

# Causal Inference Demo

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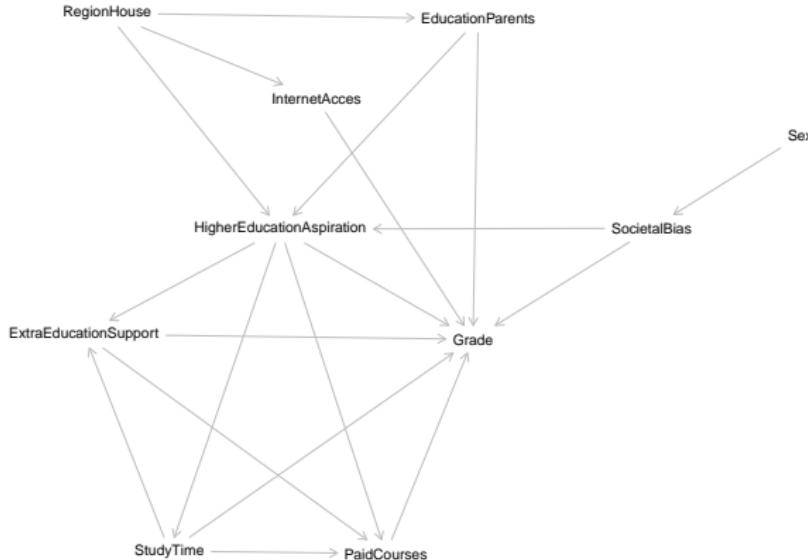
# What are we going to see

- Defining the problem
- DAG
- Simulating the data
- Can we use BRMS to retrieve the parameters
- **Real World Data...**
- Is our dag valid?
- Results

## Defining the Problem

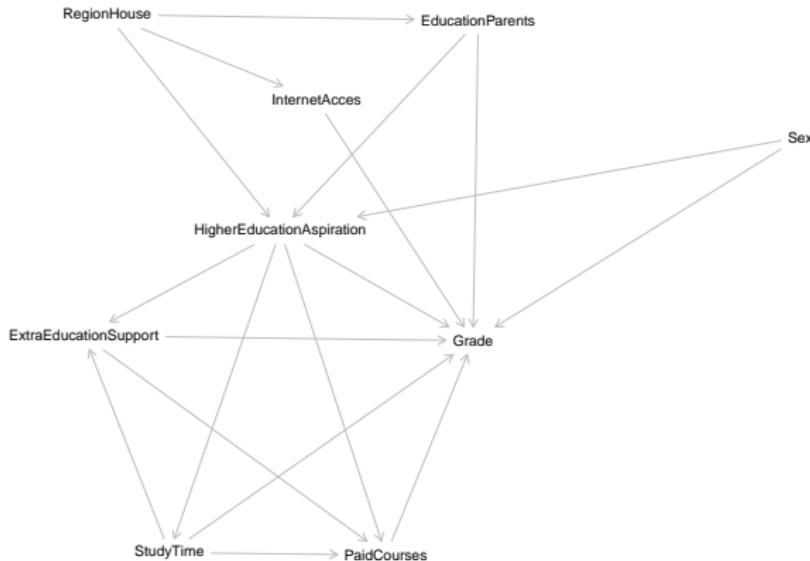
- Mathematics is one of THE fundamental school subjects...
- ... yet, it is stereotypically seen as boring and difficult.
- In this demo we explore what influences school performance in Math
- ... and possible intervention paths we could use.
- As outcome variable we take the end of year grade in Mathematics for high school students.

# DAG - The Full Causal Pentagram



The unmeasured variable SocietalBias explains how the student's Sex effects Grade and HigherEducationAspiration. However, since Sex is only a 'Mechanism', we can remove it from the DAG and simplify it.

