# See chapter 2 in Regression and Other Stories.

**Widen the notebook.**

```
html"""
<style>
    main {
        margin: 0 auto;
        max-width: 2000px;
        padding-left: max(160px, 10%);
        padding-right: max(160px, 10%);
    }
</style>
"""
```

```
using Pkg ✓, DrWatson ✓
```

**A typical set of Julia packages to include in notebooks.**

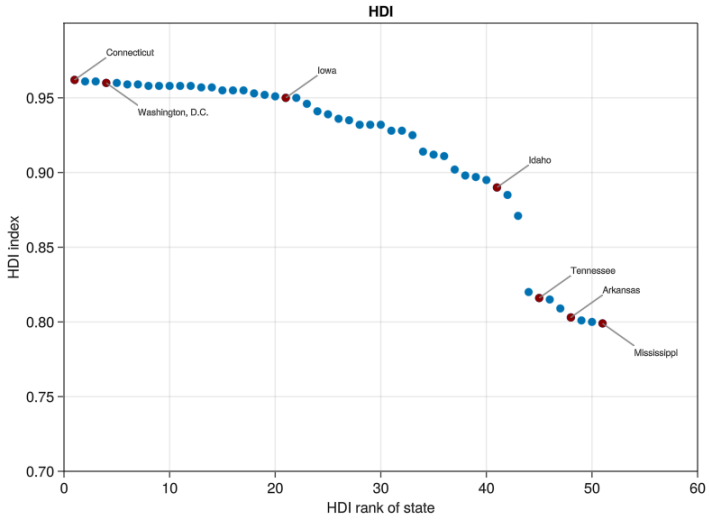
```
begin
    # Specific to this notebook
    using GLM ✓

    # Specific to ROSStanPluto
    using StanSample ✓

    # Graphics related
    using GLMakie ✓

    # Common data files and functions
    using RegressionAndOtherStories ✓
end
```

## 2.1 Examining where data come from.

hdi =

| | rank | state | hdi | canada |
|---|---|---|---|---|
| 1 | 1 | "Connecticut" | 0.962 | 2 |
| 2 | 2 | "Massachusetts" | 0.961 | 2 |
| 3 | 3 | "New Jersey" | 0.961 | 2 |
| 4 | 4 | "Washington, D.C." | 0.96 | 4 |
| 5 | 5 | "Maryland" | 0.96 | 3 |
| 6 | 6 | "Hawaii" | 0.959 | 2 |
| 7 | 7 | "New York" | 0.959 | 1 |
| 8 | 8 | "New Hampshire" | 0.958 | 1 |
| 9 | 9 | "Minnesota" | 0.958 | 1 |
| 10 | 10 | "Rhode Island" | 0.958 | 3 |
| ⋮ | more | | | |
| 51 | 51 | "Mississippi" | 0.799 | 5 |

```
hdi = CSV.read(ros_datadir("HDI",
"hdi.csv"), DataFrame)
```




```
let
    f = Figure()
    ax = Axis(f[1, 1]; title = "HDI",
        xlabel = "HDI rank of state", ylabel
         = "HDI index")
    limits!(ax, 0, 60, 0.7, 1)
    scatter!(hdi.rank, hdi.hdi)
    selection = 1:20:50
    scatter!(hdi.rank[selection],
    hdi.hdi[selection]; color=:darkred)
    for i in selection
        lines!([hdi.rank[i], hdi.rank[i] +
        3],
            [hdi.hdi[i], hdi.hdi[i] +
            0.015]; color=:grey)
        annotations!(hdi.state[i],
            position = (hdi.rank[i] + 3,
            hdi.hdi[i] + 0.015),
            textsize = 10)
    end
    selection = [4, 51]
    scatter!(hdi.rank[selection],
    hdi.hdi[selection]; color=:darkred)
    for i in selection
        lines!([hdi.rank[i], hdi.rank[i] +
        3],
            [hdi.hdi[i], hdi.hdi[i] -
            0.015]; color=:grey)
        annotations!(hdi.state[i],
            position = (hdi.rank[i] + 3,
            hdi.hdi[i] - 0.023),
            textsize = 10)
    end
    selection = 45:3:50
    scatter!(hdi.rank[selection],
    hdi.hdi[selection]; color=:darkred)
```

