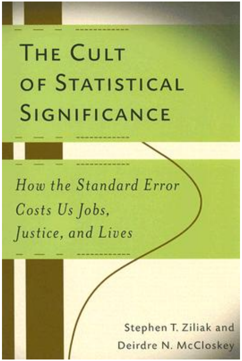
Correlation

1. Review: Statistical tests
2. Review: *t*-test
3. Review: Chi-squared test
4. Correlation

1. Statistical tests



Additional references

Leahey, "Alphas and Asterisks: The Development of Statistical Significance Testing Standards in Sociology", *Social Forces*, 2005.

Ziliak and McCloskey, *The Cult of Statistical Significance: How the Standard Error Costs Us Jobs, Justice, and Lives*, University of Michigan Press, 2008.

Hypothesis testing

Substantive hypotheses

There is an association between X and Y, ...
There is a difference of X between groups of Y, ...

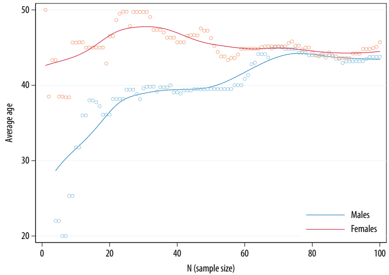
Null hypothesis tests

H_0: the association of X by Y is likely to be random.
H_0: the difference in X between groups of Y is likely to be random.

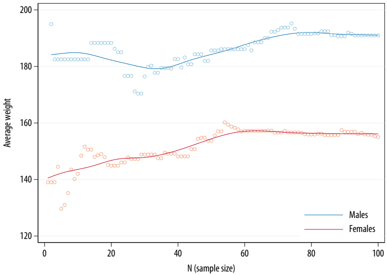
Rejecting the null

H_0 estimates the likelihood of an association or difference being attributable to sampling error under a certain level of confidence.

Hypothesis testing

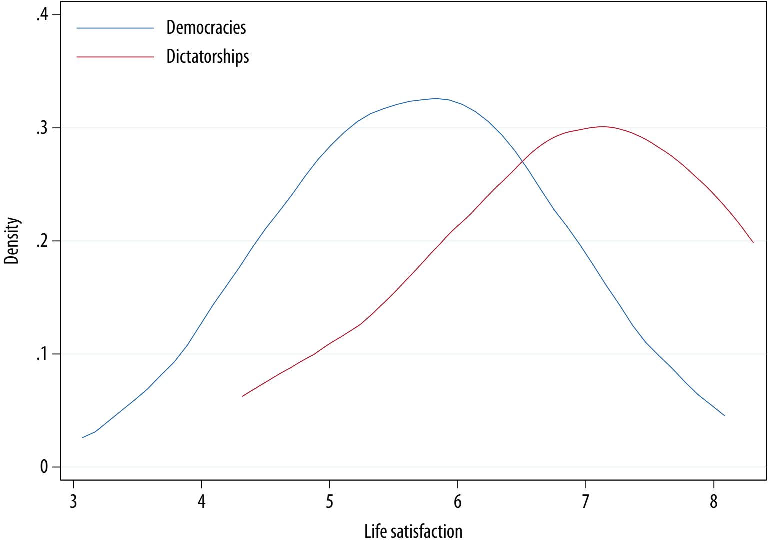


Type I error



Type II error

2. *t*-test



Democracies
Dictatorships
Density
.4
.3
.2
.1
0
3
4
5
6
7
8
Life satisfaction

t-test

Measuring association as the difference in means between two groups of i.i.d. observations:

- Population notation: $\delta = \mu_1 - \mu_2$
- Sample notation: $D = \bar{X}_1 - \bar{X}_2$

The t-test computes a 95% CI around the difference of their means and returns its p-value against the t-distribution.

- Null hypothesis H_0: $\mu_1 - \mu_2 = 0$
- Test statistic: $t = \frac{D}{SE_D}$

t-test

`ttest v1, by(v2)`

- v1 is continuous, v2 is a dummy
- use `prtest` if v1 is also a dummy (proportions test)
- use `tab, gen()` to create dummies from categorical variables

`use datasets/qog2011, clear`

- Variables: `d gol_enep gol_est2`
- Create dummies and compare parties across electoral systems.

