Estimation and inference for quantiles and indices of inequality and poverty with survey data

Philippe Van Kerm
University of Luxembourg and Luxembourg Institute of Socio-Economic Research

2017 UK Stata Users Group meeting
September 7–8 2017, London

UNIVERSITÉ DU LUXEMBOURG

LISER
LUXEMBOURG INSTITUTE OF SOCIO-ECONOMIC RESEARCH

Stata for income distribution analysis

Many user-written commands

`findit inequality` or `net search inequality` returns a long list of packages and programs (see [R] inequality), such as

- Distribution description: `sumdist`, `xfrac`
- Percentile shares and Lorenz curves and Gini: `lorenz`, `svylorenz`, `glcurve`, `pshare`
- Generalized entropy, Atkinson, Gini indices: `ineqdeco`, `inequal7`, `svygei`, `svyatk`
- Generalized Gini: `sgini`
- Lorenz dominance testing: `ldtest`

- DASP: Stata implementation of DAD, very rich collection of functionality on its own (need to register to obtain download key)

UNIVERSITÉ DU LUXEMBOURG

LISER LUXEMBOURG INSTITUTE OF SOCIO-ECONOMIC RESEARCH

Stata for income distribution analysis

More user-written commands

- Decomposition by population subgroups: `ineqdeco`, `ineqrbd`
- Decomposition by income source: `sgini`, `ineqfac`, `ineqrbd`
- Tax progressivity analysis: `progres`
- Poverty measures: `poverty`, `povdeco`
- Distribution models: `paretofit`, `lognfit`, `dagumfit`, `smfit`, `gb2fit`
- Polarization: `er`
- Segregation: `duncan`, `hutchens`
- Equality of opportunity: `iop`

Inference with user-written commands

- The majority of user-written commands provide point estimates but no variance calculation
  - possible to bootstrap or jackknife
- Some commands do provide variance calculations and have built-in support for survey design (respect `svyset`)
- But typically ‘non-standard’ interaction with the `svy` prefix

UNIVERSITÉ DU LUXEMBOURG

LISER
LUXEMBOURG INSTITUTE OF SOCIO-ECONOMIC RESEARCH

`yadap`

Inference

Implementation

Illustration

Yet another distribution analysis package (`yadap`)

Three estimation commands for *quantiles* and indices of *inequality* and *poverty* from (household- or individual-level) data

⟹ estimation of quantiles not just of interest to economists and distribution analysts!

- "estimation commands" means 'e-class' commands with complete inference functionality (`e(b)` *and* `e(V)`) to allow interaction with post-estimation `test`, `nlcom`, etc.
- ... also means integrating with `svy` suite—an essential feature given nature of data on income distribution
- ... and with the `mi` suite for handling multiply imputed data—an increasingly critical feature

UNIVERSITÉ DU LUXEMBOURG

LISER LUXEMBOURG INSTITUTE OF SOCIO-ECONOMIC RESEARCH

`percentils` **Estimation of quantiles**

`percentils` *varname* [*if*] [*in*] [*weight*] [, `percentiles(`*numlist*`)`]

- NB: No built-in estimation command for percentiles (similar to `mean`)?
- Hyndman and Fan (1996) definition 4 (and optionally definition 1):

$$P_4(\theta) = y_{k-1} + (y_k - y_{k-1}) \left(\frac{\theta N - N_{k-1}}{w_k} \right)$$

where $N_k = \sum_{j=1}^{n} w_j \mathbf{1}(y_j \leqslant y_k)$ and k is the smallest integer such that $N_k \geqslant \theta N$

Estimation of (relative) inequality indices

`inequaly` *varname* [*if*] [*in*] [*weight*] [,
selection-of-indices `keepnonpositive`]

- Calculates summary statistics capturing the 'relative' dispersion in a vector of incomes/expenditure/wealth (see, e.g., Cowell, 2000, Jenkins and Van Kerm, 2009)
  - 'Relative': $I(y_1, \ldots, y_N) = I(\lambda y_1, \ldots, \lambda y_N)$
- 12 different (families of) measures: (generalized) Gini coefficients, percentile ratios, quantile share ratios, (generalized) entropy measures, coeff of variation, Atkinson measures, SD of logs (and Pietra ratios, de Vergottini, Piesch, Bonferroni, Kakwani indices)

Estimation of poverty indices

`povery` *varname* [*if*] [*in*] [*weight*] [,
`fracmedian(#)` `fracmean(#)` `line(#|`*varname*`)`
selection-of-indices]

- Calculates summary statistics capturing the ‘concentration’ below a certain threshold in a vector of incomes/expenditure/wealth (see, e.g., Zheng, 1997)
- 7 different (families of) measures: Foster-Greer-Thorbecke, Watts, (generalized) Sen-Shorrocks-Thon index, Chakravarty, Clark-Hemming-Ulph 2 families, and median gaps
- see Van Kerm (2009) for early version

`yadap`

Inference

Implementation

Illustration

Two main approaches to inference

Two main approaches for variance estimation, construction of confidence intervals, tests

- analytic, linearization approaches
- empirical, resampling-based approaches (jackknife and bootstrap)

