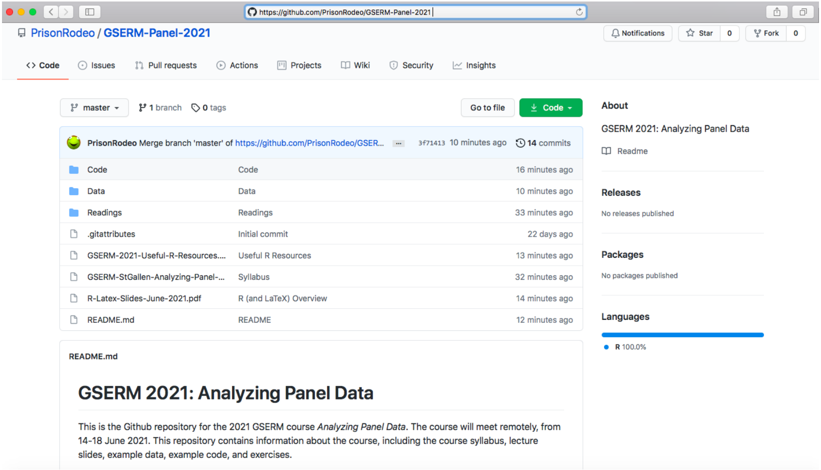
GSERM 2021
Analyzing Panel Data

June 14, 2021

Preliminaries

- Instructor: Prof. Christopher Zorn (`zorn@psu.edu`).
- Class: June 14-18, 2021, 13:00-18:00 CET, at the University of St. Gallen (via Zoom).
- The course outline / syllabus is here.
- More important: The syllabus, slides, readings, code, data, etc. are all available on the course github repo (viewable at `https://github.com/PrisonRodeo/GSERM-Panel-2021`), and on the HSG CANVAS page.
- Class sessions will be recorded; links to those recordings will be available on CANVAS **only**.


https://github.com/PrisonRodeo/GSERM-Panel-2021
PrisonRodeo / GSERM-Panel-2021
Notifications
Star 0
Fork 0
Code
Issues
Pull requests
Actions
Projects
Wiki
Security
Insights
master
1 branch
0 tags
Go to file
Code
PrisonRodeo Merge branch 'master' of https://github.com/PrisonRodeo/GSER...
3f71413 10 minutes ago
14 commits
Code | Code | 16 minutes ago
Data | Data | 10 minutes ago
Readings | Readings | 33 minutes ago
.gitattributes | Initial commit | 22 days ago
GSERM-2021-Useful-R-Resources.... | Useful R Resources | 13 minutes ago
GSERM-StGallen-Analyzing-Panel-... | Syllabus | 32 minutes ago
R-Latex-Slides-June-2021.pdf | R (and LaTeX) Overview | 14 minutes ago
README.md | README | 12 minutes ago
About
GSERM 2021: Analyzing Panel Data
Readme
Releases
No releases published
Packages
No packages published
Languages
R 100.0%
README.md
GSERM 2021: Analyzing Panel Data
This is the Github repository for the 2021 GSERM course Analyzing Panel Data. The course will meet remotely, from 14-18 June 2021. This repository contains information about the course, including the course syllabus, lecture slides, example data, example code, and exercises.

R

- All examples, plots, etc.
- Current version is 4.1.0
- Packages you'll use (see the econometrics task view for more):
    - `plm`
    - `lme4`
    - `gee`

Stata

- Current version is 17
- Mostly use the `-xt-` series of commands (for "cross-sectional time series")

- Panel data: Data comprising repeated observations over time on a set of cross-sectional units.
- Terminology:
  - "Unit" / "Units" / "Units of observation" / "Panels" = Things we observe repeatedly
  - "Observations" = Each (one) measurement of a unit
  - "Time points" = When each observation on a unit is made
  - $i \in \{1....N\}$ indexes units
  - $t \in \{1...T\}$ or $\{1...T_i\}$ indexes observations / time points
  - If $T_i = T \; \forall i$ then we have **"balanced"** panels / units
  - Balanced panels also imply $N_t = N \; \forall t$
  - NT = Total number of observations (if balanced)
- "Panel" $\neq$ "Time Series"
- "Panel" $\neq$ "Multilevel" / "Hierarchical" / etc.

$N >> T \ \rightarrow$ "panel" data...

- (American) National Election Study panel studies ($N \approx 2000$, $T = 3$)
- Swiss Household Panel (FORS) ($N =$ large, $T = 21$)
- Often:
  - Cross-sectional units are a sample from a population
  - T is (relatively) fixed

$T >> N$ or $T \approx N \ \rightarrow$ "time-series cross-sectional" ("TSCS") data

- National OECD data ($N = 20$ orignal members, $T \approx 70$)
- Often:
  - N is an entire population, and is (relatively) fixed
  - Asymptotics are in T

$N = 1 \ \rightarrow$ "time series" data

$T = 1 \ \rightarrow$ "cross-sectional" data

Panel Data Structure + Organization

id	t	Y	X_1	...
1	1	250	3.4	...
1	2	290	3.3	...
$\vdots$	$\vdots$	$\vdots$	$\vdots$	...
2	1	160	4.7	...
2	2	150	4.9	...
$\vdots$	$\vdots$	$\vdots$	$\vdots$	...

