



Workshop 1. Linear Regression, Hypothesis Testing & Papers

UNAM – FE Econometrics I

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What is a **variable**?

A variable is a **characteristic** that can be **measured** and can assume **different values**.

Height, age, income, province or country of birth, grades obtained at school and type of housing are all examples of variables.



Variables

Variables may be classified into **two** main **categories**

Variables

Categorical

A categorical variable (also called qualitative variable) refers to a characteristic that **cannot** be quantifiable.

Nominal

A nominal variable is one that **describes** a name, label or category **without** natural order.

Ordinal

An ordinal variable is a variable whose values are **defined by an order** relation between the different categories.

Numeric

A numeric variable (also called quantitative variable) is a **quantifiable characteristic** whose values are numbers

Continuous

A discrete variable can assume only a **finite number** of real values within a given interval.

Discrete

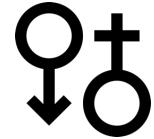
A variable is said to be continuous if it can assume **an infinite number** of real values within a given interval.

Variables

Numeric



Categorical



Variables

Nominal

Men, women
Green, Red, Blue

Ordinal

Small, Medium, Large
A, B, C (Grades)

Continuous

1, 2, 3
26 students

Discrete

Age
Weight

But really...what is **econometrics**?

What is **econometrics**?

“[Econometrics]... is the unification of statistics, economic theory and mathematics.”

-Ragnar Frisch

“Econometrics is based upon the development of statistical methods for estimating economic relationships, testing economic theories, and evaluating and implementing government and business policy.”

-Jeffrey Wooldridge

“[Econometrics is the]...social science in which the tools of economic theory mathematics, and statistical inference are applied to the analysis of economic phenomena”

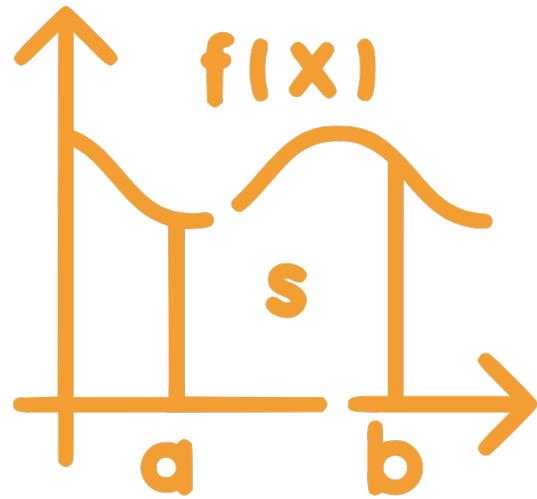
-Arthur Golberger

What is **econometrics** about?

It is about the application of...



Economics theory



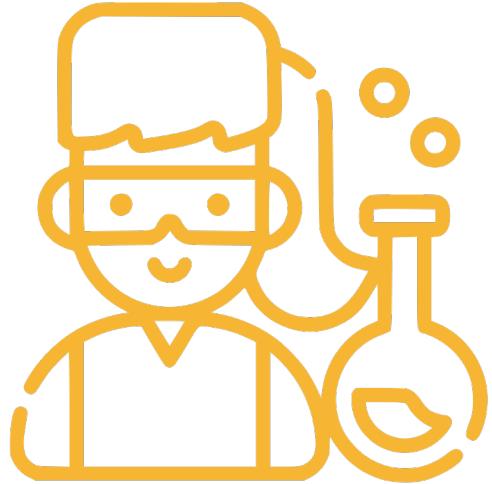
Maths



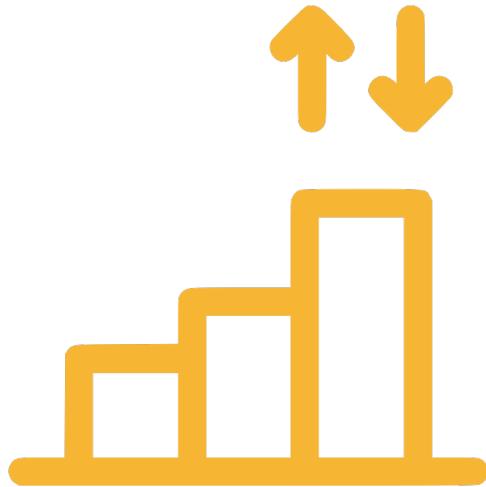
Statistical
techniques

What is **econometrics** for?