Variance estimation by linearization

general principles

- θ is the statistic of interest, estimated by $\hat{\theta}$
- A linearization variable Z for θ, is a linear variable ($\hat{Z} = \sum_i w_i z_i$) such that

$$\text{Var}(\hat{Z}) \approx \text{Var}(\hat{\theta})$$

- Once we know z_k, it is easy to estimate $\text{Var}(\hat{Z})$ and therefore $\text{Var}(\hat{\theta})$ (it is the variance of a total – methods are well-known to estimate this with various complex survey design)

Variance estimation with the influence function

An asymptotic approximation of the variance of θ is given by (Hampel, 1974)

$$V(\theta) \approx \int IF(y; \theta, F)^2 dF(y)$$

Practically boils down to estimation of a total (Deville, 1999):

$$V(\hat{\theta}, F) \approx V\left(\sum_{i=1}^{n} w_i I\hat{F}(y_i; \theta, \hat{F})\right)$$

... and formula for the variance of a total known even with complex survey design, e.g. $V(T) = \frac{1}{n-1}\sum_{i=1}^{n}(\hat{t}_i - \bar{t})^2$

UNIVERSITÉ DU LUXEMBOURG

LISER LUXEMBOURG INSTITUTE OF SOCIO-ECONOMIC RESEARCH

The influence function

Expressions for $\text{IF}(y; \theta, F)$ exist (or can be derived) for a wide range of statistics θ [1]:

... simple (linear) statistics, e.g., the mean

$$\text{IF}(y; \mu, F) = y - \mu(F)$$

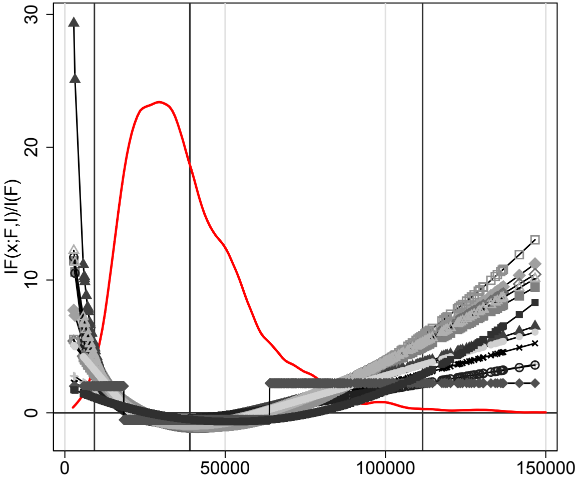
... and more complex (non linear) statistics, e.g., a quantile

$$\text{IF}(y; Q_\theta, F) = \frac{1}{f(Q_\theta(F))}(\theta - I(y \leqslant Q_\theta(F)))$$

(Estimators of IFs obtained by plugging estimates of the unknowns, e.g., $\mu(\hat{F})$, $Q_\theta(\hat{F})$, $\hat{f}$, etc.)

[1] See e.g., Essama-Nssah and Lambert (2012) for a catalogue of IFs relevant to income distribution analysis

Influence functions for inequality measures



The bootstrap

- Principle: The sample is a ‘clone’ of the population...
- ... simulate sampling from this population by drawing re-samples (with replacement) ...
- ... compute estimate in each of these re-samples...
- ... and assess the sampling variability by the variability across all re-samples
- Number of replications needs be sufficiently high to have accurate estimates (e.g., 1000)
- Leads to consistent estimates of SEs
- Some procedures provide “asymptotic refinements” over asymptotic analytic formulae (better performance in finite samples)
- Caveat: slow (real limitation if point estimation itself time-consuming)

Bootstrap confidence intervals

Various possibilities can be considered for building CIs

- If sampling distribution of estimator is normal, plug bootstrap SE into classical CI formula for a normal distribution (default reported in Stata)
- Sort bootstrap estimates and take $\alpha/2$th and $(1-\alpha/2)$th values as CI boundaries (also computed by Stata)
- Other methods can provide improved precision, e.g. Bias-corrected (BC) and accelerated bootstrap (BCa) or studentized (double)-bootstrap
  - Studentized bootstrap: recalculate $(\hat{\theta}_b - \hat{\theta})/\hat{s}(\theta_b)$, take $\alpha/2$th and $(1-\alpha/2)$th values and estimate CI as $\hat{\theta} + c_{.5\alpha}\hat{s}(\theta)$ and $\hat{\theta} + c_{1-.5\alpha}\hat{s}(\theta)$ (requires estimator of variance in the first place!)

Complex design

With any resampling method, the survey design needs to be taken into account!

In particular, it is essential to

- resample 'PSUs' together
- resample with sampling strata

Current practice typically with 'block bootstrap' (resampling PSU's with replacement) –usually OK if large number of PSUs per stratum–

But many alternative resampling techniques for inference with complex survey exist (Kolenikov, 2010, Van Kerm, 2013) yadap

Inference

Implementation

Illustration

Aim

- calculate point estimates `e(b)`: easy
- calculate linearized standard errors for `e(V)`
- work 'seamlessly' with
  - `test` (and `testnl`, `lincom`, `nlcom`)
  - `bootstrap:` (and `jackknife:`) prefixes for alternative standard errors and CIs
  - `svyset` and `svy:` prefix for complex survey data
  - `mi estimate:` prefix for multiply imputed data
  - ... and other goodies such as `esttab`, `regsave`, etc.