Introduction to Panel Variation: A Tiny (Fake) Example

id	year	gender	pres	pid	approve
1	2014	female	obama	dem	3
1	2016	female	obama	dem	3
1	2018	female	trump	dem	5
1	2020	female	trump	dem	3
2	2014	male	obama	gop	2
2	2016	male	obama	gop	1
2	2018	male	trump	gop	4
2	2020	male	trump	gop	3
3	2014	male	obama	gop	2
3	2016	male	obama	gop	2
3	2018	male	trump	gop	4
3	2020	male	trump	dem	1

Aggregation: Cross-Sectional

id	gender	pres	pid	approve
1	female	?	dem	3.50
2	male	?	gop	2.50
3	male	?	?	2.25

Aggregation: Temporal

year	female	pres	pid	approve
2014	0.33	obama	0.66(?)	2.33
2016	0.33	obama	0.66(?)	2.00
2018	0.33	trump	0.66(?)	4.33
2020	0.33	trump	0.33(?)	2.33

Aggregation:

- Loses information
- Distorts relationships
- Forces arbitrary decisions

If you have variation in multiple dimensions, use it.

Two-Way Variation

Two "dimensions" of variation:

- <u>Unit-Level</u> Variation (how each unit is – on average – different from other units on average) – a/k/a **between-unit** variation
- <u>Time-Level</u> Variation (how each measurement / time point is – on average – different from other time points on average) – a/k/a/ **within-unit** variation

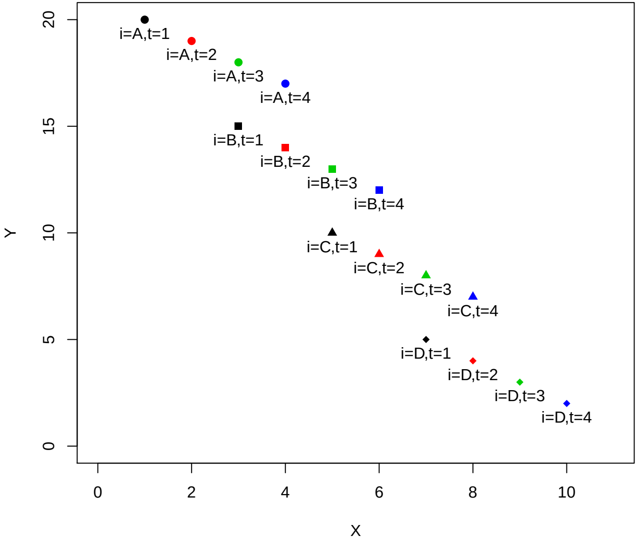
A random variable may:

- Have only between-unit variation (i.e., lack *temporal variation*)
- Have only within-unit variation (i.e., lack *cross-sectional variation*)
- Have *both* within- and between-unit variation

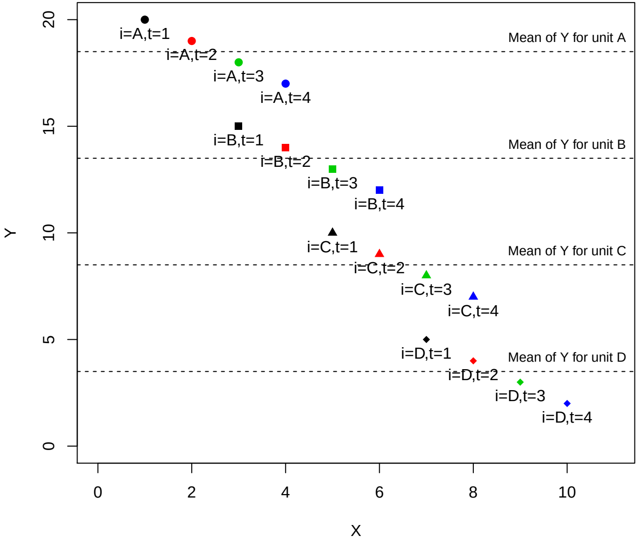
For Y_{it}, a variable that varies over both units and time:

- $\bar{Y}_i = \frac{1}{T_i}\sum_{t=1}^{T} Y_{it}$ is the over-time mean of Y for unit i,
- $\bar{Y}_t = \frac{1}{N_t}\sum_{i=1}^{N} Y_{it}$ is the across-unit mean of Y at time t, and
- $\bar{Y} = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T} Y_{it}$ is the grand mean of Y.