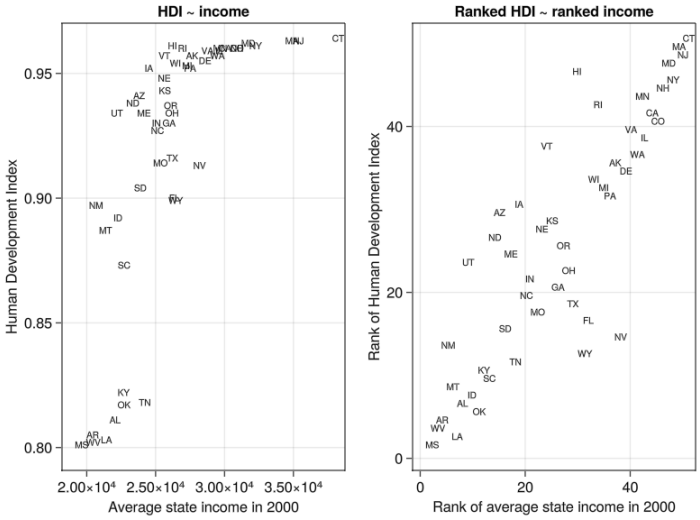
```
    for i in selection
        lines!([hdi.rank[i], hdi.rank[i] +
        3],
            [hdi.hdi[i], hdi.hdi[i] +
            0.015]; color=:grey)
        annotations!(hdi.state[i],
            position = (hdi.rank[i] + 3,
            hdi.hdi[i] + 0.015),
            textsize = 10)
    end
    f
end
```

| | st_state | st_stateabb | st_income |
|---|---|---|---|
| 1 | "Alabama" | "AL" | 21656.2 |
| 2 | "Alaska" | "AK" | 27209.7 |
| 3 | "Arizona" | "AZ" | 23381.0 |
| 4 | "Arkansas" | "AR" | 19977.9 |
| 5 | "California" | "CA" | 29581.4 |
| 6 | "Colorado" | "CO" | 30406.0 |
| 7 | "Connecticut" | "CT" | 37808.2 |
| 8 | "Delaware" | "DE" | 28128.1 |
| 9 | "Florida" | "FL" | 25977.8 |
| 10 | "Georgia" | "GA" | 25502.2 |
| ⋮ | more | | |
| 50 | "Wyoming" | "WY" | 25934.1 |

```
begin
    votes = CSV.read(ros_datadir("HDI",
    "votes.csv"), DataFrame;
        delim=",", stringtype=String,
        pool=false)
    votes[votes.st_year .== 2000,
    [:st_state, :st_stateabb, :st_income]]
end
```

| | rank | state | hdi | canada.dis |
|---|---|---|---|---|
| 1 | 1 | "Connecticut" | 0.962 | 2 |
| 2 | 2 | "Massachusetts" | 0.961 | 2 |
| 3 | 3 | "New Jersey" | 0.961 | 2 |
| 4 | 5 | "Maryland" | 0.96 | 3 |
| 5 | 6 | "Hawaii" | 0.959 | 2 |
| 6 | 7 | "New York" | 0.959 | 1 |
| 7 | 8 | "New Hampshire" | 0.958 | 1 |
| 8 | 9 | "Minnesota" | 0.958 | 1 |
| 9 | 10 | "Rhode Island" | 0.958 | 3 |
| 10 | 11 | "California" | 0.958 | 3 |
| ⋮ | more | | | |
| 50 | 51 | "Mississippi" | 0.799 | 5 |

```
let
    tmp = votes[votes.st_year .== 2000,
    [:st_state, :st_stateabb, :st_income]]
    votes2 = DataFrame(state=tmp.st_state,
    abbr=tmp.st_stateabb,
        income=tmp.st_income)
    global hdivotes = innerjoin(hdi,
    votes2, on = :state)
end
```




```
let
    f = Figure()
    ax = Axis(f[1, 1]; title = "HDI ~
    income",
        xlabel = "Average state income in
        2000",
        ylabel = "Human Development Index")
    for i in 1:size(hdivotes, 1)
        if length(hdivotes.abbr[i]) > 0
            annotations!(hdivotes.abbr[i],
                position =
                (hdivotes.income[i],
                hdivotes.hdi[i]),
                textsize = 10)
        end
    end
    hdivotes.rank_hdi =
    sortperm(hdivotes.hdi)
    global hdivotes2 = sort(hdivotes,
    :income)
    ax = Axis(f[1, 2]; title = "Ranked HDI
    ~ ranked income",
        xlabel = "Rank of average state
        income in 2000",
        ylabel = "Rank of Human Development
        Index")
    for i in 1:size(hdivotes2, 1)
        if length(hdivotes2.abbr[i]) > 0
            annotations!(hdivotes2.abbr[i],
                position = (i,
                hdivotes2.rank_hdi[i]),
                textsize = 10)
        end
    end
    current_figure()
end
```