# DAG - The (slightly simplified) Causal Pentagram



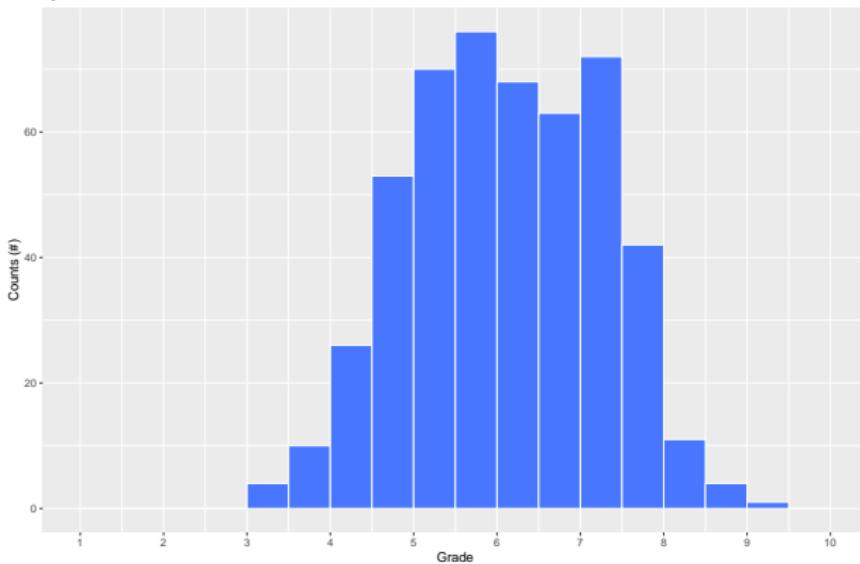
This DAG is slightly simpler, but the 'Causal Pentagram' looks like it might cause problems. Time to find out!

## Simulate data

### Simulated grades distribution

Distribution of 500 Simulated Math Grades

By Alex

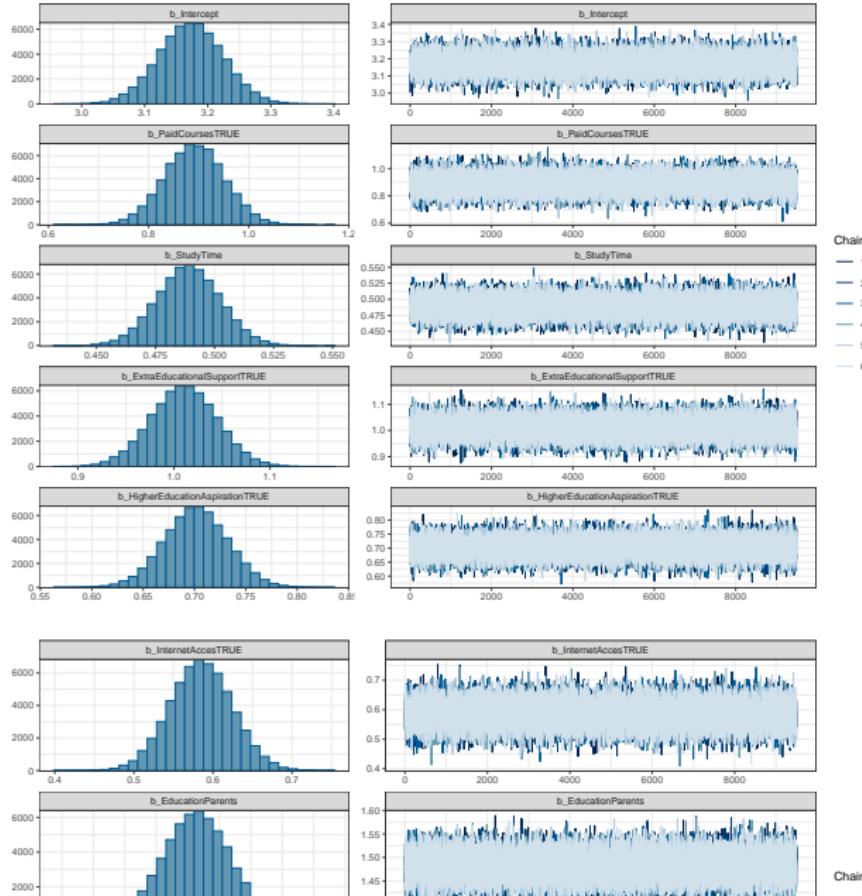


In our simulation, Most students score between a 5.5 and a 6. This seems reasonable. Also, very high scores are rare, as well as extremely low scores. The distribution is roughly normal, but not quite.