Implementation

Easy! Just follow the instructions in [SVY] Variance Estimation and [P] _robust...
(I must also thank Tech Support and Jeff Pittblado!)

Write two programmes:

- main program (say `inequaly.ado`)
  - calculates point estimates
  - does some housekeeping (e.g., initiates unit diagonal covariance matrix—prepare the bread)
  - calls `_robust` to calculate and fill `e(V)`
- secondary 'prediction' command (say `inequaly_p.ado`)
  - `predict`'s value of influence function at the data points used for estimation

(The prediction command is called by `_robust` to fill `e(V)`—fills in the sandwich.)

UNIVERSITÉ DU LUXEMBOURG

LISER LUXEMBOURG INSTITUTE OF SOCIO-ECONOMIC RESEARCH

`yadap`

Inference

Implementation

Illustration

Data

- The **Luxembourg Income Study**
  - Household survey data in 48 countries (mostly on income and employment) from early 1980s (most data for 2000s)
- The **Luxembourg Wealth Study**
  - Household survey data on household *wealth and assets* in 10 countries
- Household- and individual-level representative survey data
- *ex post* harmonization by LIS staff
- Remote access only (using (slightly restricted) Stata)
- Illustrations on small training datasets for US

Illustration 1

Mean vs. percentiles

```
. use http://www.lisdatacenter.org/wp-content/uploads/us04ip.dta
(us04: version 7.0 15 Dec 2015 14:23)

. qui merge m:1 hid using http://www.lisdatacenter.org/wp-content/uploads/us04ih.dta

. mean dpi

Mean estimation                   Number of obs   =      1,083

--------------------------------------------------------------
             |       Mean   Std. Err.     [95% Conf. Interval]
-------------+------------------------------------------------
         dpi |   51476.42   1298.885      48927.81    54025.04
--------------------------------------------------------------

. percentils dpi , percentiles(10 50 90)

Estimation of percentiles                        Number of obs    =    1,083

------------------------------------------------------------------------------
         dpi |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
Perc_10      |
       _cons |      13799   566.5702    24.36   0.000      12687.3     14910.7
-------------+----------------------------------------------------------------
Perc_50      |
       _cons |      43756   1464.913    29.87   0.000     40881.61    46630.39
-------------+----------------------------------------------------------------
Perc_90      |
       _cons |    97371.4   2698.038    36.09   0.000     92077.42    102665.4
------------------------------------------------------------------------------
```

test and nlcom

```
. test [Perc_50]_cons = 45000

 ( 1)  [Perc_50]_cons = 45000

       F(  1,  1082) =    0.72
            Prob > F =    0.3960

. test [Perc_10]_cons = [Perc_90]_cons

 ( 1)  [Perc_10]_cons - [Perc_90]_cons = 0

       F(  1,  1082) =  962.26
            Prob > F =    0.0000

. nlcom [Perc_90]_cons/[Perc_10]_cons

       _nl_1:  [Perc_90]_cons/[Perc_10]_cons
```

dpi	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_nl_1	7.05641	.3308968	21.33	0.000	6.407864	7.704956

Weights and clustered standard errors

```
. percentils dpi [pw=ppopwgt] , percentiles(10 50 90)
Estimation of percentiles                    Number of obs   =    1,083
```

dpi	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Perc_10						
_cons	12972.69	695.7431	18.65	0.000	11607.53	14337.85
Perc_50						
_cons	39179.59	1501.47	26.09	0.000	36233.46	42125.71
Perc_90						
_cons	93502	3023.02	30.93	0.000	87570.35	99433.65

```
. percentils dpi [pw=ppopwgt] , vce(cluster hid) percentiles(10 50 90)
Estimation of percentiles                    Number of obs   =    1,083
                                  (Std. Err. adjusted for 500 clusters in hid)
```

dpi	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Perc_10						
_cons	12972.69	881.3513	14.72	0.000	11241.07	14704.3
Perc_50						
_cons	39179.59	2349.247	16.68	0.000	34563.95	43795.22
Perc_90						
_cons	93502	5302.941	17.63	0.000	83083.16	103920.8

svy prefix

```
. svyset [pw=ppopwgt] , psu(hid) strata(region_c)

      pweight: ppopwgt
          VCE: linearized
  Single unit: missing
     Strata 1: region_c
         SU 1: hid
        FPC 1: <zero>

. svy: percentils dpi , percentiles(10 50 90)
(running percentils on estimation sample)

Survey: Estimation of percentiles

Number of strata   =        14                Number of obs     =      1,083
Number of PSUs     =       500                Population size   =  295,516,599
                                              Design df         =        486
                                              F(   0,    486)   =          .
                                              Prob > F          =          .

------------------------------------------------------------------------------
             |             Linearized
         dpi |      Coef.  Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
Perc_10      |
       _cons |   12972.69   879.2173    14.75   0.000     11245.15    14700.22
-------------+----------------------------------------------------------------
Perc_50      |
       _cons |   39179.59   2348.275    16.68   0.000     34565.56    43793.61
-------------+----------------------------------------------------------------
Perc_90      |
       _cons |      93502    5278.47    17.71   0.000     83130.56    103873.4
------------------------------------------------------------------------------

. test [Perc_50]_cons = 45000

Adjusted Wald test

 ( 1)  [Perc_50]_cons = 45000

       F(  1,   486) =    6.14
            Prob > F =    0.0135
```