| | rank | state | hdi | canada.dis |
|---|---|---|---|---|
| 1 | 51 | "Mississippi" | 0.799 | 5 |
| 2 | 50 | "West Virginia" | 0.8 | 3 |
| 3 | 48 | "Arkansas" | 0.803 | 4 |
| 4 | 40 | "New Mexico" | 0.895 | 4 |
| 5 | 42 | "Montana" | 0.885 | 1 |
| 6 | 49 | "Louisiana" | 0.801 | 5 |
| 7 | 47 | "Alabama" | 0.809 | 5 |
| 8 | 29 | "Utah" | 0.932 | 2 |
| 9 | 41 | "Idaho" | 0.89 | 1 |
| 10 | 46 | "Oklahoma" | 0.815 | 4 |
| ⋮ | more | | | |
| 50 | 1 | "Connecticut" | 0.962 | 2 |

```
hdivotes2
```

```
stan2_1 = "
data {
    int N;
    vector[N] rank_hdi;
    vector[N] rank_income;
}
parameters {
    real a;
    real b;
    real<lower=0> sigma;
}
model {
    vector[N] mu;
    mu = a + b * rank_income;
    a ~ normal(0, 5);
    b ~ normal(0, 5);
    sigma ~ exponential(1);
    rank_hdi ~ normal(mu, sigma);
}";
```

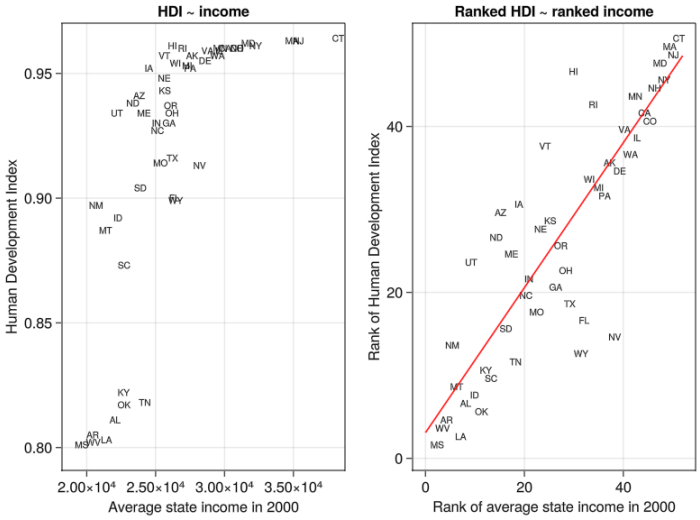
| | parameters | mean | mcse | std | 5% |
|---|---|---|---|---|---|
| 1 | "lp__" | -132.26 | 0.04 | 1.28 | -134 |
| 2 | "a" | 3.08 | 0.05 | 1.88 | -0.0 |
| 3 | "b" | 0.87 | 0.0 | 0.07 | 0.77 |
| 4 | "sigma" | 7.19 | 0.01 | 0.7 | 6.17 |

```
let
    data = (N = size(hdivotes2, 1),
    rank_income = collect(1:size(hdivotes2,
    1)), rank_hdi = hdivotes2.rank_hdi)
    global m2_1s = SampleModel("hdi",
    stan2_1)
    global rc2_1s = stan_sample(m2_1s; data)
    success(rc2_1s) && describe(m2_1s,
    [:lp__, :a, :b, :sigma])
end
```

```
/var/folders/l7/pr04h0650q5dvqttnvs8s2c00000gn/T
```