## Retrieve these direct effects using BRMS

```
## Running MCMC with 6 parallel chains...
##
## Chain 3 finished in 4.6 seconds.
## Chain 1 finished in 5.1 seconds.
## Chain 4 finished in 4.9 seconds.
## Chain 2 finished in 6.6 seconds.
## Chain 6 finished in 7.0 seconds.
## Chain 5 finished in 8.6 seconds.
##
## All 6 chains finished successfully.
## Mean chain execution time: 6.1 seconds.
## Total execution time: 9.2 seconds.
```

# Checking our posterior and chains!

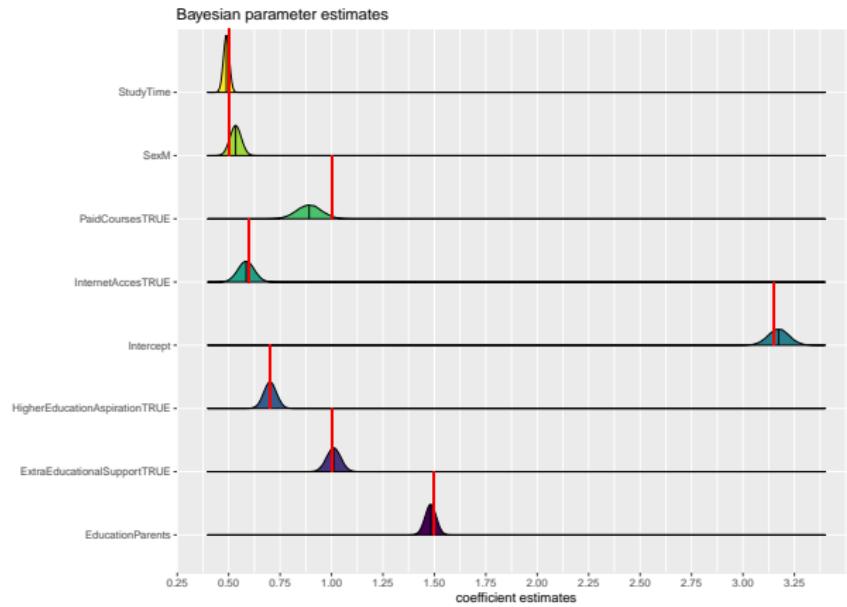


Chain

— 1  
— 2  
— 3  
— 4  
— 5  
— 6

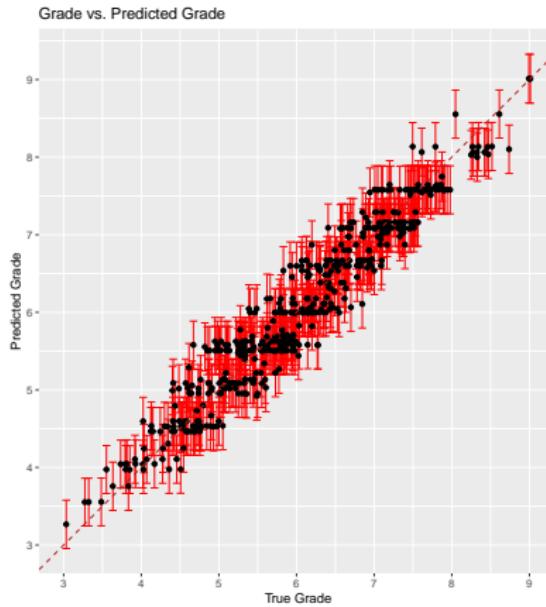
Chain

# Bayesian Parameter Estimates



Almost all Parameter values are perfectly retrieved! PaidCourses is slightly underestimated, And Sex is slightly overestimated. But these results are very promising