UNIVERSITÉ DU LUXEMBOURG

LISER
LUXEMBOURG INSTITUTE OF SOCIO-ECONOMIC RESEARCH

`suest` for testing over subpopulations

`suest` for testing over subpopulations

```
. svy , subpop(if inrange(age,40,60)) : percentils dpi , percentiles(10 50 90)
>
(running percentils on estimation sample)

Survey: Estimation of percentiles

Number of strata   =        14              Number of obs     =        1,083
Number of PSUs     =       500              Population size   =  295,516,599
                                            Subpop. no. obs   =          340
                                            Subpop. size      = 94,092,430.1
                                            Design df         =          486
                                            F(   0,    486)   =            .
                                            Prob > F          =            .

------------------------------------------------------------------------------
             |             Linearized
         dpi |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
Perc_10      |
       _cons |   14798.19    2097.141     7.06   0.000     10677.61    18918.77
-------------+----------------------------------------------------------------
Perc_50      |
       _cons |      52389    4021.873    13.03   0.000     44486.59    60291.41
-------------+----------------------------------------------------------------
Perc_90      |
       _cons |     105170    7891.038    13.33   0.000     89665.25    120674.8
------------------------------------------------------------------------------

. estimates store a1

. qui svy , subpop(if !inrange(age,40,60)) : percentils dpi , percentiles(10 50
>  90)

. estimates store a2
```

UNIVERSITÉ DU LUXEMBOURG

LISER LUXEMBOURG INSTITUTE OF SOCIO-ECONOMIC RESEARCH

suest for testing over subpopulations

```
. suest a1 a2

Simultaneous survey results for a1, a2

Number of strata   =        14          Number of obs      =        1,083
Number of PSUs     =       500          Population size    =  295,516,599
                                        Design df          =          486
```

	Coef.	Linearized Std. Err.	t	P>|t|	[95% Conf.	Interval]
a1_Perc_10						
_cons	14798.19	2097.141	7.06	0.000	10677.61	18918.77
a1_Perc_50						
_cons	52389	4021.873	13.03	0.000	44486.59	60291.41
a1_Perc_90						
_cons	105170	7891.038	13.33	0.000	89665.25	120674.8
a2_Perc_10						
_cons	12837.11	887.3294	14.47	0.000	11093.63	14580.58
a2_Perc_50						
_cons	35681	2243.504	15.90	0.000	31272.84	40089.16
a2_Perc_90						
_cons	88345.95	5881.93	15.02	0.000	76788.8	99903.11

```
. test [a1_Perc_50]_cons = [a2_Perc_50]_cons

Adjusted Wald test

 ( 1)  [a1_Perc_50]_cons - [a2_Perc_50]_cons = 0

       F(  1,   486) =   15.47
            Prob > F =    0.0001
```

inequaly now...

```
. svy: inequaly dpi
(running inequaly on estimation sample)

Survey: Estimation of inequality indices

Number of strata   =        14            Number of obs     =      1,069
Number of PSUs     =       491            Population size   = 291,258,463
                                          Design df         =        477
                                          F(   0,    477)   =          .
                                          Prob > F          =          .
```

dpi	Coef.	Linearized Std. Err.	t	P>|t|	[95% Conf.	Interval]
SGini_2						
_cons	.3949245	.0208743	18.92	0.000	.3539076	.4359414
GE_0						
_cons	.3057455	.0364963	8.38	0.000	.2340322	.3774589
GE_1						
_cons	.2800711	.0454891	6.16	0.000	.1906874	.3694549
A_1						
_cons	.263426	.0268822	9.80	0.000	.2106038	.3162482
A_2						
_cons	.9733214	.0253033	38.47	0.000	.9236016	1.023041

inequaly again

```
. svy: inequaly dpi , cov sdlogs sgini(2 4) ge(-2 1) atk(0.5 2) piesch qsr(9010) perratio(9010) schutz
> mean bonferroni vergottini kakwani
(running inequaly on estimation sample)

Survey: Estimation of inequality indices

Number of strata   =        14              Number of obs     =       1,069
Number of PSUs     =       491              Population size   =  291,258,463
                                            Design df         =         477
                                            F(   0,     477)  =           .
                                            Prob > F          =           .
```

dpi	Coef.	Linearized Std. Err.	t	P>|t|	[95% Conf.	Interval]
SGini_2						
_cons	.3949245	.0208743	18.92	0.000	.3539076	.4359414
SGini_4						
_cons	.6091519	.0183418	33.21	0.000	.5731112	.6451926
GE_m2						
_cons	74830.83	74649.12	1.00	0.317	-71850.93	221512.6
GE_1						
_cons	.2800711	.0454891	6.16	0.000	.1906874	.3694549
A_p5						
_cons	.1315336	.0151921	8.66	0.000	.1016818	.1613853
A_2						
_cons	.9733214	.0253033	38.47	0.000	.9236016	1.023041
hRMD						
_cons	.2851081	.0141072	20.21	0.000	.2573882	.312828
SDLog						
_cons	.9138877	.1304969	7.00	0.000	.6574679	1.170308
CoV						
_cons	.9356967	.1734633	5.39	0.000	.59485	1.276543

inequaly ctd.

