# See chapter 5 in Regression and Other Stories.

**Widen the notebook.**

```
# ed172871-fa4d-4111-ac0a-341898917948
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 ✓
    using PlutoUI ✓

    # Specific to ROSTuringPluto
    using Optim ✓
    using Logging ✓
    using Turing ✓

    # Graphics related
    using GLMakie ✓

    # Common data files and functions
    using RegressionAndOtherStories ✓
    import RegressionAndOtherStories: link

    Logging.disable_logging(Logging.Warn)
end;
```

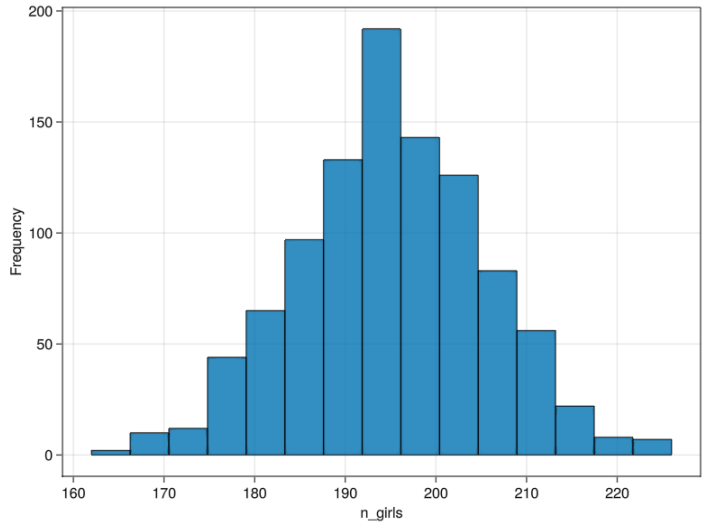
```
Replacing docs for `RegressionAndOtherStories.tr
DataFrame, AbstractString}` in module `Regressio
```

# 5.1 Simulations of discrete events.

```
@bind nsim PlutoUI.Slider(2:5, default=3)
```

```
3
```

```
nsim
```




```
let
    f = Figure()
    ax = Axis(f[1, 1]; xlabel="n_girls",
    ylabel="Frequency")
    n_girls = rand(Binomial(400, 0.488),
    10^nsim)
    hist!(n_girls; strokewidth = 1,
    strokecolor = :black)
    f
end
```

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

```
function prob_girls(bt)
    res = if bt == :single_birth
        rand(Binomial(1, 0.488), 1)
    elseif bt == :fraternal_twin
        2rand(Binomial(1, 0.495), 1)
    else
        rand(Binomial(2, 0.495), 1)
    end
    return res[1]
end
```

```
girls (generic function with 2 methods)
```

```
function girls(no_of_births = 400;
        birth_types = [:fraternal_twin,
        :identical_twin, :single_birth],
        probabilities = [1/125, 1/300, 1 -
        1/125 - 1/300])

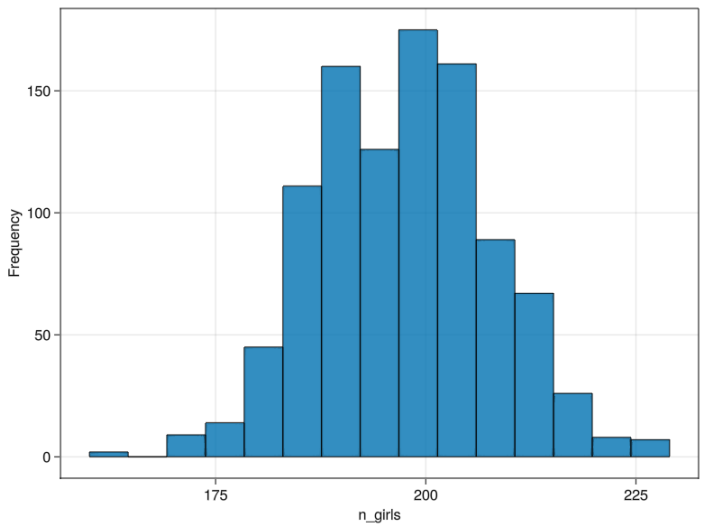
    return prob_girls.(sample(birth_types,
    Weights(probabilities), no_of_births))
end
```

```
▸ [1, 1, 1, 1, 1, 0, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, (
```

```
girls()
```