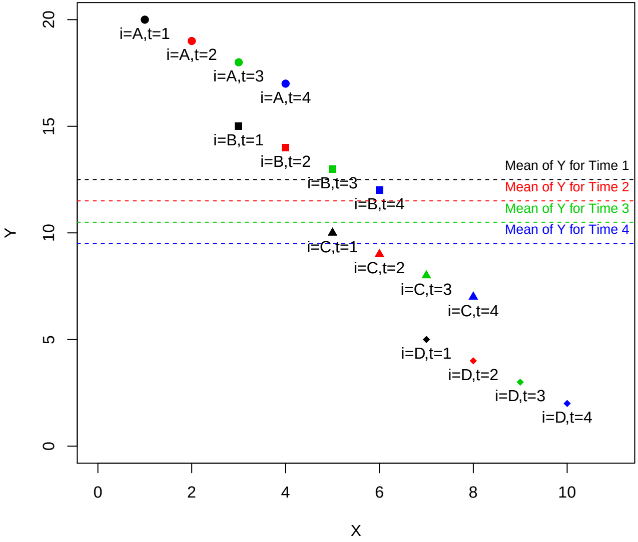
Dimensions of Variation



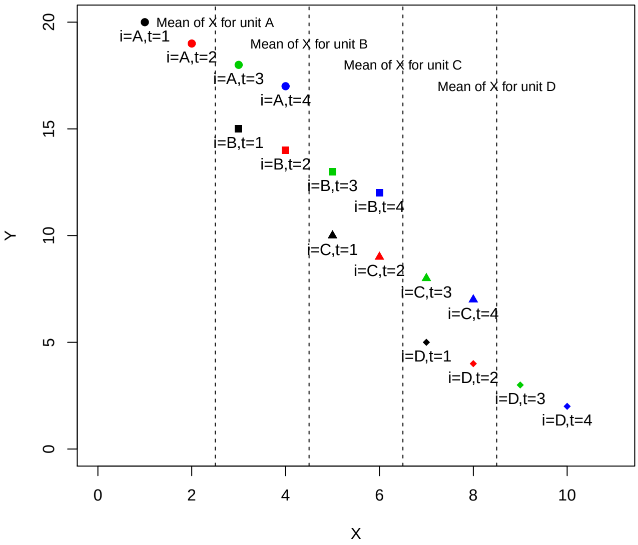
Dimensions of Variation



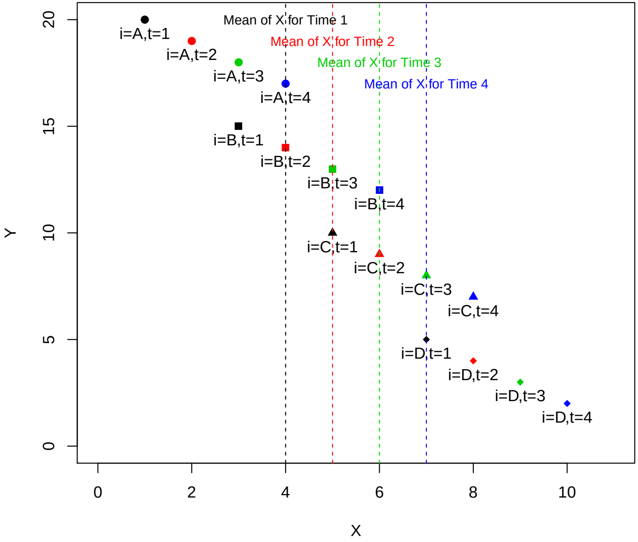
Dimensions of Variation



Dimensions of Variation



Dimensions of Variation



Within- and Between-Unit Variation

The *within-unit mean* of Y is:

$$\bar{Y}_i = \frac{1}{T_i} \sum_{t=1}^{T_i} Y_{it}$$

That means that we can write:

$$Y_{it} = \bar{Y}_i + (Y_{it} - \bar{Y}_i).$$

That is, the *total* variation in Y_{it} can be decomposed into:

- The *between-unit* variation in the $\bar{Y}_i$s, and
- The *within-unit* variation around $\bar{Y}_i$ (that is, $Y_{it} - \bar{Y}_i$).

Within- and Between-Unit Variation (continued)

Note that (while unusual) one could do a similar decomposition vis-à-vis time:

$$Y_{it} = \bar{Y}_t + (Y_{it} - \bar{Y}_t).$$

That is, the *total* variation in Y_{it} can be decomposed into:

- The *temporal* variation in the $\bar{Y}_t$s, and
- The *within-time-point* variation around $\bar{Y}_t$ (that is, $Y_{it} - \bar{Y}_t$).

In a similar fashion, we can also calculate the within- and between-unit variability (e.g., the standard deviations) of the constituent variables $\bar{Y}_i$ and $(Y_{it} - \bar{Y}_i)$...

Variation ("Toy" Data from Above)

"Total" Variation:

```
> with(toy, describe(Y))
   vars  n mean  sd median trimmed mad min max range skew kurtosis  se
X1    1 16   11 5.9     11      11 7.4   2  20    18    0     -1.5 1.5
```

"Between" Variation:

```
> Ymeans <- ddply(toy,.(ID),summarise,
+                 Y=mean(Y))
> with(Ymeans, describe(Y)) # between-unit variation
   vars n mean  sd median trimmed mad min max range skew kurtosis  se
X1    1 4   11 6.5     11      11 7.4 3.5  18    15    0     -2.1 3.2
```

"Within" Variation:

```
> toy <- ddply(toy,.(ID), mutate,
+              Ymean=mean(Y))
> toy$within <- with(toy, Y-Ymean)
> with(toy, describe(within)) # within-unit variation
   vars  n mean  sd median trimmed mad  min max range skew kurtosis   se
X1    1 16    0 1.1      0       0 1.5 -1.5 1.5     3    0     -1.6 0.29
```

Model:

$$Y_i = \beta_0 + \beta_1 X_i + u_i$$

...makes all the usual OLS assumptions, plus

- $\beta_{0i} = \beta_0 \; \forall \; i$s
- $\beta_{1i} = \beta_1 \; \forall \; i$s

For the model:

$$Y_{it} = \beta_0 + \beta_1 X_{it} + u_{it}$$

...the same is true.