QSR_9010						
_cons	15.16305	2.285513	6.63	0.000	10.67213	19.65396
PeR_9010						
_cons	6.624843	.4944219	13.40	0.000	5.653329	7.596357
Kakwani						
_cons	.1368142	.0133028	10.28	0.000	.1106749	.1629535
Piesch						
_cons	.3253333	.0218912	14.86	0.000	.2823182	.3683484
Vergo						
_cons	.8338568	.0981316	8.50	0.000	.6410331	1.02668
Bonfe						
_cons	.5265866	.0182917	28.79	0.000	.4906444	.5625288
Mean						
_cons	50381.32	2632.795	19.14	0.000	45208.01	55554.62

Another `nlcom` example

The ‘Equally-distributed-equivalent’

```
. nlcom (1-[A_p5]_cons)*[Mean]_cons

       _nl_1:  (1-[A_p5]_cons)*[Mean]_cons
```

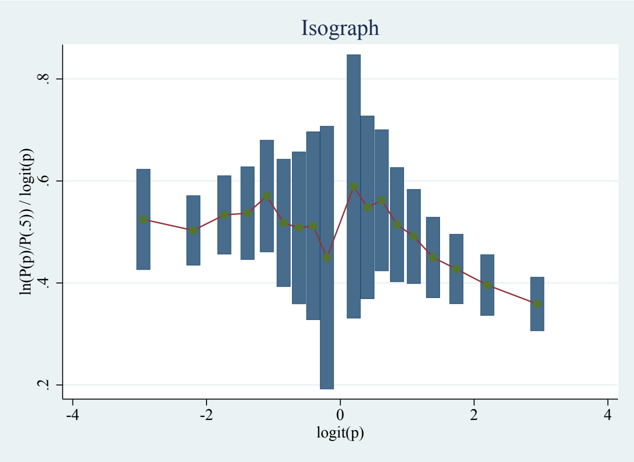
dpi	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_nl_1	43754.48	1953.915	22.39	0.000	39924.88	47584.08

UNIVERSITÉ DU LUXEMBOURG

LISER LUXEMBOURG INSTITUTE OF SOCIO-ECONOMIC RESEARCH

`nlcom` really is useful

Chauvel's isograph



`nlcom` really is useful

Chauvel's isograph

... just repeated `nlcom` calls after one `percentils`... (could be done in one call too)

```
. gen p = .
(1,083 missing values generated)

. gen iso = .
(1,083 missing values generated)

. gen iso_up = .
(1,083 missing values generated)

. gen iso_lo = .
(1,083 missing values generated)

. qui svy  : percentils dpi  , percentiles(5(5)95)

. loc i 0

. foreach p of numlist 5(5)45 55(5)95 {
  2.        qui nlcom ( ln([Perc_`p']_cons/[Perc_50]_cons) ) / logit(`p'/100)
  3.        qui replace iso = el(r(b),1,1) in `++i'
  4.        qui replace iso_up = iso + 1.96 * sqrt(el(r(V),1,1)) in `i'
  5.        qui replace iso_lo = iso - 1.96 * sqrt(el(r(V),1,1)) in `i'
  6.        qui replace p = logit(`p'/100)  in `i'
  7. }
```

UNIVERSITÉ DU LUXEMBOURG

LISER LUXEMBOURG INSTITUTE OF SOCIO-ECONOMIC RESEARCH

Bootstrap inference

A studentized bootstrap

Define a small wrapper program to be able to use `bootstrap:` with sample weights

```
. pr def inequalycalc , rclass
  1.        gettoken var therest : 0
  2.        qui inequaly `var' [pw=hpopwgt] `therest'  , gini
  3.        return scalar gini = _b[SGini_2:_cons]
  4.        mat V = e(V)
  5.        return scalar segini = sqrt(V[1,1])
  6. end
. inequalycalc dpi  if dpi>0
. loc gini = r(gini)
. loc segini = r(segini)
. tempfile bootstat
. bootstrap gini=r(gini) tstat=((r(gini)-`gini')/r(segini)) , ///
>         reps(999) cluster(hid)  saving(`"`bootstat'"' , replace ): ///
>         inequalycalc dpi  if dpi>0
```