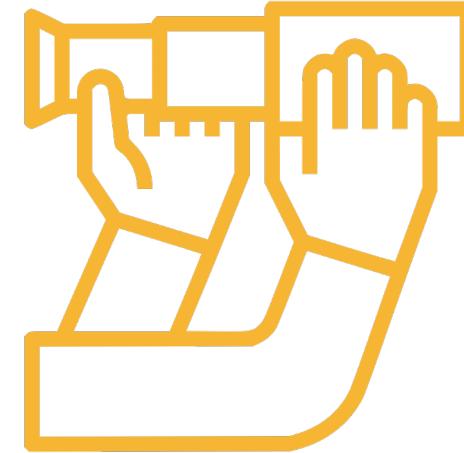
Three main **functions**



To **test** theories
or hypothesis



To **estimate**



To **forecast**

Method of **econometrics**

Researching stages

3

MAIN
STAGES

Method of **econometrics**

Researching stages



Method of econometrics

1

Theoretical foundation

Establish economic theory

Demand theory

The quantity demanded of a product Y
is a function that depends on

P_i = Price per unit of good X

I_i = Consumers' Income

S_i = Price of another good

Method of econometrics

1

Theoretical foundation

State equation

Explicit or linear

$$y = b_0 + b_1 P_i + b_1 I_i + b_1 S_i$$

Stochastic

$$y = b_0 + b_1 P_i + b_1 I_i + b_1 S_i + u$$

2

Data collection - modelling

Data for dependent and independents variables



2

Data collection - modelling

Empirical estimation

Logistic regression

Linear regression

Polynomial regression

Multivariate regression

Non-linear regression

Robust regression

Method of **econometrics**

2

Data collection - modelling

Choose Methodology

Least Squares

Maximum likelihood

Two stages Least Squares

Weighted Least Square

2

Data collection - modelling

Choose
Language/Software



Method of econometrics

3

Evaluation

A priori economic criteria

Sign and seize of
parameters

Here you either



reject



accept

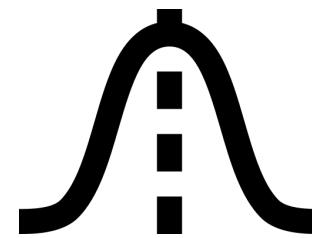
the model

Method of econometrics

3

Evaluation

Statistical criteria



The dispersion of every estimated coefficient around the parameter must be close enough to create confidence on estimation

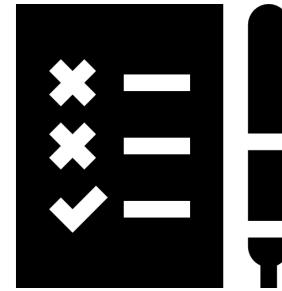
Method of **econometrics**

3

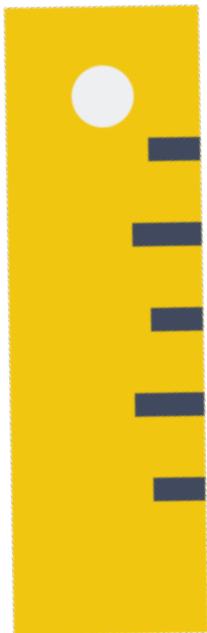
Evaluation

Econometrical criteria

We as econometricians
love tests, they indicate us
if the **assumptions** under
the model are **satisfied**