| | parameters | median | mad_sd | mean | st |
|---|---|---|---|---|---|
| 1 | "a" | 3.087 | 1.881 | 3.079 | 1.88 |
| 2 | "b" | 0.874 | 0.064 | 0.874 | 0.06 |
| 3 | "sigma" | 7.13 | 0.717 | 7.194 | 0.70 |

```
if success(rc2_1s)
    post2_1s_df = read_samples(m2_1s,
    :dataframe)
    ms2_1s = model_summary(post2_1s_df,
    [:a, :b, :sigma])
end
```




```
let
    ā, b̄, σ = ms2_1s[:, :median]
    f = Figure()
    ax = Axis(f[1, 1]; title = "HDI ~
    income",
        xlabel = "Average state income in
        2000",
        ylabel = "Human Development Index")
    for i in 1:size(hdivotes, 1)
        if length(hdivotes.abbr[i]) > 0
            annotations!(hdivotes.abbr[i],
                position =
                (hdivotes.income[i],
                hdivotes.hdi[i]),
                textsize = 10)
        end
    end
    ax = Axis(f[1, 2]; title = "Ranked HDI
    ~ ranked income",
        xlabel = "Rank of average state
        income in 2000",
        ylabel = "Rank of Human Development
        Index")
    for i in 1:size(hdivotes2, 1)
        if length(hdivotes2.abbr[i]) > 0
            annotations!(hdivotes2.abbr[i],
                position = (i,
                hdivotes2.rank_hdi[i]),
                textsize = 10)
        end
    end
    x = 0:52
    lines!(x, ā .+ b̄ .* x; color=:red)
    f
end
```

# 2.2 Validity and reliability.

| | survey | regicert |
|---|---|---|
| 1 | "june08voter" | "absolutely certain" |
| 2 | "aug08relig" | "absolutely certain" |
| 3 | "aug08relig" | "absolutely certain" |
| 4 | "aug08relig" | "absolutely certain" |
| 5 | "june08voter" | "absolutely certain" |
| 6 | "july08poli-econ" | "absolutely certain" |
| 7 | "june08voter" | "absolutely certain" |
| 8 | "aug08relig" | "absolutely certain" |
| 9 | "june08voter" | "absolutely certain" |
| 10 | "july08poli-econ" | "absolutely certain" |
| ⋮ | more | |
| 31201 | "sept08forpoli" | "absolutely certain" |

```
begin
    pew_pre_raw =
    CSV.read(ros_datadir("Pew", "pew.csv"),
    DataFrame; missingstring="NA",
    pool=false)
    pew_pre = pew_pre_raw[:, [:survey,
    :regicert,  :party, :state, :heat2,
    :heat4, :income2, :party4, :date,
        :weight, :voter_weight2, :pid,
        :ideology, :inc]]
end
```

```
pid_incprob =
```

| | Column1 | V1 | V2 | V3 | |
|---|---|---|---|---|---|
| 1 | 1 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2 | 2 | 0.434068 | 0.410585 | 0.40081 | 0.3 |
| 3 | 3 | 0.583262 | 0.54593 | 0.51899 | 0.5 |
| 4 | 4 | 0.780714 | 0.717176 | 0.67472 | 0.6 |
| 5 | 5 | 0.849178 | 0.818929 | 0.778284 | 0.7 |
| 6 | 6 | 1.0 | 1.0 | 1.0 | 1.0 |

```
pid_incprob = CSV.read(ros_datadir("Pew",
"pid_incprop.csv"), DataFrame;
missingstring="NA", pool=false)
```