UNIVERSITÉ DU LUXEMBOURG

LISER LUXEMBOURG INSTITUTE OF SOCIO-ECONOMIC RESEARCH

Bootstrap inference

A studentized bootstrap

SE estimates allow estimation of studentized bootstrap

```
Bootstrap replications (999)
----+--- 1 ---+--- 2 ---+--- 3 ---+--- 4 ---+--- 5
..................................................    50
(SNIP)
Bootstrap results                               Number of obs     =      1,069
                                                Replications      =        999

      command:  inequalycalc dpi
         gini:  r(gini)
        tstat:  (r(gini)-.3955275207125588)/r(segini)
                                   (Replications based on 491 clusters in hid)
------------------------------------------------------------------------------
             |   Observed   Bootstrap                         Normal-based
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        gini |   .3955275    .0206435    19.16   0.000     .3550671     .435988
       tstat |          0    1.831699     0.00   1.000    -3.590065    3.590065
------------------------------------------------------------------------------

. use `"`bootstat'"' , clear
(bootstrap: inequalycalc)

. _pctile tstat , p(2.5 97.5)

. di "Studentized CI: [ " %6.5f `=`gini'+r(r1)*`segini''  " ; " %6.5f `=`gini'+
> r(r2)*`segini'' " ] "
Studentized CI: [ 0.31265 ; 0.43071 ]

.  sjlog close , replace
```

UNIVERSITÉ DU LUXEMBOURG

LISER LUXEMBOURG INSTITUTE OF SOCIO-ECONOMIC RESEARCH

Illustration 2

Now move to data on wealth to illustrate survey bootstrap replications and multiple imputation

```
. use http://www.lisdatacenter.org/wp-content/uploads/us10wh.dta
(us10: version 7.0 23 Mar 2016 10:05)

. keep if inum==1
(400 observations deleted)

. merge 1:1 hid using http://www.lisdatacenter.org/wp-content/uploads/us10wr.dt
> a

    Result                           # of obs.
    -----------------------------------------
    not matched                             0
    matched                               100  (_merge==3)
    -----------------------------------------
```

Survey bootstrap weights?

```
. svyset [pw=hpopwgt] ,  bsrweight(hrwgt1-hrwgt99)

      pweight: hpopwgt
          VCE: linearized
    bsrweight: hrwgt1 hrwgt2 hrwgt3 hrwgt4 hrwgt5 hrwgt6 hrwgt7 hrwgt8 hrwgt9
               hrwgt10 hrwgt11 hrwgt12 hrwgt13 hrwgt14 hrwgt15 hrwgt16
               hrwgt17 hrwgt18 hrwgt19 hrwgt20 hrwgt21 hrwgt22 hrwgt23
               hrwgt24 hrwgt25 hrwgt26 hrwgt27 hrwgt28 hrwgt29 hrwgt30
               hrwgt31 hrwgt32 hrwgt33 hrwgt34 hrwgt35 hrwgt36 hrwgt37
               hrwgt38 hrwgt39 hrwgt40 hrwgt41 hrwgt42 hrwgt43 hrwgt44
               hrwgt45 hrwgt46 hrwgt47 hrwgt48 hrwgt49 hrwgt50 hrwgt51
               hrwgt52 hrwgt53 hrwgt54 hrwgt55 hrwgt56 hrwgt57 hrwgt58
               hrwgt59 hrwgt60 hrwgt61 hrwgt62 hrwgt63 hrwgt64 hrwgt65
               hrwgt66 hrwgt67 hrwgt68 hrwgt69 hrwgt70 hrwgt71 hrwgt72
               hrwgt73 hrwgt74 hrwgt75 hrwgt76 hrwgt77 hrwgt78 hrwgt79
               hrwgt80 hrwgt81 hrwgt82 hrwgt83 hrwgt84 hrwgt85 hrwgt86
               hrwgt87 hrwgt88 hrwgt89 hrwgt90 hrwgt91 hrwgt92 hrwgt93
               hrwgt94 hrwgt95 hrwgt96 hrwgt97 hrwgt98 hrwgt99
  Single unit: missing
     Strata 1: <one>
         SU 1: <observations>
        FPC 1: <zero>
```

Estimation equally easy!

```
. svy : inequaly anw , gini ge(2)
(running inequaly on estimation sample)

Survey: Estimation of inequality indices

Number of strata   =         1                  Number of obs      =        85
Number of PSUs     =        85                  Population size    = 1,612,590
                                                Design df          =        84
                                                F(    0,      84)  =         .
                                                Prob > F           =         .

------------------------------------------------------------------------------
             |             Linearized
         anw |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
SGini_2      |
       _cons |   .7251663   .0334275    21.69   0.000     .6586921    .7916405
-------------+----------------------------------------------------------------
GE_2         |
       _cons |   8.759125   4.482467     1.95   0.054     -.154752      17.673
------------------------------------------------------------------------------

. svy bootstrap , nodots : inequaly anw , gini ge(2)

Survey: Estimation of inequality indices        Number of obs      =        85
                                                Population size    = 1,612,590
                                                Replications       =        99
                                                Wald chi2(0)       =         .
                                                Prob > chi2        =         .

------------------------------------------------------------------------------
             |   Observed   Bootstrap                         Normal-based
         anw |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
SGini_2      |
       _cons |   .7251663   .0283444    25.58   0.000     .6696123    .7807203
-------------+----------------------------------------------------------------
GE_2         |
       _cons |   8.759125   6.912019     1.27   0.205    -4.788183    22.30643
------------------------------------------------------------------------------
```