t-test

```
use datasets/qog2011, clear
```

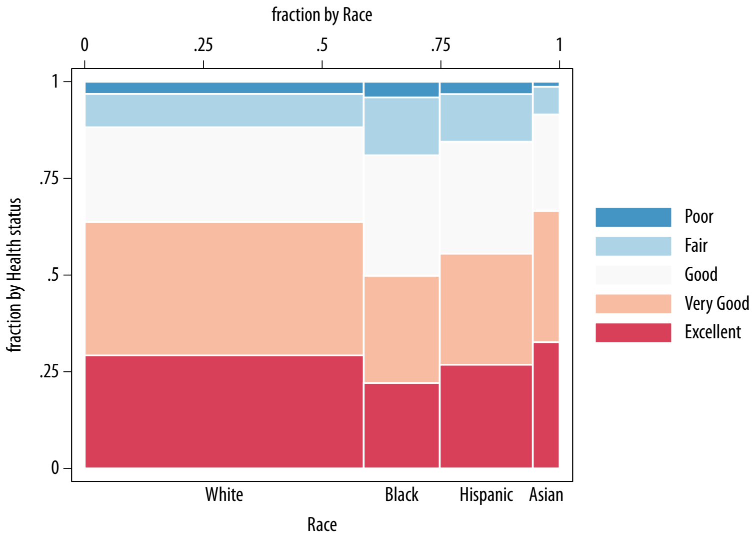
Explore the variables and interpret the output below.

```
. prtest no_mes, by(gol_polreg)

Two-sample test of proportions           0. Democracy: Number of obs =      109
                                         1. Dictators: Number of obs =       79
------------------------------------------------------------------------------
    Variable |       Mean   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
0. Democracy |    .293578   .0436195                      .2080853    .3790706
1. Dictators |   .2911392   .0511113                      .1909628    .3913156
-------------+----------------------------------------------------------------
        diff |   .0024387    .067194                      -.129259    .1341365
             |  under Ho:   .0672205     0.04   0.971
------------------------------------------------------------------------------
        diff = prop(0. Democracy) - prop(1. Dictators)            z =   0.0363
    Ho: diff = 0

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(Z < z) = 0.5145         Pr(|Z| < |z|) = 0.9711          Pr(Z > z) = 0.4855
```

3. Chi-squared test



Chi-squared test

The Chi-squared test is a nonparametric test of association that measures the deviation in orthogonality between groups:

- Null hypothesis H_0: $\chi^2 = 0$
- Test statistic: $\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i}$ (deviation between observed frequencies O_i and expected frequencies E_i for each table cell i)

```
tab v1 v2, exp chi2 V
```

- add `V` to measure the association with Cramér's V $(0 < V < 1)$
- use `tabchi` to inspect residuals, `tabodds` for odds ratios

Chi-squared test

use datasets/nhis2009, clear

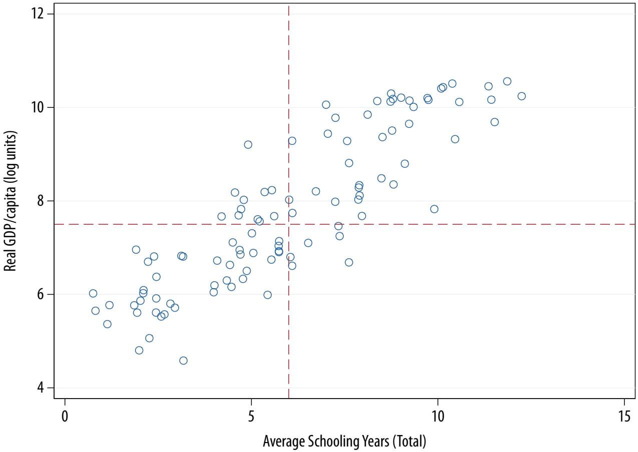
- Variables: `d raceb marstat`
- Analyze the frequencies and residuals with `tabchi`

```
. tab marstat raceb if marstat < 8, chi2 V
```

Legal marital status	Race White	Black	Hispanic	Asian	Total
Married	7,151	1,059	2,231	780	11,221
Widowed	1,215	352	223	84	1,874
Divorced	2,367	641	595	93	3,696
Separated	343	264	274	25	906
Total	11,076	2,316	3,323	982	17,697

```
Pearson chi2(9) = 733.4437   Pr = 0.000
     Cramér's V =   0.1175
```

4. Correlation



Pearson correlation coefficient

Measuring association as the linear dependence of two variables:

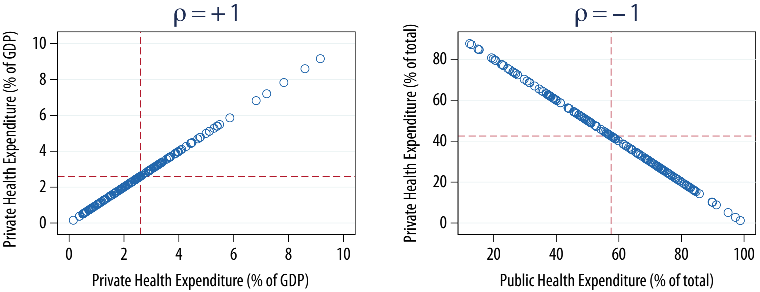
$$\text{Population notation} \quad \rho = \frac{\mathrm{Cov}(X,Y)}{\mathrm{Var}_X \mathrm{Var}_Y}, \quad -1 \leq \rho \leq 1$$

$$\text{Sample notation} \quad r = \frac{1}{n-1}\sum_{i=1}^{n}\left(\frac{X_i - \bar{X}}{s_X}\right)\left(\frac{Y_i - \bar{Y}}{s_Y}\right)$$

