument**

- Advantages:
  - Parsimonious non-parametric model (Angrist & Pischke, 2009)
  - Easy interpretation of the variation used
- Risks:
  - Choice of boundaries for binary instrument often arbitrary
  - Sensitivity of second stage results

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discretize command

The discretize command offers a **data-driven procedure** to build discrete instruments $\rightarrow$ boundaries chosen to maximize F-statistic in first stage

Main advantages:

1. Parsimonious model for first stage relation - No overfitting
2. By construction, minimizes weak instrument problem
3. Transparent procedure that does not depend on arbitrary decisions made by the researcher
4. Graphs to check robustness of second stage results

First stage estimation

```
discretize contvarname, endogenous(varname)
    range(min/max) interval(min(step)max)
```

contvarname = continuous instrument to be discretized (integer because loops do not handle well decimals)

`endogenous(`*varname*`)` = endogenous variable

`range(`*min/max*`)` = minimum/maximum values of range

`interval(`*min(step)max*`)` = minimum/maximum width of interval

Second stage estimation

```
discretize contvarname, endogenous(varname)
     range(min/max) interval(min(step)max)
     second depvar(varname)
```

One needs to specify also `second` and the name of the dependent variable with `depvar(`*varname*`)`

Estimation performed using the command `ivregress` with the two-stage least squares (2sls) estimator

Available options

`exogenous(`*varlist*`)`	exogenous variable(s) used in first and second stage
`interact(`*varname*`)`	interaction with discretized instrument
`xt(`*estimator*`)`	panel-data estimators available with the commands `xtreg` and `xtivreg`
`vce(`*vcetype*`)`	for robust or cluster standard errors
`print`	displays values contained in matrix 'results'
`save`	saves file with variables stored in matrix 'results' + 95% CI
`graph(`*string*`)`	graph coefficient estimates (coef) or F-statistics (ftstat)

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Example from Curci & Masera (2018): Rise of violent crime in city centers and suburbanization

Instrument used: **lead poisoning**

- Heavy metal that generates violent behavior
- People exposed principally through car emissions
- Most commonly because lead mixed with soil dust
- Lead is less dangerous when mixed with neutral pH soil

$\Rightarrow$ Chemical theory predicts that cities with neutral soil (around 6.5-7.5 pH) should have lower increase in violent crime

After first stage estimation, the matrix 'results' stores: Instruments' boundaries, F-statistic, parameter estimate of discrete instrument and standard error

```
. discretize ph10, range(65/80) interval(5(1)10) endogenous(totnpcc_cc_offenses_vc)
>  exogenous(i.year) interact(tetra_corr) xt(fe) graph(fstat) print
results[51,5]
             lb          ub       fstat        beta          se
 r1          68          77   262.16462  -.00527984   .00032609
 r2          68          76   234.77293  -.00515082   .00033617
 r3          69          77   227.45227  -.00527996   .00035009
 r4          68          78   223.39974  -.00461751   .00030893
 r5          68          75   222.05374  -.00523717   .00035145
 r6          67          77   207.42131  -.00451308   .00031336
 r7          69          76   201.19534   -.0051533   .00036331
 r8          70          77   199.14216  -.00526872   .00037336
 r9          71          77   199.14216  -.00526872   .00037336
r10          65          75   191.22497  -.00381797    .0002761
r11          69          75   189.88088  -.00529106   .00038397
r12          69          78   188.03554  -.00449492   .00032779
r13          67          76   182.06497  -.00434235   .00032182
r14          66          76   176.64343  -.00396422   .00029827
r15          72          77   175.57532  -.00550638   .00041556
r16          71          76   173.76344  -.00514243   .00039011
r17          70          76   173.76344  -.00514243   .00039011
r18          68          74   173.53996  -.00487553    .0003701
r19          67          75   168.13245  -.00433725   .00033449
r20          70          75    163.5051  -.00533389   .00041714
```

We can use the new discrete instrument with boundaries 6.8 and 7.7 that has been found to maximize the F-stat in the first stage

```
. gen good_soil = (ph1_plc_wtm_wtm_0_r>=6.8 & ph1_plc_wtm_wtm_0_r<=7.7)
. xtivreg perc_cc i.year (standardized_vc = c.good_soil#c.tetra_corr), fe
Fixed-effects (within) IV regression            Number of obs     =      9,481
Group variable: fipsplace_00                    Number of groups  =        305
R-sq:                                           Obs per group:
     within  =      .                                         min =          8
     between = 0.0855                                         avg =       31.1
     overall = 0.0795                                         max =         32
                                                Wald chi2(32)     =  633103.54
corr(u_i, Xb)  = 0.0259                         Prob > chi2       =     0.0000
```