What's a **mathematical** model



$$y = \frac{\text{cm. growth per day}}{\text{Days I want to know}}$$

What's is a **mathematical** model

Plant 1		
	Width	Height
Day 1	0.3	1.4
Day 2	0.4	1.4
Day 3	0.6	15

Plant 2		
	Width	Height
Day 1	0.4	1.2
Day 2	0.5	1.3
Day 3	0.5	13

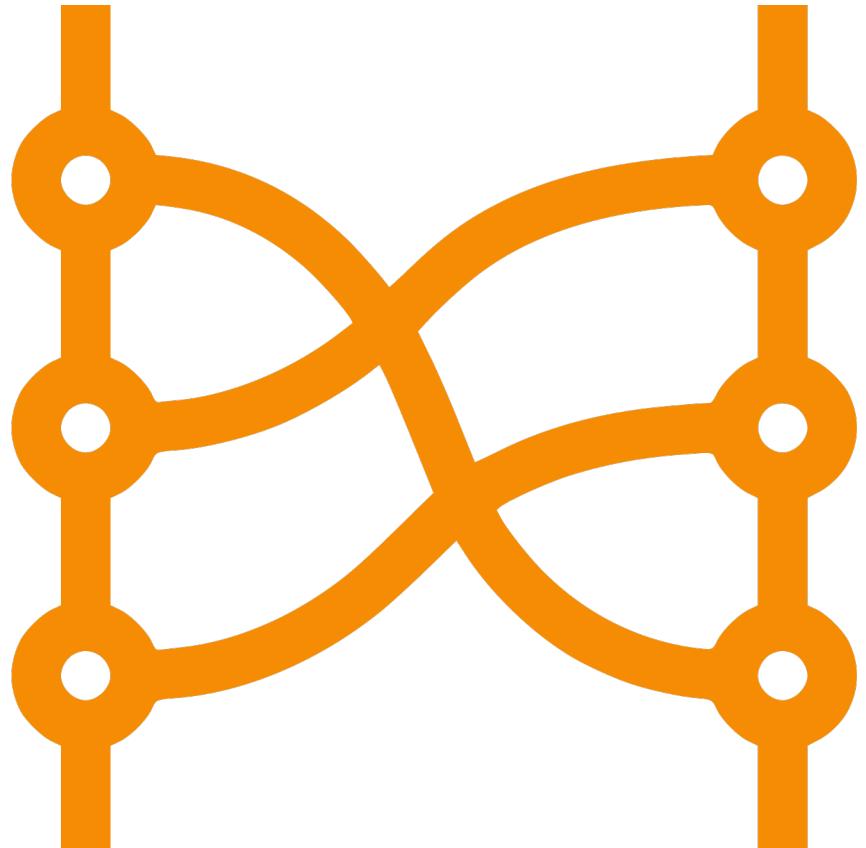


Mathematics



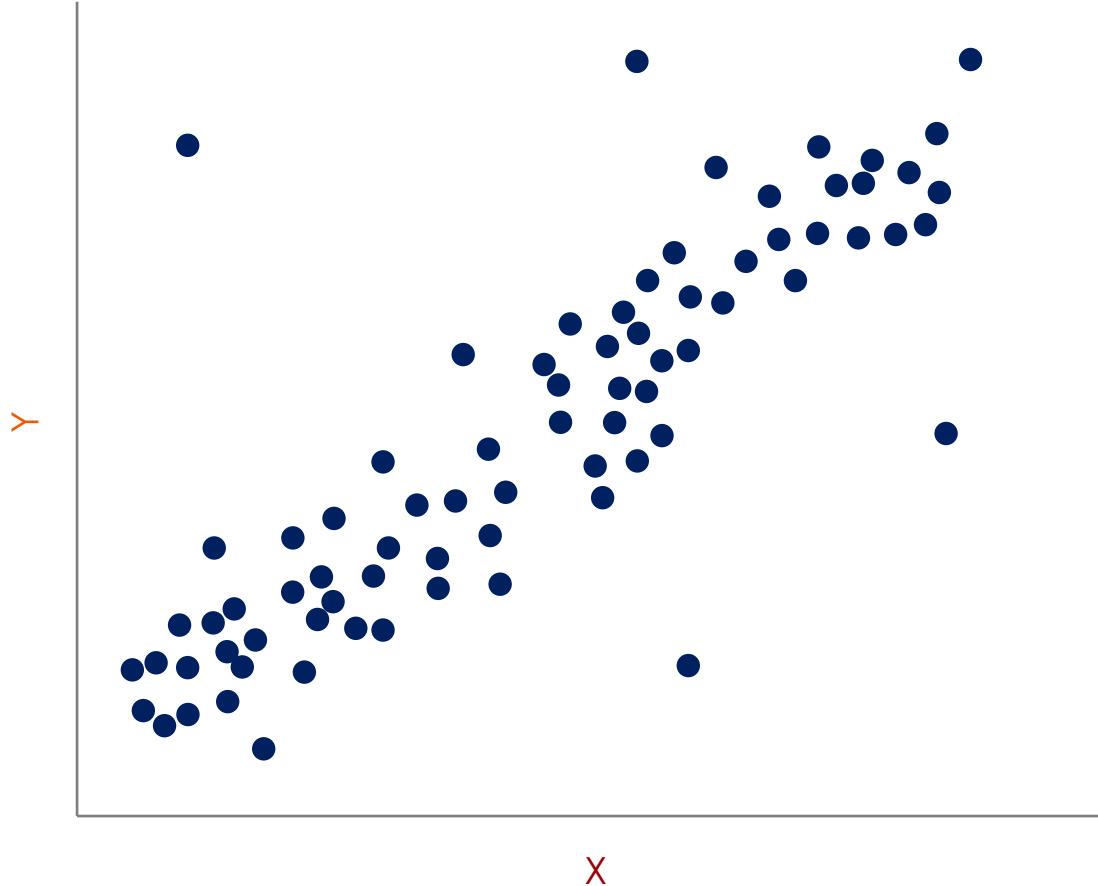
Statistics