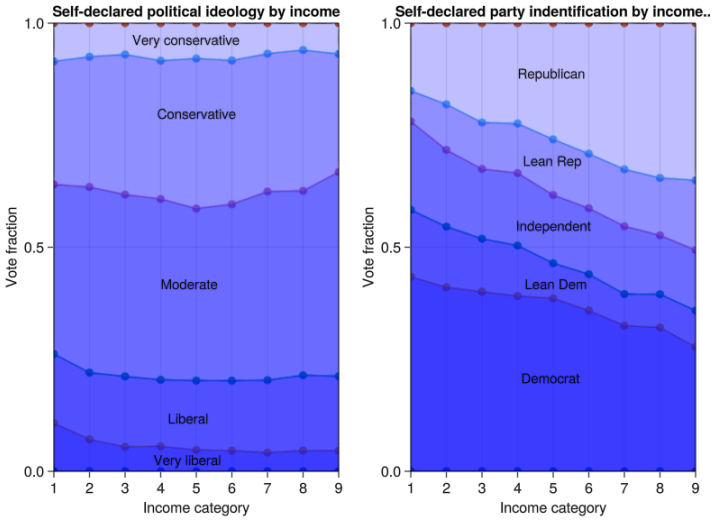
```
ideo_incprob =
```

| | Column1 | V1 | V2 | V3 | |
|---|---|---|---|---|---|
| 1 | 1 | 0.0 | 0.0 | 0.0 | 0 |
| 2 | 2 | 0.10736 | 0.0713431 | 0.0545858 | 0 |
| 3 | 3 | 0.261838 | 0.220291 | 0.211839 | 0 |
| 4 | 4 | 0.640184 | 0.634329 | 0.617531 | 0 |
| 5 | 5 | 0.914783 | 0.925208 | 0.930161 | 0 |
| 6 | 6 | 1.0 | 1.0 | 1.0 | 1 |

```
ideo_incprob = CSV.read(ros_datadir("Pew",
"ideo_incprop.csv"), DataFrame;
missingstring="NA", pool=false)
```

```
3×3 Matrix{Float64}:
 0.00984338  0.00647884  0.00217881
 0.00367166  0.0158111   0.00531952
 0.00075453  0.00769068  0.0152036
```

```
begin
    party_incprob_df =
    CSV.read(ros_datadir("Pew",
    "party_incprop.csv"), DataFrame;
    missingstring="NA", pool=false)
    party_incprob =
    reshape(Array(party_incprob_df)[:,
    2:end], :, 3, 9)
    party_incprob[:, :, 9]
end
```




```
let
    x1 = 1.0:1.0:9.0
    f = Figure()
    ax = Axis(f[1, 1], title = "Self-
    declared political ideology by income",
        xlabel = "Income category", ylabel
        = "Vote fraction")
    limits!(ax, 1, 9, 0, 1)
    for i in 1:6
        sca1 = scatter!(x1,
        Array(ideo_incprob[i, 2:end]))
        lin = lines!(x1,
        Array(ideo_incprob[i, 2:end]))
        band!(x1, fill(0, length(x1)),
        Array(ideo_incprob[i, 2:end]);
            color = (:blue, 0.25), label =
            "Label")
    end
    annotations!("Very conservative",
    position = (3.2, 0.945), textsize=15)
    annotations!("Conservative", position =
    (3.9, 0.78), textsize=15)
    annotations!("Moderate", position =
    (4.0, 0.4), textsize=15)
    annotations!("Liberal", position =
    (4.2, 0.1), textsize=15)
    annotations!("Very liberal", position =
    (3.8, 0.0075), textsize=15)
    ax = Axis(f[1, 2], title = "Self-
    declared party indentification by
    income..",
        xlabel = "Income category", ylabel
        = "Vote fraction")
    limits!(ax, 1, 9, 0, 1)
    for i in 1:6
```

```
            sca1 = scatter!(x1,
            Array(pid_incprob[i, 2:end]))
            lin = lines!(x1,
            Array(pid_incprob[i, 2:end]))
            band!(x1, fill(0, length(x1)),
            Array(pid_incprob[i, 2:end]);
                color = (:blue, 0.25), label =
                "Label")
        end
        annotations!("Republican", position =
        (4.0, 0.87), textsize=15)
        annotations!("Lean Rep", position =
        (4.15, 0.675), textsize=15)
        annotations!("Independent", position =
        (3.95, 0.53), textsize=15)
        annotations!("Lean Dem", position =
        (4.2, 0.4), textsize=15)
        annotations!("Democrat", position =
        (4.1, 0.19), textsize=15)
        current_figure()
    end
```

## 2.3 All graphs are comparisons.

health =

| | country | spending | lifespan |
|---|---|---|---|
| 1 | "Australia" | 3357 | 81.4 |
| 2 | "Austria" | 3763 | 80.1 |
| 3 | "Belgium" | 3595 | 79.8 |
| 4 | "Canada" | 3895 | 80.7 |
| 5 | "Czech" | 1626 | 77.0 |
| 6 | "Denmark" | 3512 | 78.4 |
| 7 | "Finland" | 2840 | 79.5 |
| 8 | "France" | 3601 | 81.0 |
| 9 | "Germany" | 3588 | 80.0 |
| 10 | "Greece" | 2727 | 79.6 |
| ⋮ | more | | |
| 30 | "USA" | 7290 | 78.1 |

```
health = CSV.read(ros_datadir("HealthExpenditure", "healthdata.csv"), DataFrame; missingstring="NA", pool=false)
```

```
expm = StatsModels.TableRegressionModel{LinearModel{GLM.
```