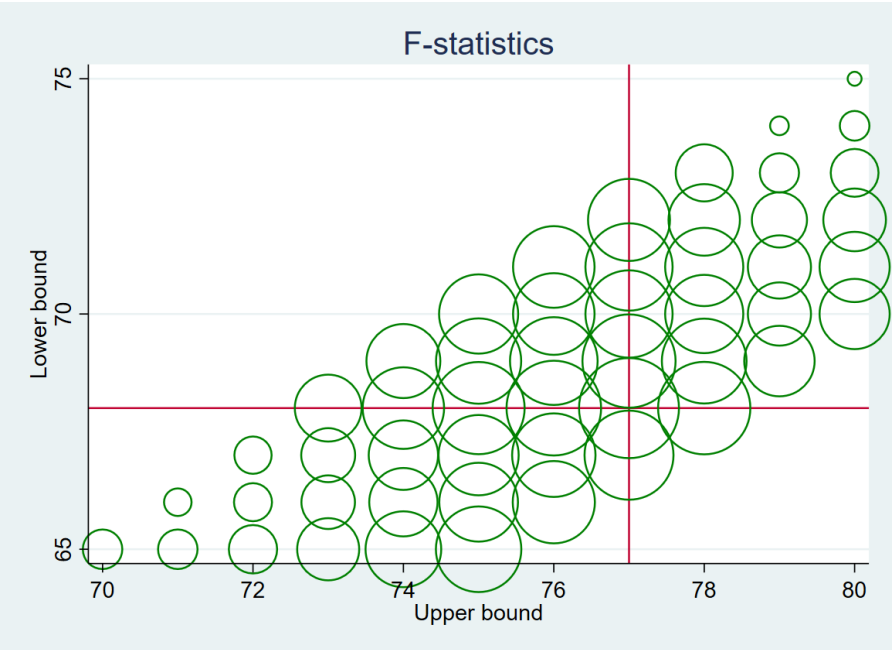
perc_cc	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
standardized_vc	-.0717297	.00594	-12.08	0.000	-.0833718	-.0600876
year						
1961	.0017654	.0040017	0.44	0.659	-.0060779	.0096087
...						
1991	.0768294	.0113749	6.75	0.000	.0545349	.0991238
_cons	.4348947	.0031643	137.44	0.000	.4286929	.4410965
sigma_u	.18215015					
sigma_e	.04846004					
rho	.93389896	(fraction of variance due to u_i)				

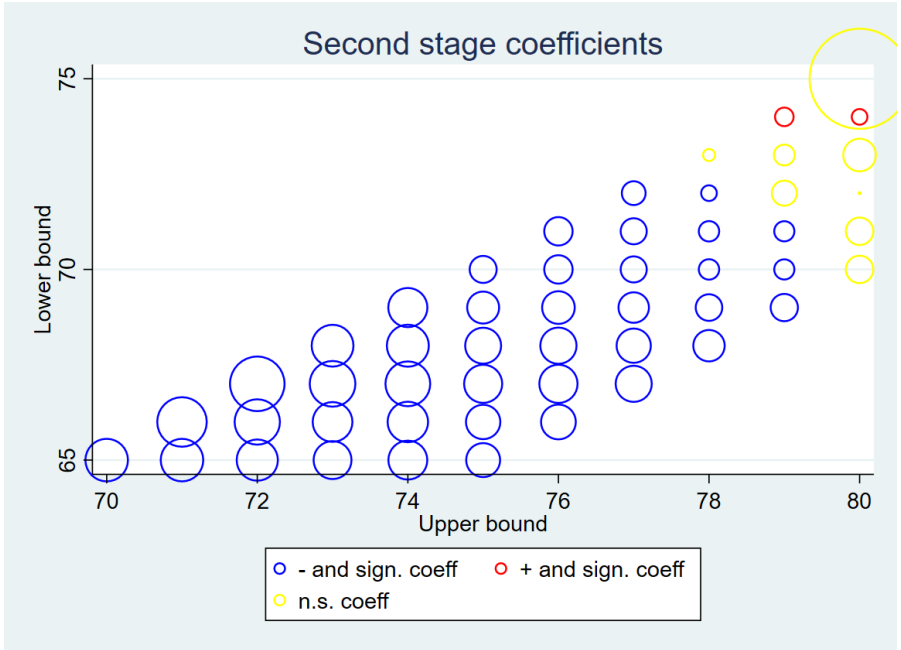
```
F  test that all u_i=0:     F(304,9144) =   435.91        Prob > F    = 0.0000

Instrumented:   standardized_vc
```

After second stage estimation, the matrix 'results' stores: Instruments' boundaries, parameter estimate of endogenous variable and standard error

```
. discretize ph10, range(65/80) interval(5(1)10) endogenous(standardized_vc) second
>  depvar(perc_cc) exogenous(i.year) interact(tetra_corr) xt(fe) graph(coef) print
results[51,4]
              lb          ub        beta          se
 r1           70          77  -.04097976   .00580547
 r2           71          77  -.04097976   .00580547
 r3           69          77  -.05647729   .00583521
 r4           68          77  -.07172966   .00593996
 r5           68          78  -.05994759   .00599139
 r6           69          78    -.042527   .00599988
 r7           72          77  -.03381604   .00603609
 r8           71          78  -.02463927   .00619798
 r9           70          78  -.02463927   .00619798
r10           71          76  -.04882763   .00641164
r11           70          76  -.04882763   .00641164
r12           70          75  -.04405828   .00647297
r13           69          76  -.06484251   .00648862
r14           69          75  -.06214748   .00657464
r15           68          76  -.08023395   .00660769
r16           68          75  -.07907977   .00674165
r17           72          78  -.01415127   .00674563
r18           65          75  -.07021066   .00684718
r19           71          80  -.01309482   .00686332
r20           70          80  -.01309482   .00686332
```

Graphics allow users to check the sensitivity of the results to the choice of instruments





Package available from:
https://sites.google.com/view/sebastien-fontenay/stata

Comments and suggestions are very much welcomed!
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