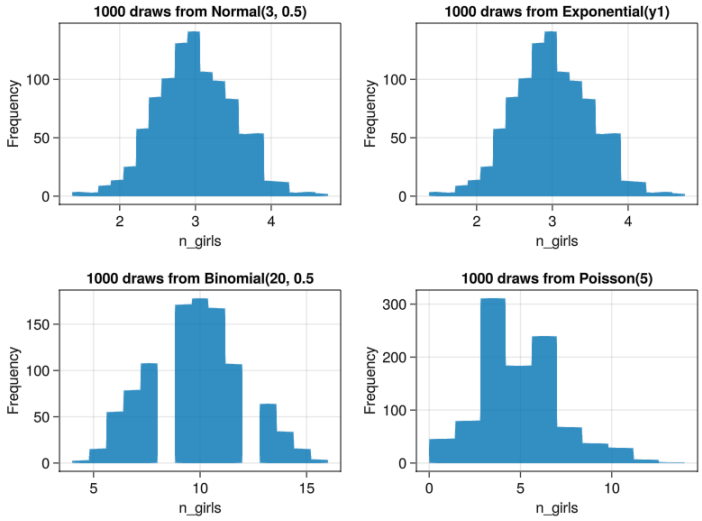
```
216
```

```
sum(girls())
```




```
let
    #Random.seed!(1)
    f = Figure()
    ax = Axis(f[1, 1]; xlabel="n_girls",
    ylabel="Frequency")
    girls_sim = [sum(girls()) for i in
    1:1000]
    hist!(f[1, 1], girls_sim; strokewidth =
    1, strokecolor = :black, xlabel="Girls")
    f
end
```

# 5.2 Simulation of continuous and mixed/continuous models.




```
let
    n_sims = 1000
    y1 = rand(Normal(3, 0.5), n_sims)
    y2 = [Exponential(y1[i]).θ for i in
    1:length(y1)]
    y3 = rand(Binomial(20, 0.5), n_sims)
    y4 = rand(Poisson(5), n_sims)

    f = Figure()
    ax = Axis(f[1, 1]; title="1000 draws
    from Normal(3, 0.5)", xlabel="n_girls",
    ylabel="Frequency")
    hist!(y1; bins=20)
    ax = Axis(f[1, 2]; title="1000 draws
    from Exponential(y1)",
    xlabel="n_girls", ylabel="Frequency")
    hist!(y2; bins=20)

    ax = Axis(f[2, 1]; title="1000 draws
    from Binomial(20, 0.5",
    xlabel="n_girls", ylabel="Frequency")
    hist!(y3; bins=15)

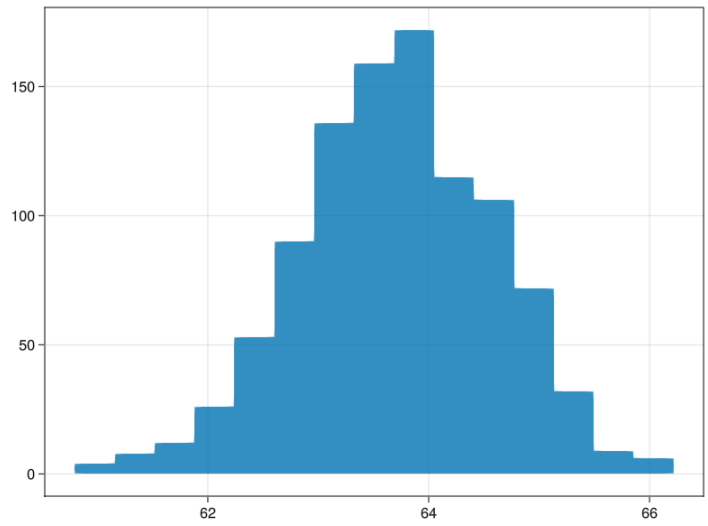
    ax = Axis(f[2, 2]; title="1000 draws
    from Poisson(5)", xlabel="n_girls",
    ylabel="Frequency")
    hist!(y4; bins=10)
    f
end
```

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

```
function sim()
    N = 10
    male = rand(Binomial(1, 0.48), N)
    height = male == 1 ? rand(Normal(69.1,
    2.9), N) : rand(Normal(63.7, 2.7), N)
    avg_height = mean(height)
end
```

```
61.9167859781684
```

```
sim()
```




```
let
    n_sim = 1000
    avg_height = Float64[]
    for i in 1:n_sim
        append!(avg_height, [sim()])
    end
    hist(avg_height)
end
```

## 5.3 Summarizing a set of simulations using median and median absolute deviation.

```
(mean = 4.96, median = 4.95, std = 2.0, mad = 2
```

```
let
    N = 10000
    z = rand(Normal(5, 2), N)
    vals = round.([mean(z), median(z),
    std(z), mad(z), 1.483 .* median(abs.(z
    .- median(z))), std(z)/sqrt(N)];
    digits=2)
    (mean=vals[1], median=vals[2],
    std=vals[3], mad=vals[4],
    mad_sd=vals[5], std_mean = vals[6])
end
```

**Standard deviation of the mean:**

```
[3.64673, 6.35273]
```

```
quantile(rand(Normal(5, 2), 10000), [0.25,
0.75])
```