Variable Intercepts

Unit-specific intercepts:

$$Y_{it} = \beta_{0i} + \beta_1 X_{it} + u_{it} \tag{1}$$

Time-point-specific intercepts:

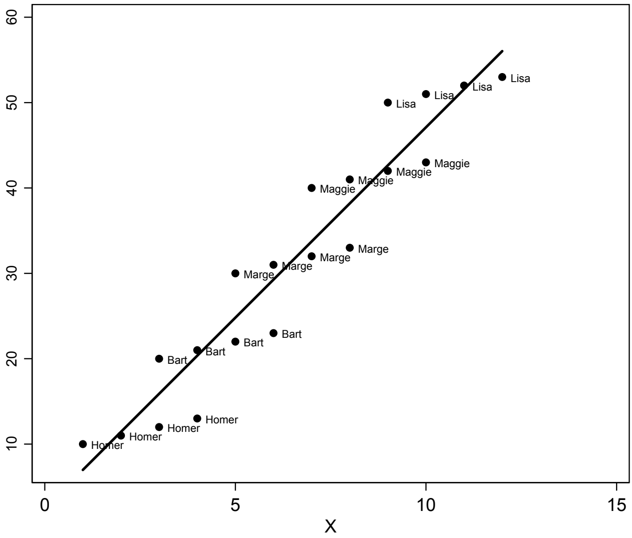
$$Y_{it} = \beta_{0t} + \beta_1 X_{it} + u_{it} \tag{2}$$

Both:

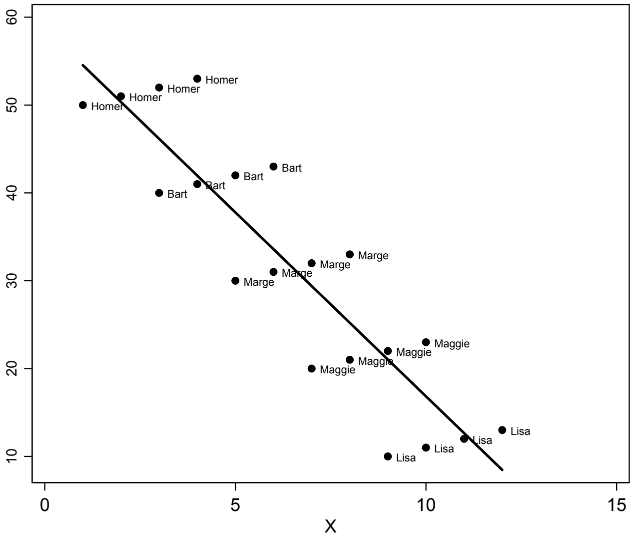
$$Y_{it} = \beta_{0it} + \beta_1 X_{it} + u_{it} \tag{3}$$

<u>Note</u>: Equation 3 is not identified (as written)!

Varying Intercepts



Varying Intercepts



Varying Slopes (+ Intercepts)

Unit-specific slopes:

$$Y_{it} = \beta_0 + \beta_{1i} X_{it} + u_{it} \tag{4}$$

(...one can also have time-point specific slopes, or both – again, the last of those is not identified as written.)

Unit-specific slopes + intercepts:

$$Y_{it} = \beta_{0i} + \beta_{1i} X_{it} + u_{it} \tag{5}$$

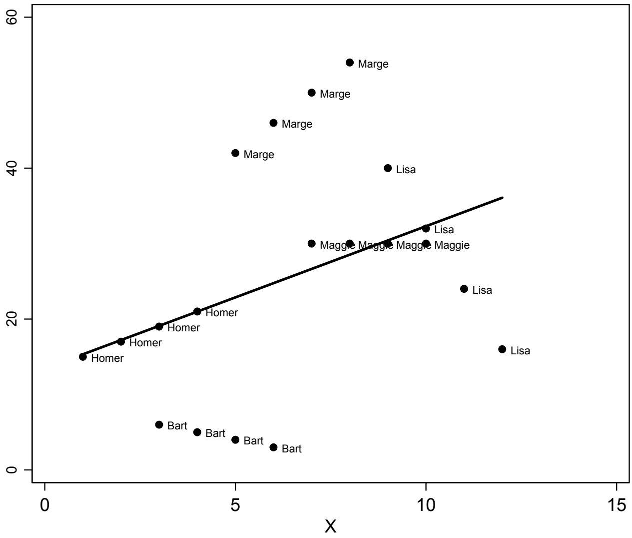
Time-point-specific-specific slopes + intercepts:

$$Y_{it} = \beta_{0t} + \beta_{1t} X_{it} + u_{it} \tag{6}$$

Both...:

$$Y_{it} = \beta_{0it} + \beta_{1it} X_{it} + u_{it} \tag{7}$$

Varying Slopes + Intercepts



Usual OLS assumption:

$$u_{it} \sim \text{i.i.d.} N(0, \sigma^2) \; \forall \; i, t$$

or, equivalently:

$$\mathbf{u}\mathbf{u}' \sim \sigma^2 \mathbf{I}$$

implies:

$$\begin{aligned}
\text{Var}(u_{it}) &= \text{Var}(u_{jt}) \; \forall \; i \neq j \text{ (i.e., no cross-unit heteroscedasticity)} \\
\text{Var}(u_{it}) &= \text{Var}(u_{is}) \; \forall \; t \neq s \text{ (i.e., no temporal heteroscedasticity)} \\
\text{Cov}(u_{it}, u_{js}) &= 0 \; \forall \; i \neq j, \; \forall \; t \neq s \text{ (i.e., no auto- or spatial correlation)}
\end{aligned}$$

Pooling pros:

- Adds data ($\rightarrow$ precision)
- Enhances generalizability

BUT: fitting the model:

$$Y_{it} = \beta_0 + \beta_1 X_{it} + u_{it}$$

Implies

- that the process governing the relationship between X and Y is exactly the same for each i,
- that the process governing the relationship between X and Y is the same for all t,
- that the process governing the us is the same $\forall$ i and t as well.

Q: When can we "pool" data on different units?

“Partial” Pooling (Bartels 1996)

Two regimes:

$$Y_A = \beta'_A \mathbf{X}_A + u_A$$

$$Y_B = \beta'_B \mathbf{X}_B + u_B$$

with $\sigma^2_A = \sigma^2_B$, and $\mathrm{Cov}(u_A, u_B) = 0$.

Estimators:

$$\hat{\beta}_{A,B} = (\mathbf{X}'_{A,B}\mathbf{X}_{A,B})^{-1}\mathbf{X}'_{A,B} Y_{A,B}$$

and

$$\widehat{\mathrm{Var}(\beta_{A,B})} = \hat{\sigma}^2_{A,B}(\mathbf{X}'_{A,B}\mathbf{X}_{A,B})^{-1},$$

A Pooled Estimator

$$
\begin{aligned}
\hat{\beta}_P &= (\mathbf{X}_A'\mathbf{X}_A + \mathbf{X}_B'\mathbf{X}_B)^{-1}(\mathbf{X}_A' Y_A + \mathbf{X}_B' Y_B) \\
&= (\mathbf{X}_A'\mathbf{X}_A + \mathbf{X}_B'\mathbf{X}_B)^{-1}[\beta_A(\mathbf{X}_A'\mathbf{X}_A) + \beta_B(\mathbf{X}_B'\mathbf{X}_B)],
\end{aligned}
$$

$$
\begin{aligned}
\mathrm{E}(\hat{\beta}_P) &= \beta_A + (\mathbf{X}_A'\mathbf{X}_A + \mathbf{X}_B'\mathbf{X}_B)^{-1}\mathbf{X}_B'\mathbf{X}_B(\beta_B - \beta_A) \\
&= \beta_B + (\mathbf{X}_A'\mathbf{X}_A + \mathbf{X}_B'\mathbf{X}_B)^{-1}\mathbf{X}_A'\mathbf{X}_A(\beta_A - \beta_B)
\end{aligned}
$$

$$F = \frac{\frac{\hat{\mathbf{u}}_P'\hat{\mathbf{u}}_P - (\hat{\mathbf{u}}_A'\hat{\mathbf{u}}_A + \hat{\mathbf{u}}_B'\hat{\mathbf{u}}_B)}{K}}{\frac{(\hat{\mathbf{u}}_A'\hat{\mathbf{u}}_A + \hat{\mathbf{u}}_B'\hat{\mathbf{u}}_B)}{(N_A + N_B - 2K)}} \sim F_{[K,(N_A+N_B-2K)]}$$

Bartels suggests:

$$\hat{\beta}_\lambda = (\lambda^2 \mathbf{X}'_A \mathbf{X}_A + \mathbf{X}'_B \mathbf{X}_B)^{-1} (\lambda^2 \mathbf{X}'_A Y_A + \mathbf{X}'_B Y_B)$$

with $\lambda \in [0, 1]$:

- $\lambda = 0 \ \rightarrow$ separate estimators for $\hat{\beta}_A$ and $\hat{\beta}_B$,
- $\lambda = 1 \ \rightarrow$ "fully pooled" estimator $\hat{\beta}_P$,
- $0 < \lambda < 1 \ \rightarrow$ a regression where data in regime A are given some "partial" weighting in their contribution towards an estimate of β.

Pooling, Summarized

"(R)oughly speaking, it makes sense to pool disparate observations if the underlying parameters governing those observations are sufficiently similar, but not otherwise."