UNIVERSITÉ DU LUXEMBOURG

LISER LUXEMBOURG INSTITUTE OF SOCIO-ECONOMIC RESEARCH

Multiple imputation: the mi suite

First some manipulation needed to convert to valid mi data format

```
. use http://www.lisdatacenter.org/wp-content/uploads/us10wh.dta

. * First we need to generate the unimputed version that stata can work with(m=0)
. qui bys hid (anw) : gen imputed = (anw[1] != anw[_N])

.  // set as imputed if there are differences in the value of anw across inum
. expand 2 if inum==1 , gen(original)
(100 observations created)

. qui replace inum=0 if inum==1 & original==1

.  // set inum to 0 for the newly created obs
. qui replace anw = . if inum==0 & imputed==1

.  // set 'unimputed' anw to missing in inum==0
. * Now we can 'import' the data into Stata mi flong format
. mi import flong   , m(inum) id(hid) imputed(anw) clear
(89 m=0 obs. now marked as incomplete)

. drop inum original imputed

. mi convert wide , clear

. * and merge replication weights
. qui merge m:1 hid using http://www.lisdatacenter.org/wp-content/uploads/us10wr.dta
```

Multiple imputation: the `mi` suite

Then `mi svyset` is specified (note use of both multiple imputation and bootstrap replication weights)

```
. * Now -mi svyset-   instead of -svyset-
. mi svyset [pw=hpopwgt] , psu(hid) bsrweight(hrwgt1-hrwgt99) vce(linearized)

      pweight: hpopwgt
          VCE: linearized
    bsrweight: hrwgt1 hrwgt2 hrwgt3 hrwgt4 hrwgt5 hrwgt6 hrwgt7 hrwgt8 hrwgt9
               hrwgt10 hrwgt11 hrwgt12 hrwgt13 hrwgt14 hrwgt15 hrwgt16
               hrwgt17 hrwgt18 hrwgt19 hrwgt20 hrwgt21 hrwgt22 hrwgt23
               hrwgt24 hrwgt25 hrwgt26 hrwgt27 hrwgt28 hrwgt29 hrwgt30
               hrwgt31 hrwgt32 hrwgt33 hrwgt34 hrwgt35 hrwgt36 hrwgt37
               hrwgt38 hrwgt39 hrwgt40 hrwgt41 hrwgt42 hrwgt43 hrwgt44
               hrwgt45 hrwgt46 hrwgt47 hrwgt48 hrwgt49 hrwgt50 hrwgt51
               hrwgt52 hrwgt53 hrwgt54 hrwgt55 hrwgt56 hrwgt57 hrwgt58
               hrwgt59 hrwgt60 hrwgt61 hrwgt62 hrwgt63 hrwgt64 hrwgt65
               hrwgt66 hrwgt67 hrwgt68 hrwgt69 hrwgt70 hrwgt71 hrwgt72
               hrwgt73 hrwgt74 hrwgt75 hrwgt76 hrwgt77 hrwgt78 hrwgt79
               hrwgt80 hrwgt81 hrwgt82 hrwgt83 hrwgt84 hrwgt85 hrwgt86
               hrwgt87 hrwgt88 hrwgt89 hrwgt90 hrwgt91 hrwgt92 hrwgt93
               hrwgt94 hrwgt95 hrwgt96 hrwgt97 hrwgt98 hrwgt99
  Single unit: missing
     Strata 1: <one>
         SU 1: hid
        FPC 1: <zero>

.    // declare boot weights , but set linearized as default vce
```

UNIVERSITÉ DU LUXEMBOURG

LISER
LUXEMBOURG INSTITUTE OF SOCIO-ECONOMIC RESEARCH

Multiple imputation: the `mi estimate` prefix

The combined `mi estimate:svy:` is all we need to obtain combined estimates across multiply imputed data

```
. mi estimate , nosmall: ///
>         svy : inequaly anw , gini keepnonpositive

Multiple-imputation estimates                   Imputations       =          5
Survey: Estimation of inequality indices        Number of obs     =        100

Number of strata   =         1                  Population size   =  1,876,013
Number of PSUs     =       100
                                                Average RVI       =     0.0147
                                                Largest FMI       =     0.0146
                                                Complete DF       =         99
                                                DF:     min       =  18,958.15
                                                        avg       =  18,958.15
DF adjustment:   Large sample                           max       =  18,958.15
                                                F(   0,      .)   =          .
Within VCE type:    Linearized                  Prob > F          =          .

------------------------------------------------------------------------------
         anw |      Coef.   Std. Err.       t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       _cons |   .7752888    .031739    24.43    0.000     .7130775    .8375001
------------------------------------------------------------------------------
```