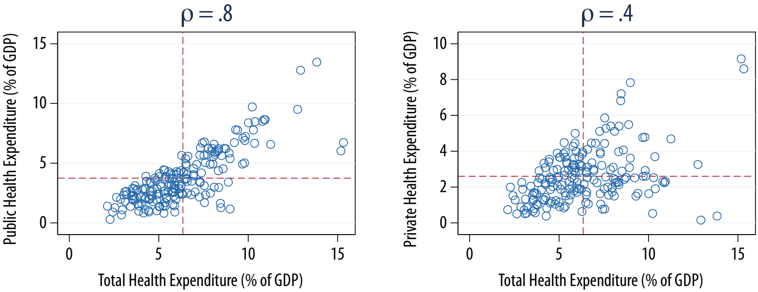
Detects linear correlation

- Uncorrelated $\neq$ unrelated
- Correlated $\neq$ unconfounded

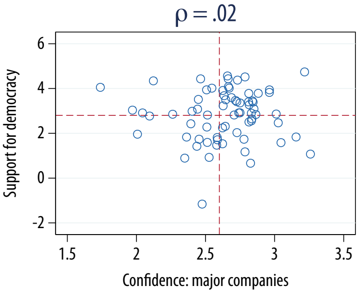
Perfect (positive, negative) correlation



Significant (moderate, strong) correlation



Insignificant (weak, non-linear) correlation



Pearson correlation coefficient

Significance test:

$$\text{Null hypothesis } H_0 \quad r = 0$$

$$\text{Test statistic} \quad T = r\sqrt{\frac{n-2}{1-r^2}}$$

Sanity check

- Uncorrelated $\neq$ independent
- Correlated $\neq$ causally related

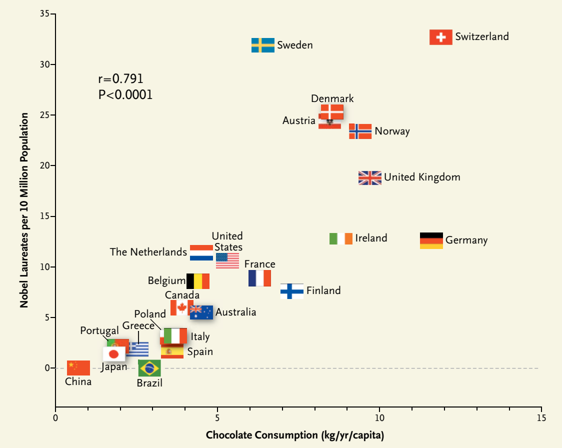


Figure 1. **Correlation between Countries' Annual Per Capita Chocolate Consumption and the Number of Nobel Laureates per 10 Million Population.**

Source: Messerli, "Chocolate Consumption, Cognitive Function, and Nobel Laureates", *New England Journal of Medicine*, 2012.

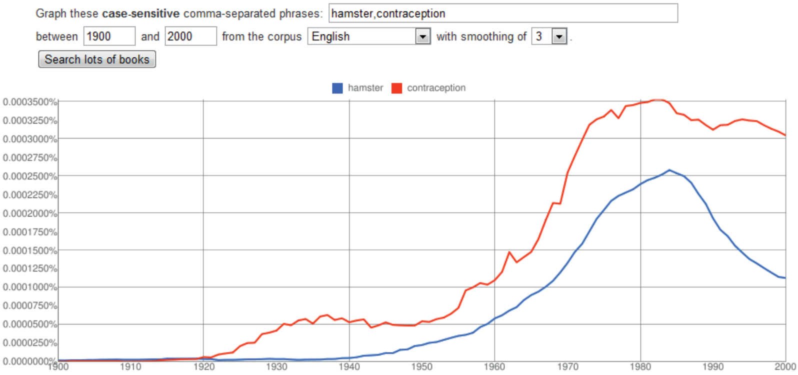


Figure 1: Frequencies of the words “hamster” and “contraception” in Google Books, 1900–2000

Source: Harkness, “Seduced by Stats?”, *Significance*, 2012.

Correlation matrixes

`pwcorr [varlist], [obs sig]`

- `obs` shows the number of observations
- `sig` shows the coefficient's *p*-value

`gr mat [varlist], [half etc.]`

- `half` plots only half of all graphs (quicker)
- accepts scatterplot options (`jitter`, `mlab`, etc.)