- Bartels (1996)

Exploring Variation: A Running Example

The U.S. Supreme Court, 1946-2020

- Court has nine “justices” at any time
- Appointed by the President, confirmed by the Senate (simple majority vote)
- Serve for life / good behavior
- One is appointed as the “Chief Justice” (a sitting justice may be elevated to that position)
- Sit in annual “terms” (October through June/July); decide 80-150 cases per term
- Cases are appealed from lower federal and state supreme courts
- Simple majority decision rule (“five”)
- Nearly all decisions have a ideological (left / right) valence (“liberal” vs. “conservative”)

The Supreme Court Database

http://scdb.wustl.edu/

Supreme Court Panel Data

Structure: One observation per justice (i) per term (t)

Important variables:

- `justice`: A justice (unit) ID variable [range: 78-116]
- `term`: A term (time) variable [range: 1946-2019]
- `LiberalPct`: The percentage of cases in that term in which that justice voted in a politically left / "liberal" direction
- `MajPct`: The percentage of cases in that term in which that justice voted with the majority in a case
- `Ideology`: A variable measuring the justice's (pre-confirmation) political ideology [range: 0 (most conservative) - 1 (most liberal)]*
- `Qualifications`: A measure of the justice's qualifications prior to his/her appointment [range: 0 (least qualified) - 1 (most qualified)]*
- `President`: The name of the president who appointed that justice*
- `YearApptd`: The year that justice was appointed*
- `NCases`: The number of cases the Court decided *during that term***
- `ChiefJustice`: The identity of the Chief Justice *during that term***

* indicates variables that are non-time-varying (that is, that have only between-unit variation)

** indicates variables that are non-unit-varying (that is, that have only within-unit variation)

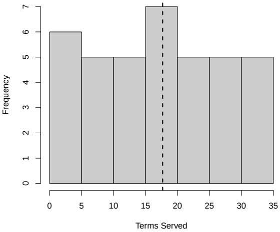
Summary Statistics

```
> summary(SCData)
      term         justice       justiceName          LiberalPct        MajPct
 Min.   :1946   Min.   : 78.0   Length:672         Min.   :16.7   Min.   : 46.7
 1st Qu.:1964   1st Qu.: 91.0   Class :character   1st Qu.:38.4   1st Qu.: 76.2
 Median :1982   Median :100.0   Mode  :character   Median :49.5   Median : 82.8
 Mean   :1982   Mean   : 98.1                      Mean   :51.9   Mean   : 81.7
 3rd Qu.:2001   3rd Qu.:106.0                      3rd Qu.:65.7   3rd Qu.: 88.0
 Max.   :2019   Max.   :116.0                      Max.   :87.7   Max.   :100.0
     Order         Nominee           SenateVote           Ideology      Qualifications
 Min.   : 1.0   Length:672         Length:672         Min.   :0.000   Min.   :0.125
 1st Qu.:15.0   Class :character   Class :character   1st Qu.:0.160   1st Qu.:0.750
 Median :27.0   Mode  :character   Mode  :character   Median :0.488   Median :0.885
 Mean   :24.5                                         Mean   :0.488   Mean   :0.802
 3rd Qu.:36.0                                         3rd Qu.:0.750   3rd Qu.:0.978
 Max.   :47.0                                         Max.   :1.000   Max.   :1.000
  President           YearApptd        NCases     ChiefJustice
 Length:672         Min.   :1937   Min.   : 76   Length:672
 Class :character   1st Qu.:1955   1st Qu.: 96   Class :character
 Mode  :character   Median :1970   Median :141   Mode  :character
                    Mean   :1970   Mean   :142
                    3rd Qu.:1988   3rd Qu.:182
                    Max.   :2018   Max.   :258
```

How many justices are in the data?

```
> length(unique(SCData$justice))
[1] 38
```

How many terms do justices typically serve?

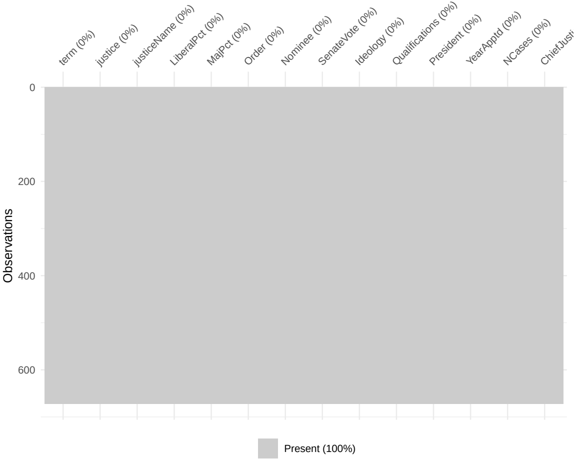


So we have:

- $N = 38$ units (justices)
- $\bar{T} = 17.7$ time periods (terms) of data per justice, on average [range: 2-35], for a total of
- $NT = 672$ justice-terms in the data