What's is an **econometric** model



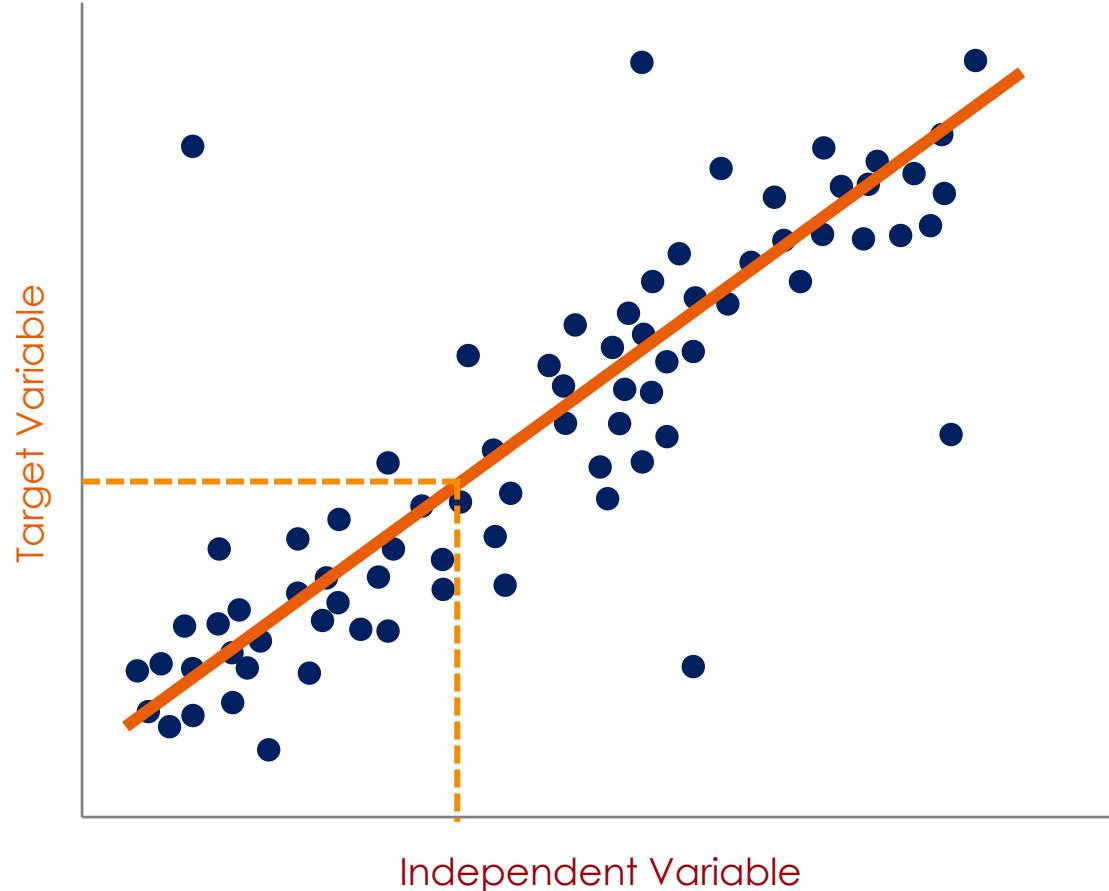
It is a mathematical model
that tries to explain a **linear**
or non linear relationship
under the context of an
economic phenomenon

What is a **scatter**?



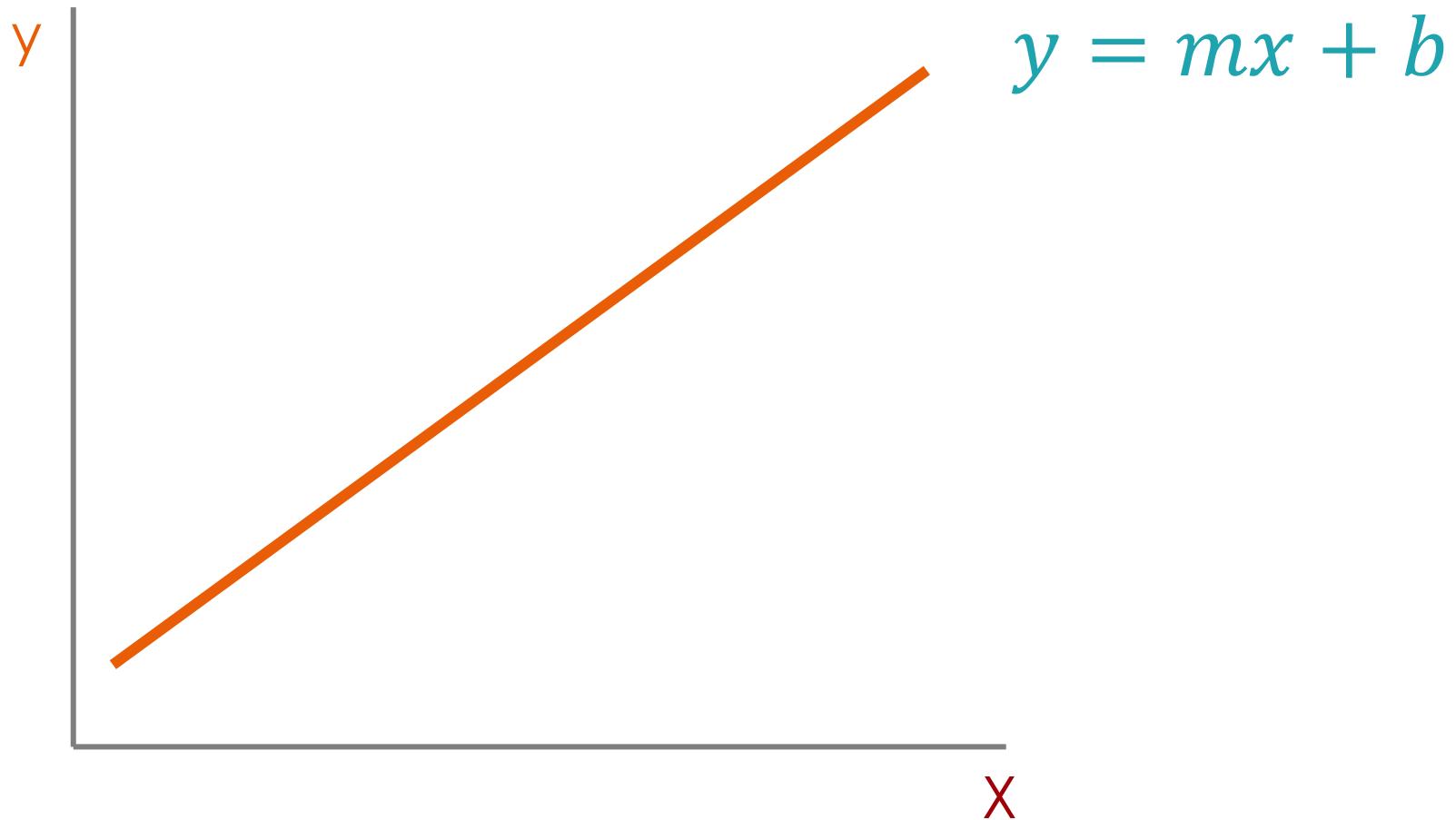
It is the **relationship**
between a **dependent**
variable and **one or more**
explanatory variables