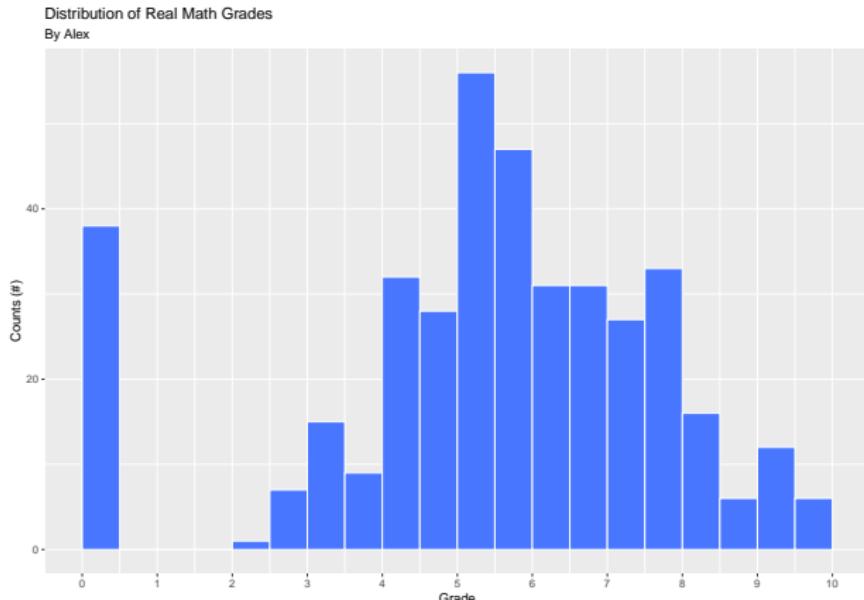
# How does the model perform in terms of predictions?



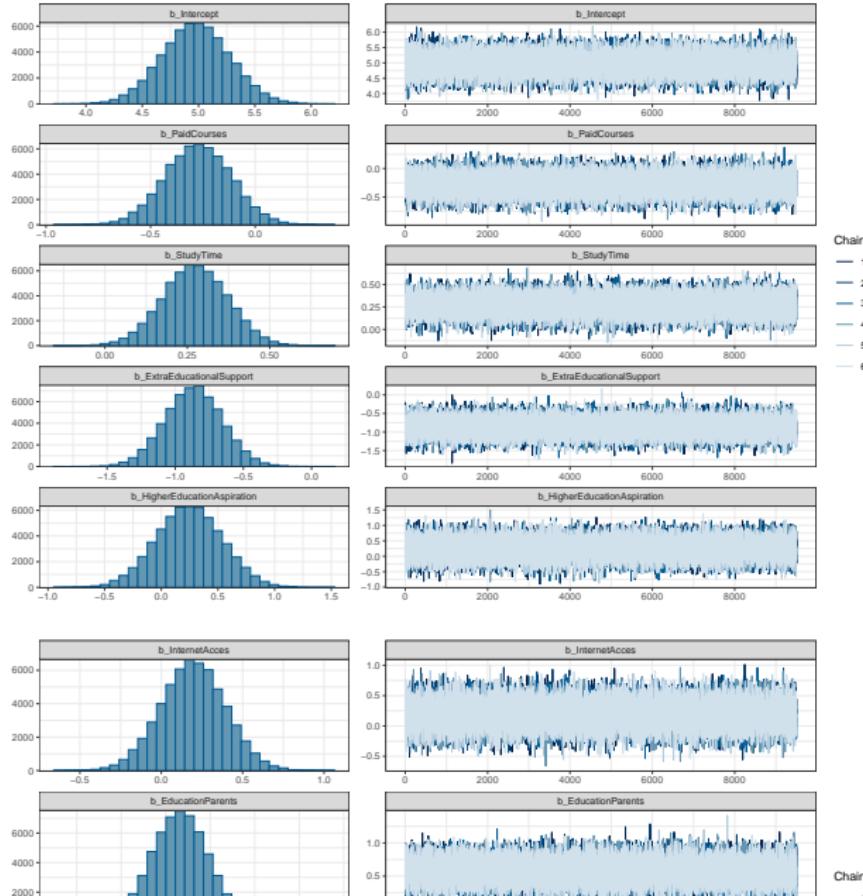
- This looks good! Most estimates overlap the true value within 1 sigma deviation.
- Estimates seem consistent across the whole domain

## Time for real data

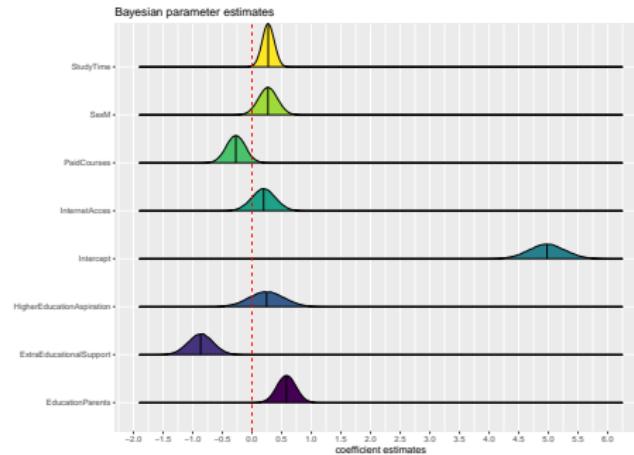
- We'll use <https://www.kaggle.com/dipam7/student-grade-prediction>
- This dataset contains portugese data on Math grades of 395 students
- Collected from 2 schools using Questionnaires and the schools grading Administration