Missing Data

```
> library(naniar)
> vis_miss(SCData)
```



Variation: LiberalPct

```
> # Total variation:
>
> with(SCData, describe(LiberalPct))
   vars   n mean   sd median trimmed mad  min  max range skew kurtosis   se
X1    1 672 51.9 16.2   49.5    51.5  19 16.7 87.7    71 0.19       -1 0.63
```

```
> # Between-Justice variation:
>
> LibMeans <- ddply(SCData,.(justice),summarise,
+                 MeanLibPct=mean(LiberalPct))
> with(LibMeans, describe(MeanLibPct))
   vars  n mean   sd median trimmed  mad  min  max range skew kurtosis   se
X1    1 38 52.5 14.8   48.3    52.2 16.5 29.9 77.2  47.2 0.31    -1.29 2.39
```

```
> # Within-Justice variation:
>
> SCData <- ddply(SCData,.(justice), mutate,
+               LibMean=mean(LiberalPct))
> SCData$LibWithin <- with(SCData, LiberalPct-LibMean)
> with(SCData, describe(LibWithin))
   vars   n mean   sd median trimmed  mad   min  max range skew kurtosis   se
X1    1 672    0 7.36  -0.16   -0.02 7.05 -30.8 32.8  63.6 0.04     1.03 0.28
```

```
> # Total variation:
>
> with(SCData, describe(Ideology))
   vars   n mean   sd median trimmed  mad min max range skew kurtosis   se
X1    1 672 0.49 0.32   0.49    0.48 0.39   0   1     1 0.09     -1.3 0.01


> # Between-Justice variation:
>
> IdeoMeans <- ddply(SCData,.(justice),summarise,
+                   MeanIdeo=mean(Ideology))
> with(IdeoMeans, describe(MeanIdeo))
   vars  n mean   sd median trimmed  mad min max range  skew kurtosis   se
X1    1 38 0.54 0.33   0.58    0.54 0.43   0   1     1 -0.11    -1.46 0.05


> # Within-Justice variation (hint - there is none):
>
> SCData <- ddply(SCData,.(justice), mutate,
+                 IdeoMean=mean(Ideology))
> SCData$IdeoWithin <- with(SCData, Ideology-IdeoMean)
> with(SCData, describe(IdeoWithin))
   vars   n mean sd median trimmed mad min max range skew kurtosis se
X1    1 672    0  0      0       0   0   0   0     0  NaN      NaN  0
```

Variation: NCases

```
> # Total variation:
>
> with(SCData, describe(NCases))
   vars   n mean   sd median trimmed  mad min max range skew kurtosis   se
X1    1 672  142 44.7    141     141 60.8  76 258   182 0.18    -1.06 1.73


> # Between-Term variation:
>
> NCMeans <- ddply(SCData,.(term),summarise,
+                    MeanNCases=mean(NCases))
> with(NCMeans, describe(MeanNCases))
   vars  n mean   sd median trimmed  mad min max range skew kurtosis   se
X1    1 74  142 45.1    142     141 60.8  76 258   182 0.17    -1.11 5.24


> # Within-Term variation (none):
>
> SCData <- ddply(SCData,.(term), mutate,
+                 NCMean=mean(NCases))
> SCData$NCWithin <- with(SCData, NCases-NCMean)
> with(SCData, describe(NCWithin))
   vars   n mean sd median trimmed mad min max range skew kurtosis se
X1    1 672    0  0      0       0   0   0   0     0  NaN      NaN  0
```

An interactive tool for exploring panel data...

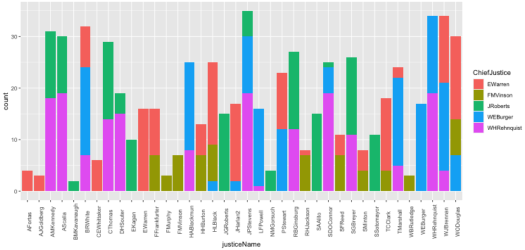
- Creator: Joachim Gassen (Department of Accounting, Humboldt-Universität zu Berlin)
- Built upon / consistent with `ggplot` / `tidyverse`
- Requires installing the `ExPanDaR` package
- Calling

  ```
  > ExPanD()
  ```

  ...opens the Shiny app, and asks for a (pre-formatted) data frame (typically in CSV format)
- More information is here: https://joachim-gassen.github.io/ExPanDaR/

Some examples...

Counts by factors:



Summary statistics:

Descriptive Statistics

Hover over variable names with mouse to see variable definitions.

Select Tab to choose the analysis set of variables or the base set of variables (to define new variables).

Click here to delete selected variables from the analysis sample.

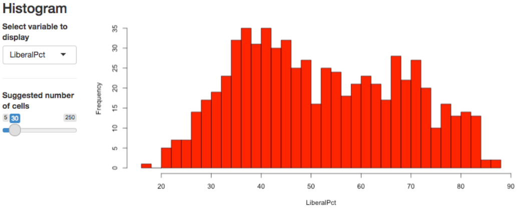
Delete Variables

Analysis Set | Base Set

Variable	N	Mean	Std. dev.	Min.	25 %	Median	75 %	Max.
V1	672	351.475	208.836	1.000	168.750	336.500	538.250	707.000
LiberalPct	672	51.856	16.213	16.667	38.446	49.473	65.713	87.662
MajPct	672	81.714	8.827	46.667	76.193	82.828	87.964	100.000
Order	672	24.531	12.784	1.000	15.000	27.000	36.000	47.000
Ideology	672	0.488	0.320	0.000	0.160	0.487	0.750	1.000
Qualifications	672	0.802	0.245	0.125	0.750	0.885	0.978	1.000
YearApptd	672	1,970.324	20.975	1,937.000	1,955.000	1,970.000	1,988.000	2,018.000