UNIVERSITÉ DU LUXEMBOURG

LISER
LUXEMBOURG INSTITUTE OF SOCIO-ECONOMIC RESEARCH

Multiple imputation: the `mi estimate` prefix

```
. * finally estimate, NB: I use -noisily- so we can see what is going on:
. mi estimate , vartable noisily nosmall: ///
>         svy : inequaly anw , gini keepnonpositive

(running svy:inequaly on m=1)
(running inequaly on estimation sample)

Survey: Estimation of inequality indices

Number of strata   =         1                Number of obs     =       100
Number of PSUs     =       100                Population size   = 1,876,013
                                              Design df         =        99
                                              F(   0,     99)   =         .
                                              Prob > F          =         .

------------------------------------------------------------------------------
             |             Linearized
         anw |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       _cons |   .7704014   .0313707    24.56   0.000     .7081552    .8326476
------------------------------------------------------------------------------

(running svy:inequaly on m=2)
(running inequaly on estimation sample)

Survey: Estimation of inequality indices

Number of strata   =         1                Number of obs     =       100
Number of PSUs     =       100                Population size   = 1,876,013
                                              Design df         =        99
                                              F(   0,     99)   =         .
                                              Prob > F          =         .

------------------------------------------------------------------------------
             |             Linearized
         anw |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       _cons |   .7748665   .0314854    24.61   0.000     .7123926    .8373403
------------------------------------------------------------------------------

(running svy:inequaly on m=3)
(running inequaly on estimation sample)

Survey: Estimation of inequality indices

Number of strata   =         1                Number of obs     =       100
Number of PSUs     =       100                Population size   = 1,876,013
                                              Design df         =        99
                                              F(   0,     99)   =         .
                                              Prob > F          =         .

------------------------------------------------------------------------------
             |             Linearized
         anw |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       _cons |   .7789197   .0317733    24.51   0.000     .7158745    .8419648
------------------------------------------------------------------------------

(running svy:inequaly on m=4)
(running inequaly on estimation sample)

Survey: Estimation of inequality indices

Number of strata   =         1                Number of obs     =       100
Number of PSUs     =       100                Population size   = 1,876,013
```

Multiple imputation: the `mi estimate` prefix

... and works with bootstrap replication weights too!

```
. * works also with bootstrap , but we need to give the vceok option
. mi estimate , vceok nosmall: ///
>         svy bootstrap : inequaly anw , gini keepnonpositive

Multiple-imputation estimates                   Imputations       =          5
Survey: Estimation of inequality indices        Number of obs     =        100
                                                Population size   =  1,876,013
                                                Average RVI       =     0.0215
                                                Largest FMI       =     0.0212
                                                DF:     min       =   9,064.50
                                                        avg       =   9,064.50
DF adjustment:   Large sample                           max       =   9,064.50
                                                F(   0,      .)   =          .
Within VCE type:    Bootstrap                   Prob > F          =          .

------------------------------------------------------------------------------
         anw |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       _cons |   .7752888   .0263925    29.38   0.000     .7235536     .827024
------------------------------------------------------------------------------
```

Conclusion

- Ensuring the compatibility of one's user-written estimation command with Stata's internal engines can bring huge benefits both in terms of 'functionality' and 'useability'
- (and is easier to code!)
- Illustration with a new set of commands for estimation of percentiles and of inequality and poverty indices
  - The possibility to account for multiple imputation and complex survey design is a key and important feature!

References I

Cowell, F. A. (2000), *Measuring Inequality*, LSE Handbooks in Economics, 3rd edn, Oxford University Press, Oxford, UK.

Deville, J.-C. (1999), ‘Variance estimation for complex statistics and estimators: linearization and residual techniques’, *Survey Methodology* **25**, 193–204.

Essama-Nssah, B. and Lambert, P. J. (2012), Influence functions for policy impact analysis, *in* J. A. Bishop and R. Salas, eds, ‘Inequality, Mobility and Segregation: Essays in Honor of Jacques Silber’, Vol. 20 of *Research on Economic Inequality*, Emerald Group Publishing, chapter 6, pp. 135–159.

Hampel, F. R. (1974), ‘The influence curve and its role in robust estimation’, *Journal of the American Statistical Association* **69**(346), pp. 383–393.

Hyndman, R. J. and Fan, Y. (1996), ‘Sample quantiles in statistical packages’, *The American Statistician* **50**(4), 361–365.

Jenkins, S. P. and Van Kerm, P. (2009), The measurement of economic inequality, *in* W. Salverda, B. Nolan and T. M. Smeeding, eds, ‘Oxford Handbook of Economic Inequality’, Oxford University Press, chapter 3.

Kolenikov, S. (2010), ‘Resampling variance estimation for complex survey data’, *Stata Journal* **10**, 165199.

UNIVERSITÉ DU LUXEMBOURG

LISER LUXEMBOURG INSTITUTE OF SOCIO-ECONOMIC RESEARCH

References II

Van Kerm, P. (2009), Computing poverty measures with survey data, German Stata Users' Group Meetings 2009 03, Stata Users Group.
URL: *https://ideas.repec.org/p/boc/dsug09/03.html*

Van Kerm, P. (2013), Repeated half-sample bootstrap resampling, United Kingdom Stata Users' Group Meetings 2013 10, Stata Users Group.
URL: *http://ideas.repec.org/p/boc/usug13/10.html*

Zheng, B. (1997), 'Aggregate poverty measures', *Journal of Economic Surveys* **11**(2), 123–62.

UNIVERSITÉ DU LUXEMBOURG

LISER
LUXEMBOURG INSTITUTE OF SOCIO-ECONOMIC RESEARCH