What is a **linear** regression?

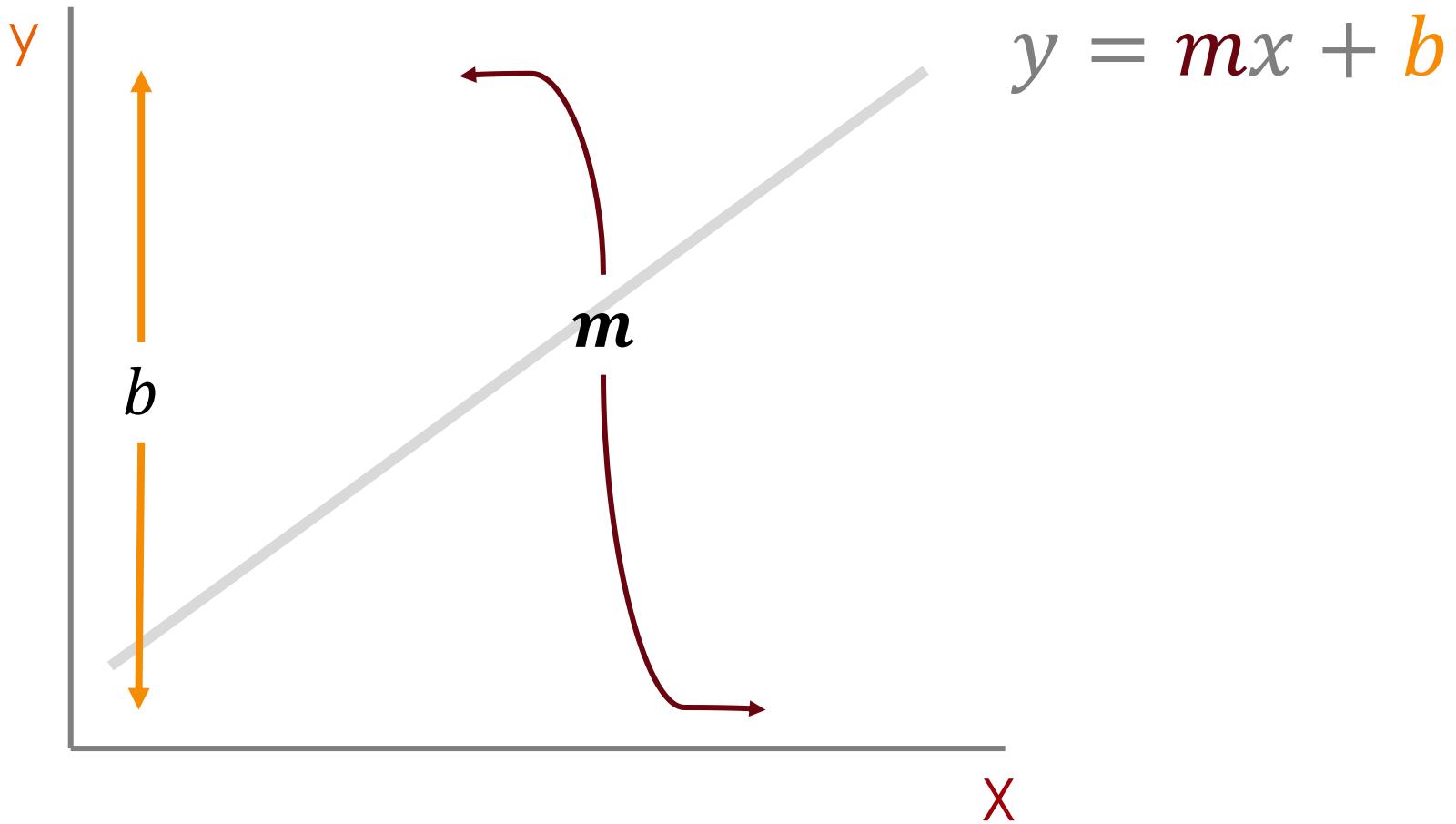


The line that **best fit** to
predict y-values for any x-
values

Do you remember the **equation** for a **straight line**?