ExPanDaR: Distributions

Histograms:



Outlier Detection:

Extreme Observations

Select variable to sort data by

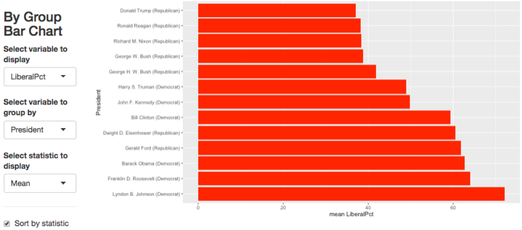
LiberalPct

Select period to subset to

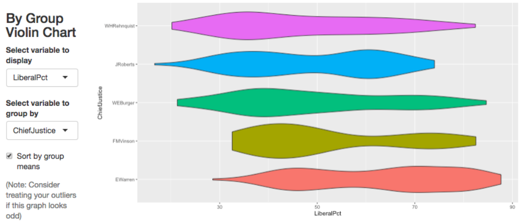
All

justice	term	LiberalPct
81	1958	87.7
81	1956	87.0
81	1971	84.7
90	1963	84.1
81	1955	83.7
...	...	...
102	1979	21.3
108	2003	21.3
102	1998	20.2
108	1998	20.2
115	2016	16.7

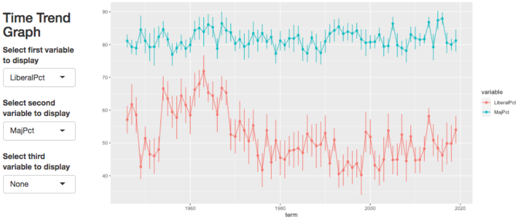
Bar Charts of Means (by factors):



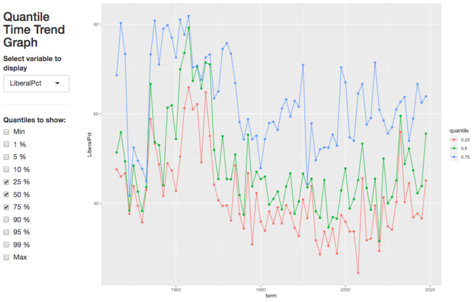
Violin Plots:



General Trends + Variation:



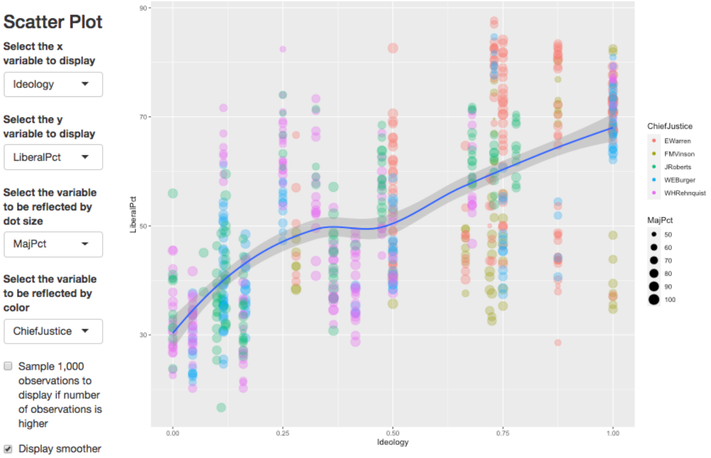
Trends in Quantiles:



ExPanDaR: More Trends

Trends By Group:

Fancy Scatterplots:

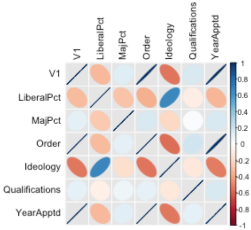


ExPanDaR: Correlations / Regression

Bivariate Correlations:

Correlation Plot

This plot visualizes sample correlations (Pearson above, Spearman below diagonal). Reports correlations for all continuous variables. Hover over ellipse to get rho, P-Value and n.



Regression (OLS) Analysis:

Regression Analysis

Select the dependent variable

LiberalPct

Select independent variable(s)

Ideology
MajPct

Select a categorial variable as the first fixed effect

None

	Dependent variable:
	LiberalPct
Ideology	31.200***
	(1.490)
MajPct	-0.287***
	(0.054)
Constant	60.100***
	(4.650)
Estimator	ols
Fixed effects	None
Std. errors clustered	No
Observations	672
R^2	0.445
Adjusted R^2	0.443
Note:	*p<0.1; **p<0.05; ***p<0.01

The Plan

- Tuesday, 15 June: One- and Two-Way "Unit Effects" Models (fixed, "random," etc.)
- Wednesday, 16 June: Dynamics in Panel Data
- Thursday, 17 June: Panel Data and Causal Inference
- Friday, 18 June: Models for Discrete Responses