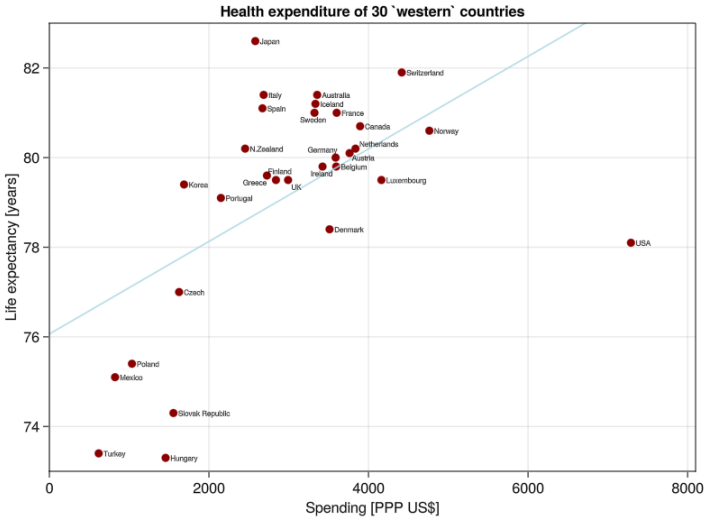
```
lifespan ~ 1 + spending

Coefficients:
```

| | Coef. | Std. Error | t | Pr(> |
|---|---|---|---|---|
| (Intercept) | 76.0642 | 0.95546 | 79.61 | <1 |
| spending | 0.00103241 | 0.00029198 | 3.54 | 0. |

```
expm = lm(@formula(lifespan ~ spending), health)
```

▸ [76.0642, 0.00103241]

```
â, b̂ = coef(expm)
```




```
let
    x = 0:8000
    f = Figure()
    ax = Axis(f[1, 1], title = "Health
    expenditure of 30 `western` countries",
        xlabel = "Spending [PPP US\$]",
        ylabel = "Life expectancy [years]")
    limits!(ax, 0, 8100, 73, 83)
    sca = scatter!(health.spending,
    health.lifespan; color=:darkred)
    lin = lines!(x, â .+ b̂ * x;
    color=:lightblue)
    for i in 1:nrow(health)
        if health.country[i] == "UK"
            annotations!(health.country[i],
            position =
            (health.spending[i]+40,
            health.lifespan[i]-0.25),
            textsize=8)
        elseif health.country[i] ==
        "Finland"
            annotations!(health.country[i],
            position =
            (health.spending[i]-100,
            health.lifespan[i]+0.1),
            textsize=8)
        elseif health.country[i] == "Greece"
            annotations!(health.country[i],
            position =
            (health.spending[i]-300,
            health.lifespan[i]-0.25),
            textsize=8)
        elseif health.country[i] == "Sweden"
            annotations!(health.country[i],
            position =
            (health.spending[i]-180,
```

```
            health.lifespan[i]-0.25),
            textsize=8)
        elseif health.country[i] ==
        "Ireland"
            annotations!(health.country[i],
            position =
            (health.spending[i]-150,
            health.lifespan[i]-0.25),
            textsize=8)
        elseif health.country[i] ==
        "Netherlands"
            annotations!(health.country[i],
            position =
            (health.spending[i]+50,
            health.lifespan[i]+0.01),
            textsize=8)
        elseif health.country[i] ==
        "Germany"
            annotations!(health.country[i],
            position =
            (health.spending[i]-350,
            health.lifespan[i]+0.08),
            textsize=8)
        elseif health.country[i] ==
        "Austria"
            annotations!(health.country[i],
            position =
            (health.spending[i]+30,
            health.lifespan[i]-0.2),
            textsize=8)
        else
            annotations!(health.country[i],
            position =
            (health.spending[i]+60,
            health.lifespan[i]-0.1),
            textsize=8)
        end
    end
    current_figure()
end
```

## Names example.

```
cleannames =
```

| | X | name | sex | X1880 | X1 |
|---|---|---|---|---|---|
| **1** | 1 | "Mary" | "F" | 7065 | 69 |
| **2** | 2 | "Anna" | "F" | 2604 | 26 |
| **3** | 3 | "Emma" | "F" | 2003 | 20 |
| **4** | 4 | "Elizabeth" | "F" | 1939 | 18 |
| **5** | 5 | "Minnie" | "F" | 1746 | 16 |
| **6** | 6 | "Margaret" | "F" | 1578 | 16 |
| **7** | 7 | "Ida" | "F" | 1472 | 14 |
| **8** | 8 | "Alice" | "F" | 1414 | 13 |
| **9** | 9 | "Bertha" | "F" | 1320 | 13 |
| **10** | 10 | "Sarah" | "F" | 1288 | 12 |
| ⋮ more | | | | | |
| **98012** | 98148 | "Zzyzx" | "M" | 0 | 0 |

```
cleannames = CSV.read(ros_datadir("Names", "allnames_clean.csv"), DataFrame)
```

```
(98012, 134)
```

```
size(cleannames)
```

```
["X", "name", "sex", "X1880", "X1881", "X1882",
```

```
names(cleannames)
```

```
df =
```