It changes given the ***b*** and ***m*** values



Population **regression**
function

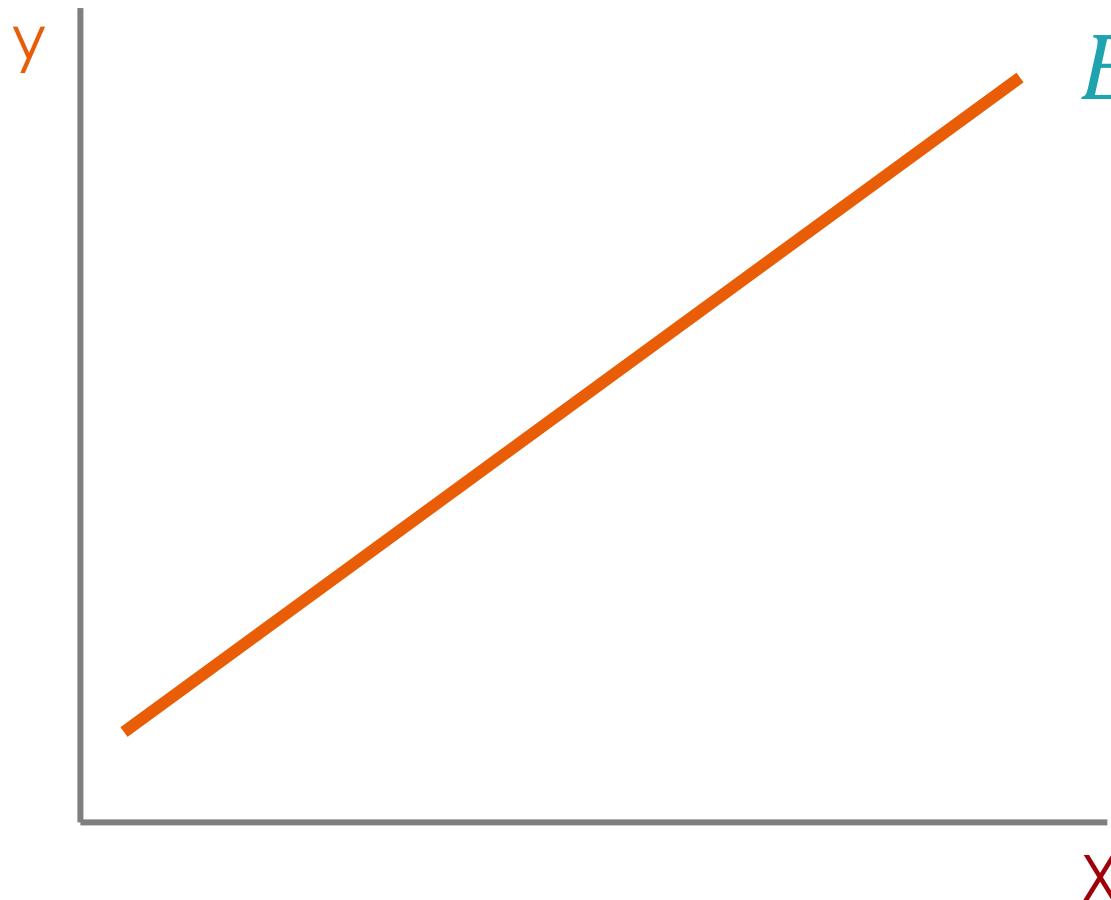
VS

Sample **regression**
function



Population regression function

In econometrics, that equation turns into this



$$E(Y|X_i) = \beta_1 + \beta_2 X_i$$

Now, the regression is
estimated, linear and
mathematical

Population regression function

$$E(Y|X_i) = \boxed{\beta_1} + \boxed{\beta_2} X_i$$

Regression coefficients

Intercept

$$E(Y|X_i) = \boxed{\beta_1} + \boxed{\beta_2} X_i$$

Slope

Population **regression function**

$$E(Y|X_i) = \boxed{\beta_1} + \boxed{\beta_2} X_i$$

Intercept
Slope

What is the **intercept**?

$$E(Y|X_i) = \boxed{\beta_1} + \beta_2 X_i$$

Intercept

What is the **intercept**?

It is the **expected mean**
value when all $X = 0$

What is the **intercept**?

$$E(Y|X_i) = \beta_1 + \boxed{\beta_2} X_i$$

Slope

What is the **slope**?

It measures the **change** in the mean conditional value of Y for a change in X

“How much you can expect Y to change as X increases”

Interpretation

$$E(Y|X_i) = \beta_1 + 2 X_i$$

If the **slope** is 2, it means that if the value of X **increases** by 1 then the value of Y **increases** by 2