# Checking our posterior and chains!

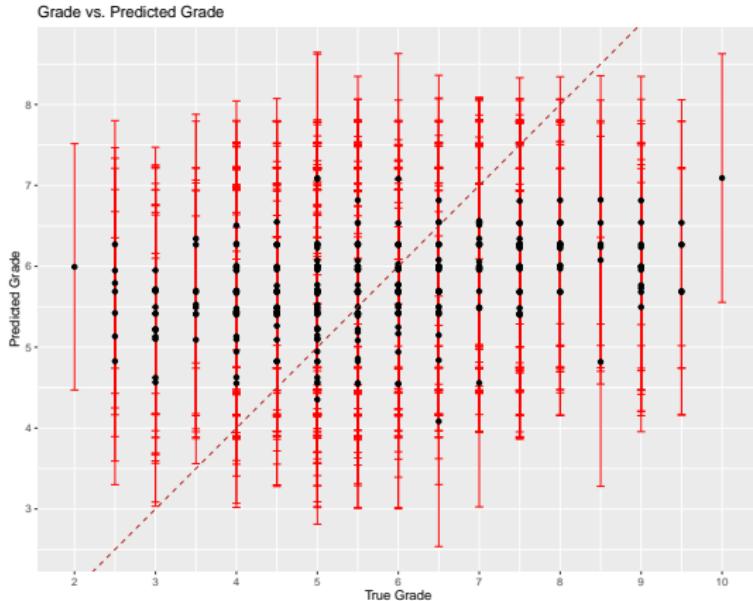


# Bayesian Parameter Estimates on the real data



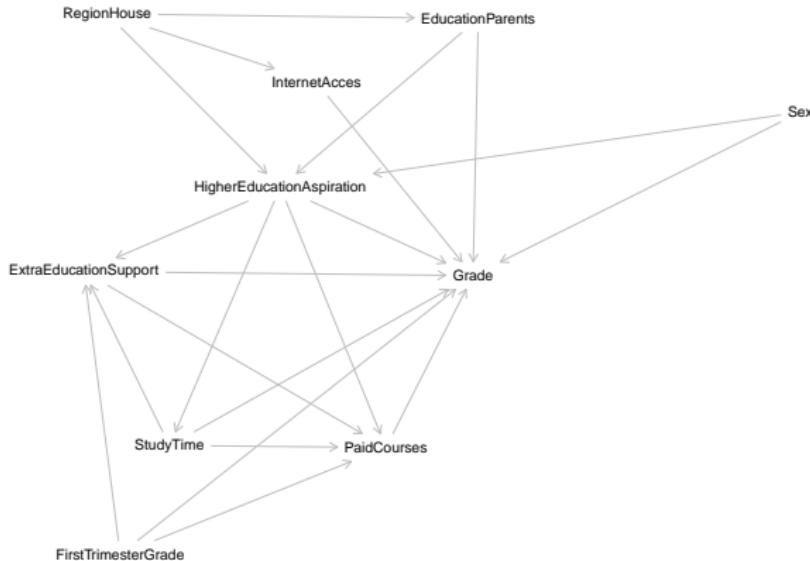
- Most parameters appear to have some effect
- InternetAcces, HigherEducationAspiration and PaidCourses are questionable
- The effect of ExtraEducationalSupport and PaidCourses is negative Hypothesis: Only 'problematic' students receive this support, Biassing the inference

# How does the model do, predicting on the real data?



- Hmm, our model has very little predictive power, let's update the DAG

## Updated DAG



- When we don't include FirstTrimesterGrade, its influence flows via ExtraEducationSupport and PaidCourses.

```
## Running MCMC with 6 parallel chains...
##
## Chain 1 finished in 4.9 seconds.
```