| | name | sex | X1906 | X1956 | X20 |
|---|---|---|---|---|---|
| 1 | "John" | "M" | 8263 | 80735 | 1514 |
| 2 | "William" | "M" | 6567 | 58927 | 1891 |
| 3 | "James" | "M" | 5908 | 84840 | 1621 |
| 4 | "Charles" | "M" | 3607 | 35198 | 7999 |
| 5 | "George" | "M" | 4201 | 17228 | 2699 |
| 6 | "Frank" | "M" | 2798 | 11126 | 1399 |
| 7 | "Joseph" | "M" | 3527 | 32706 | 1839 |
| 8 | "Thomas" | "M" | 2177 | 44785 | 9493 |
| 9 | "Henry" | "M" | 2111 | 5951 | 4661 |
| 10 | "Robert" | "M" | 3636 | 83869 | 9874 |
| ⋮ | more | | | | |
| 36659 | "Zzyzx" | "M" | 0 | 0 | 0 |

```
df = cleannames[cleannames.sex .== "M",
["name", "sex", "X1906", "X1956", "X2006"]]
```

```
letters = 'a':'z';
```

```
count_letters (generic function with 1 method)
```

```
function count_letters(df::DataFrame,
years::Vector{String})
    letter_counts = DataFrame()
    for year in Symbol.(years)

        !(year in Symbol.(names(df))) &&
        begin
            @warn "The year $(year) is not
            present in df."
            continue
        end

        tmpdf = df[:, [:name, year]]

        yrcounts = zeros(Int,
        length(letters))
        for (ind, letter) in
        enumerate(letters)
            yrcounts[ind] = sum(filter(row -
            > row.name[end] == letter,
            tmpdf)[:, 2])
        end
        letter_counts[!, year] = 100 *
        yrcounts / sum(yrcounts)
    end
    letter_counts
end
```