Population regression function

This equation that is **conditional**

$$E(Y|X_i) = \beta_1 + \beta_2 X_i$$

turns into this

$$Y_i = \beta_1 + \beta_2 X_i + \mu_i$$

Now we add more characteristics

$$Y = \beta_0 + \beta_1 \overline{X}_1 + \beta_2 \overline{X}_2 + u_i$$

Or this

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + u_i$$

Where

β_0 is the intercept

β_1 is the change in y with respect to x_1 , *ceteris paribus*

β_i is the change in y with respect to x_i , *ceteris paribus*

Error term

$$Y_1 = \beta_1 + \beta_2 X_i + \boxed{\mu_i}$$

Stochastic Term

Random

Error term

Error term

$$Y_1 = \beta_1 + \beta_2 X_i + \mu_i$$

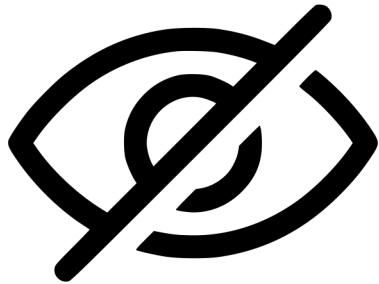
Systemic or deterministic

Non-systemic or noise

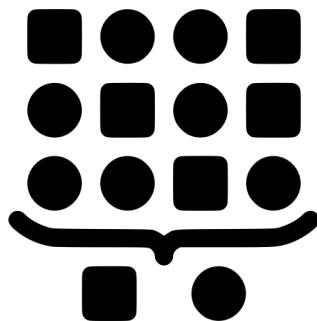
$$Y_1 = \beta_1 + \beta_2 X_i + \boxed{\mu_i}$$

One or **more** of the following:

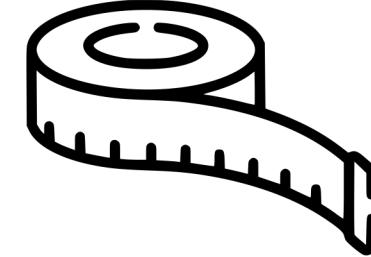
Not specified variables
that may impact in the
model



Even when all significant
variables are included in
the model, there is an
intrinsic random factor
that **cannot be explained**



Measurement errors



We estimate coefficient
from data using OLS

O Ordinary
L Least
S Squares

$$E(Y|X_i) = \boxed{\beta_1} + \boxed{\beta_2} X_i$$

Regression coefficients

$$Y_t = (a + bX_i) + e_i$$

or

$$Y_t = (b_0 + bX_i) + e$$

where

a or b_0 are ordinate axis

b or b_1 slope or gradient, both are regression coefficients

e is the residual term that represents the difference between the observed value and the predicted one