# 5.4 Bootstrapping to simulate a sampling distribution.

```
earnings =
```

| | height | weight | male | earn | earnk |
|---|---|---|---|---|---|
| 1 | 74 | "210" | 1 | 50000.0 | 50.0 |
| 2 | 66 | "125" | 0 | 60000.0 | 60.0 |
| 3 | 64 | "126" | 0 | 30000.0 | 30.0 |
| 4 | 65 | "200" | 0 | 25000.0 | 25.0 |
| 5 | 63 | "110" | 0 | 50000.0 | 50.0 |
| 6 | 68 | "165" | 0 | 62000.0 | 62.0 |
| 7 | 63 | "190" | 0 | 51000.0 | 51.0 |
| 8 | 64 | "125" | 0 | 9000.0 | 9.0 |
| 9 | 62 | "200" | 0 | 29000.0 | 29.0 |
| 10 | 73 | "230" | 1 | 32000.0 | 32.0 |
| ⋮ more | | | | | |
| 1816 | 68 | "150" | 1 | 6000.0 | 6.0 |

```
earnings = CSV.read(ros_datadir("Earnings", "earnings.csv"), DataFrame)
```

```
ratio = 0.6
```

```
ratio = median(earnings[earnings.male .== 0, :earn]) /  median(earnings[earnings.male .== 1, :earn])
```

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

```
function take_df_sample(df, size; replace = true, ordered = true)
    df[sample(axes(df, 1), size; replace, ordered), :]
end
```

| | height | weight | male | earn | earnk | e |
|---|---|---|---|---|---|---|
| 1 | 70 | "200" | 1 | 25000.0 | 25.0 | " |
| 2 | 69 | "185" | 1 | 0.0 | 0.0 | " |
| 3 | 65 | "130" | 0 | 18000.0 | 18.0 | " |

```
take_df_sample(earnings, 3)
```

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

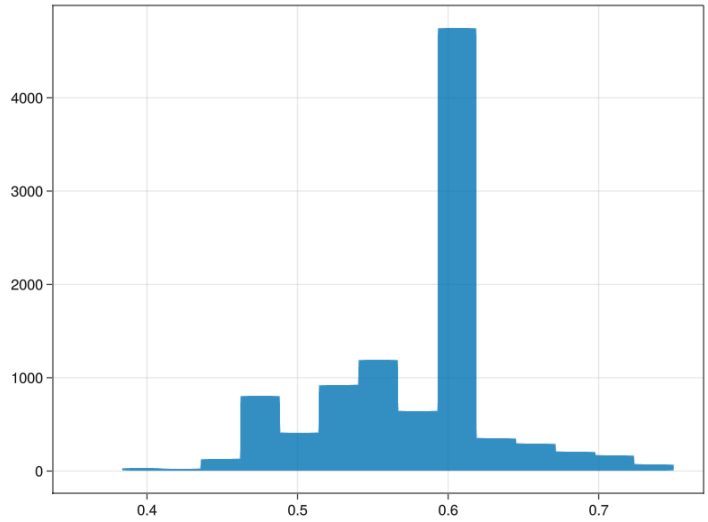
```
function boot_ratio(df::DataFrame,
sym::Symbol; draws=1000, replace=true)
    df = take_df_sample(df, draws; replace)
    ratio = median(df[df.male .== 0, sym])
    /  median(df[df.male .== 1, sym])
end
```

| | height | weight | male | earn | earnk |
|---|---|---|---|---|---|
| 1 | 71 | "140" | 1 | 35000.0 | 35.0 |
| 2 | 63 | "150" | 0 | 35000.0 | 35.0 |
| 3 | 68 | "116" | 0 | 45000.0 | 45.0 |
| 4 | 62 | "135" | 0 | 50000.0 | 50.0 |
| 5 | 61 | "110" | 0 | 25000.0 | 25.0 |
| 6 | 68 | "171" | 1 | 21000.0 | 21.0 |
| 7 | 63 | "115" | 0 | 96000.0 | 96.0 |
| 8 | 69 | "165" | 1 | 25000.0 | 25.0 |
| 9 | 73 | "175" | 1 | 45000.0 | 45.0 |
| 10 | 74 | "180" | 0 | 10000.0 | 10.0 |

```
take_df_sample(earnings, 10)
```

```
0.35714285714285715
```

```
boot_ratio(earnings, :earn; draws=5)
```




```
let
    n_sims = 10000
    global boot_output =
    [boot_ratio(earnings, :earn; draws=500)
    for _ in 1:n_sims]
    hist(boot_output)
end
```

```
▸ [0.6, 0.6, 0.58, 0.588235, 0.6, 0.56, 0.6, 0.6,
```

```
boot_output
```

```
0.05449066081503355
```

```
std(boot_output)
```

# 5.5 Fake-data simulations as a way of life.

**Not done yet.**

**Note**

Quick math notation test.

$$\begin{cases} x+y=7 \\ -x+3y=1 \end{cases}$$

```
md"""
```math
    \begin{cases}
      x+y=7\\
      -x+3y=1
    \end{cases}
```
"""
```