Correlation matrixes

`mkcorr [varlist], lab num sig log(file.txt) replace`

- `ssc install mkcorr` to install
- `help mkcorr` to understand the options

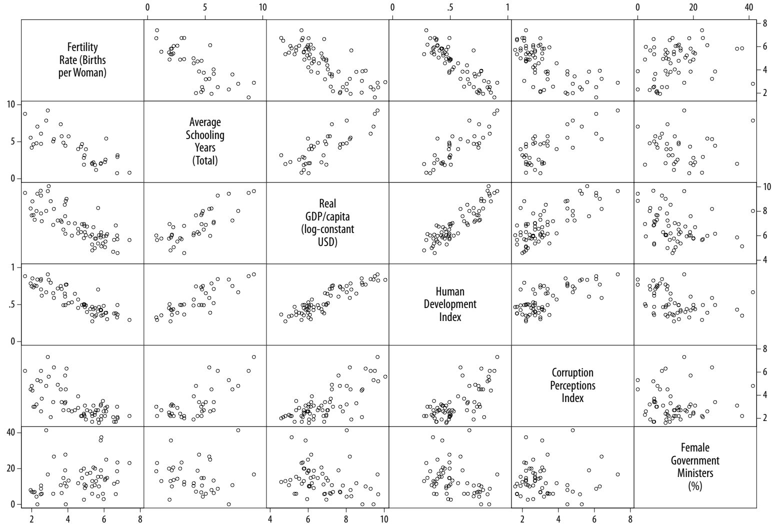
Computer skills

- Import as a table in a spreadsheet editor.
- Convert from text to table in a rich text editor.

`use datasets/qog2011, clear`

- Variables: `d wdi_puhegdp wdi_the wdi_prhe`
- Visualize, compute, export and import the correlation matrix.

gr mat



Showing only Africa and the Middle East ($N = 68$).

From Stata output...

```
. pwcorr wdi_hiv wdi_hec wdi_prhe wdi_puhegdp, obs sig star(.05)

             |  wdi_hiv  wdi_hec wdi_prhe wdi_pu~p
-------------+------------------------------------
     wdi_hiv |   1.0000 
             |
             |      141
             |
     wdi_hec |  -0.1953*  1.0000 
             |   0.0207
             |      140      187
             |
    wdi_prhe |   0.0979  -0.0555   1.0000 
             |   0.2497   0.4509
             |      140      187      188
             |
 wdi_puhegdp |  -0.0607   0.5490* -0.2099*  1.0000 
             |   0.4759   0.0000   0.0038
             |      140      187      188      188
```

$r = -.2$
$p < .02$
$N = 140$

coefficient

p-value

observations

… to publishing standard

Table 4
Pearson pairwise correlations among the dependent and explanatory variables

	ETRC	ETRI	CAPINT	LEV	SIZE	POLCON1	POLCON2	MKBV	INVINT	ROA
ETRC	1									
ETRI	0.031*	1								
CAPINT	−0.033**	−0.044**	1							
LEV	−0.051*	−0.021	−0.041**	1						
SIZE	−0.124	−0.190	−0.163**	0.337**	1					
POLCON1	−0.023**	−0.047**	0.129	0.031**	0.146**	1				
POLCON2	−0.011*	−0.044*	−0.064	0.116	0.179**	0.138**	1			
MKBV	0.045	−0.036	−0.051	−0.035	−0.077**	−0.130	−0.026	1		
INVINT	0.020	−0.014	0.067**	−0.128**	−0.195**	0.193**	−0.005	−0.041	1	
ROA	0.073*	0.047*	0.067**	−0.038	0.073	0.049	0.012	0.053	−0.019	1

Variable definitions: ETRC = (Tax expenses − Deferred tax expenses)/(Operating cash flows); ETRI = (Tax expenses − Deferred tax expenses)/(Profit before interest and tax); POLCON1 = Percentage of government equity ownership; POLCON2 = 1 if the firm is connected with top politicians; 0 otherwise; SIZE = Natural log of total assets; LEV = (Total debt)/(Total assets); CAPINT = (Property, plant and equipment)/(Total assets); INVINT = (Inventory/Total assets); ROA = (Pre-tax profits)/(Total assets); MKBV = (Market price of share)/(Shareholders equity/Number of ordinary shares outstanding).

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Source: Adhikari *et al.*, "Public Policy, Political Connections, and Effective Tax Rates: Longitudinal Evidence from Malaysia", *Journal of Accounting and Public Policy*, 2006.

Thanks for your attention

Project

- Start testing associations in your data
- Refine hypotheses and write draft findings

Readings

- *Stata Guide*, Sec. 10
- *Making History Count*, ch. 3

Practice

- Replicate do-file
- Exercises in slides