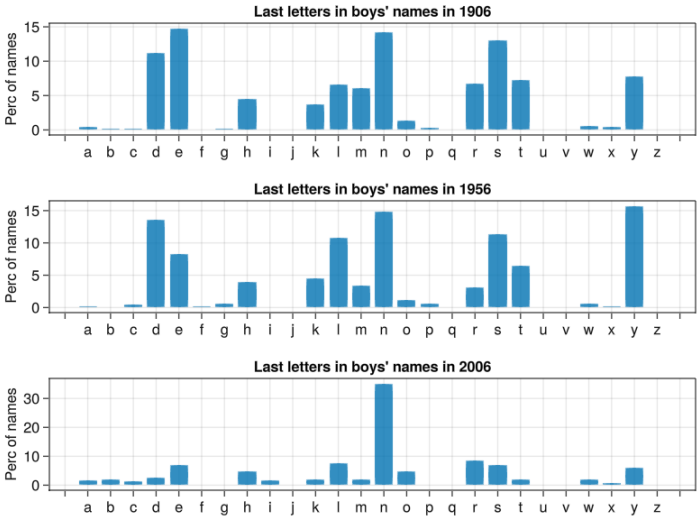
```
letter_count =
```

| | X1906 | X1956 | X2006 |
|---|---|---|---|
| 1 | 0.473516 | 0.201557 | 1.76002 |
| 2 | 0.208106 | 0.0938356 | 2.07864 |
| 3 | 0.237512 | 0.466714 | 1.29964 |
| 4 | 11.2287 | 13.5269 | 2.50852 |
| 5 | 14.7936 | 8.31948 | 6.97453 |
| 6 | 0.104807 | 0.13137 | 0.0960275 |
| 7 | 0.200566 | 0.562255 | 0.0941245 |
| 8 | 4.5082 | 3.9746 | 4.79937 |
| 9 | 0.0806786 | 0.054927 | 1.63744 |
| 10 | 0.0 | 0.0 | 0.0605539 |
| ⋮ | more | | |
| 26 | 0.0180961 | 0.0176297 | 0.15058 |

```
letter_count = count_letters(df, ["X1906", "X1956", "X2006"])
```

```
[100.0, 100.0, 100.0]
```

```
sum.(eachcol(letter_count))
```




```
let
    f = Figure()
    for (ind, year) in enumerate(["X1906",
    "X1956", "X2006"])
        ax = Axis(f[ind, 1], title="Last
        letters in boys' names in
        $(year[2:end])",
            ylabel="Perc of names")
        ax.xticks = (0:27, vcat(" ", string.
        (letters), " "))
        barplot!(f[ind, 1], 1:26,
        letter_count[:, Symbol(year)],
        width=0.8, gap=0.01)
    end
    f
end
```

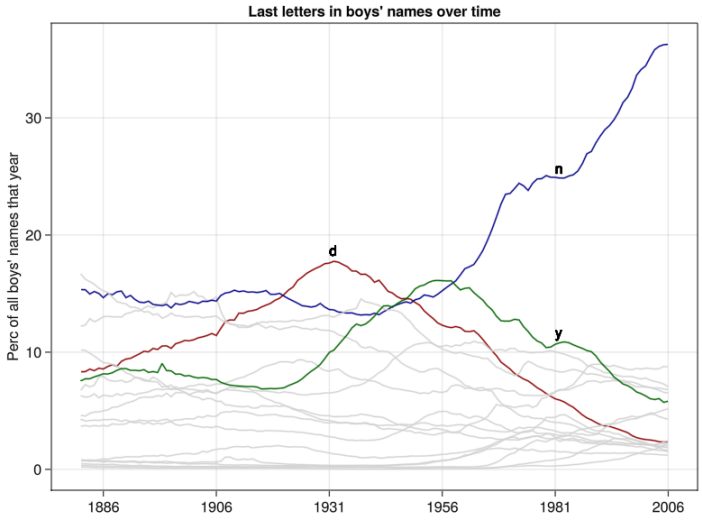
```
all_letter_count =
```

| | X1880 | X1881 | X1882 | X1883 |
|---|---|---|---|---|
| 1 | 0.683795 | 0.738044 | 0.675187 | 0.703254 |
| 2 | 0.461607 | 0.467494 | 0.446011 | 0.433066 |
| 3 | 0.316504 | 0.329235 | 0.307625 | 0.286475 |
| 4 | 8.32253 | 8.34229 | 8.55178 | 8.42755 |
| 5 | 12.2122 | 12.3229 | 12.855 | 12.602 |
| 6 | 0.0979441 | 0.0825575 | 0.118995 | 0.10156 |
| 7 | 0.133313 | 0.145222 | 0.128691 | 0.129345 |
| 8 | 3.66383 | 3.74095 | 3.66858 | 3.74142 |
| 9 | 0.181378 | 0.204902 | 0.182459 | 0.160005 |
| 10 | 0.0 | 0.0 | 0.0 | 0.0 |
| ⋮ | more | | | |
| 26 | 0.0262998 | 0.00795735 | 0.0273248 | 0.011497 |

```
all_letter_count = count_letters(cleannames[cleannames.sex .== "M", :], names(cleannames[:, vcat(4:end)]))
```

```
[0.473516, 0.208106, 0.237512, 11.2287, 14.7936,
```

```
all_letter_count[:, "X1906"]
```




```
let
    f = Figure()
    ax = Axis(f[1, 1], title="Last letters
    in boys' names over time",
        ylabel="Perc of all boys' names
        that year")
    ax.xticks = (6:25:131, ["1886", "1906",
    "1931", "1956", "1981", "2006"])

    for l in 1:length(letters)
        col = :lightgrey
        if letters[l] == 'n'
            col = :darkblue
        elseif letters[l] == 'd'
            col = :darkred
        elseif letters[l] == 'y'
            col = :darkgreen
        end
        if maximum(Array(all_letter_count)
        [l,:]) > 1
            lines!(1:size(all_letter_count,
            2), Array(all_letter_count)
            [l,:], color=col)
        end
        annotations!("n", position = (106,
        25), textsize=15)
        annotations!("d", position = (56,
        18), textsize=15)
        annotations!("y", position = (106,
        11), textsize=15)

    end
    current_figure()
end
```

## 2.4 Data and adjustment.

**Not yet done.**