Visit the following **webpage**



Target: Predict house prices

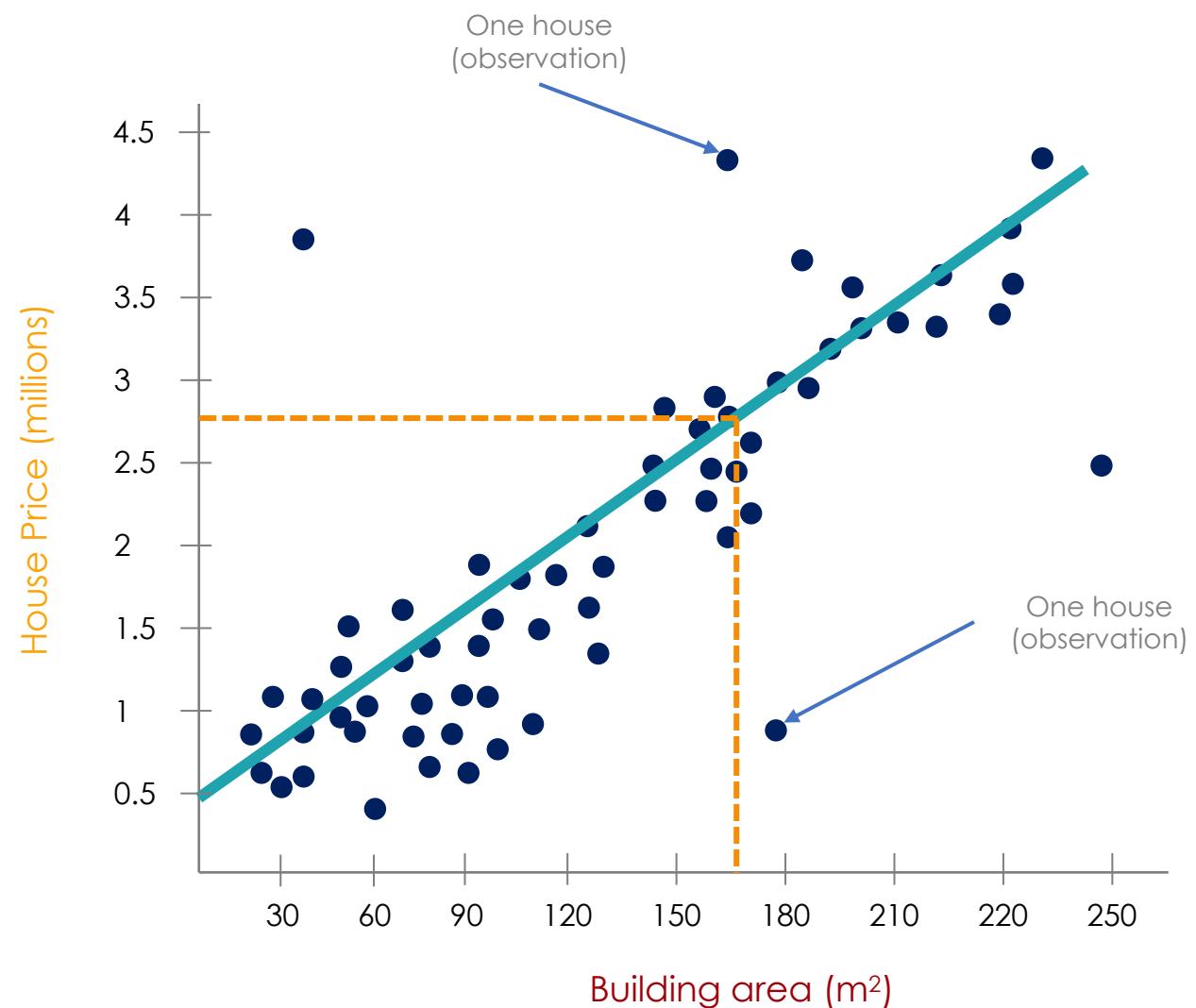
Independent variable: Building area

Dependent variable: House price

Each blue point is a single house with a known area and corresponding house price

You give me the area (m^2) and I will give you the price given my regression

Example



Example

The line of **best fit** is described as:

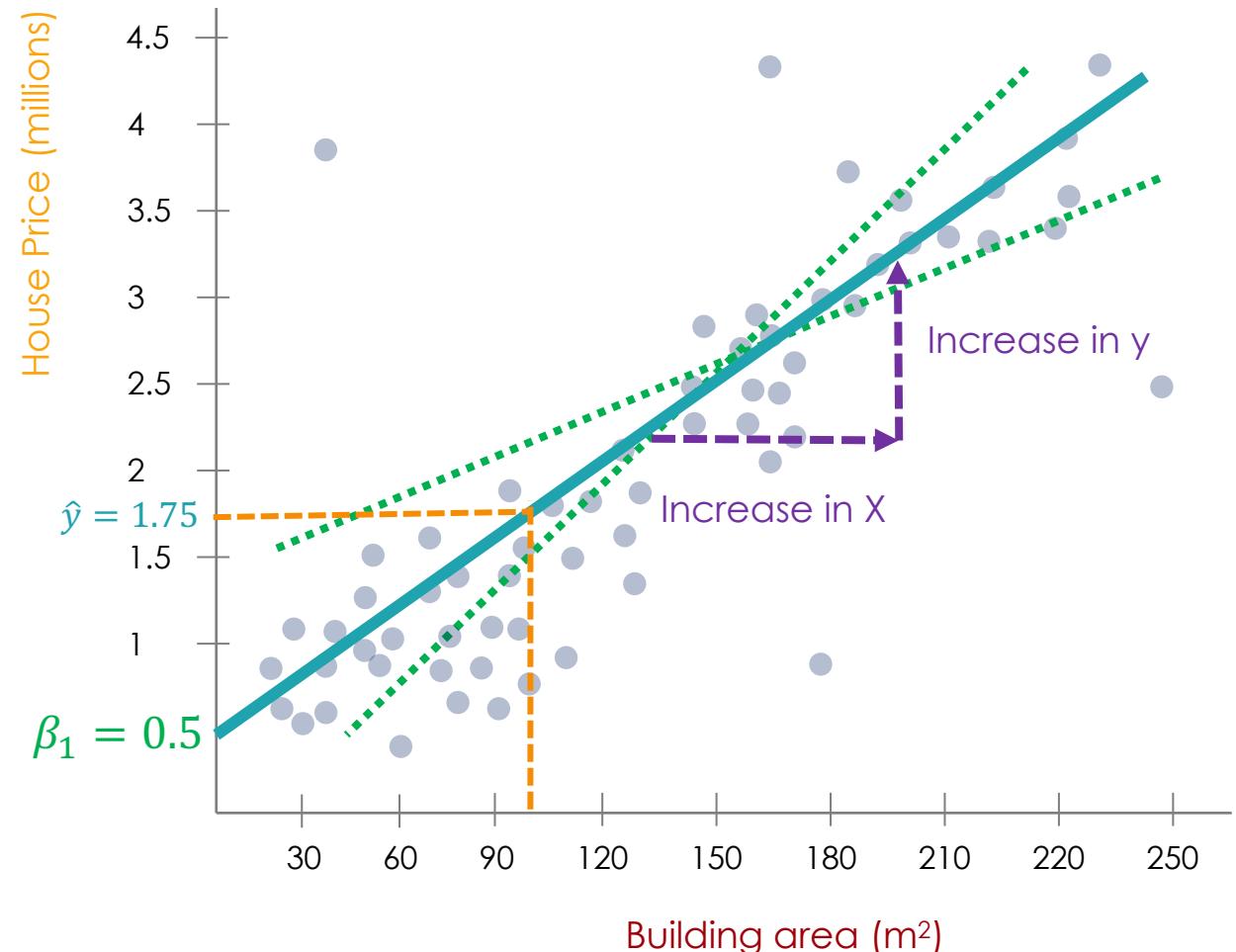
$$\hat{y} = \beta_0 x + \beta_1$$

β_0 and β_1 are the parameters (or coefficients) that define the regression line

β_0 is the intercept

β_1 is the slope

Question: *How can we find the optimal line?*



Example

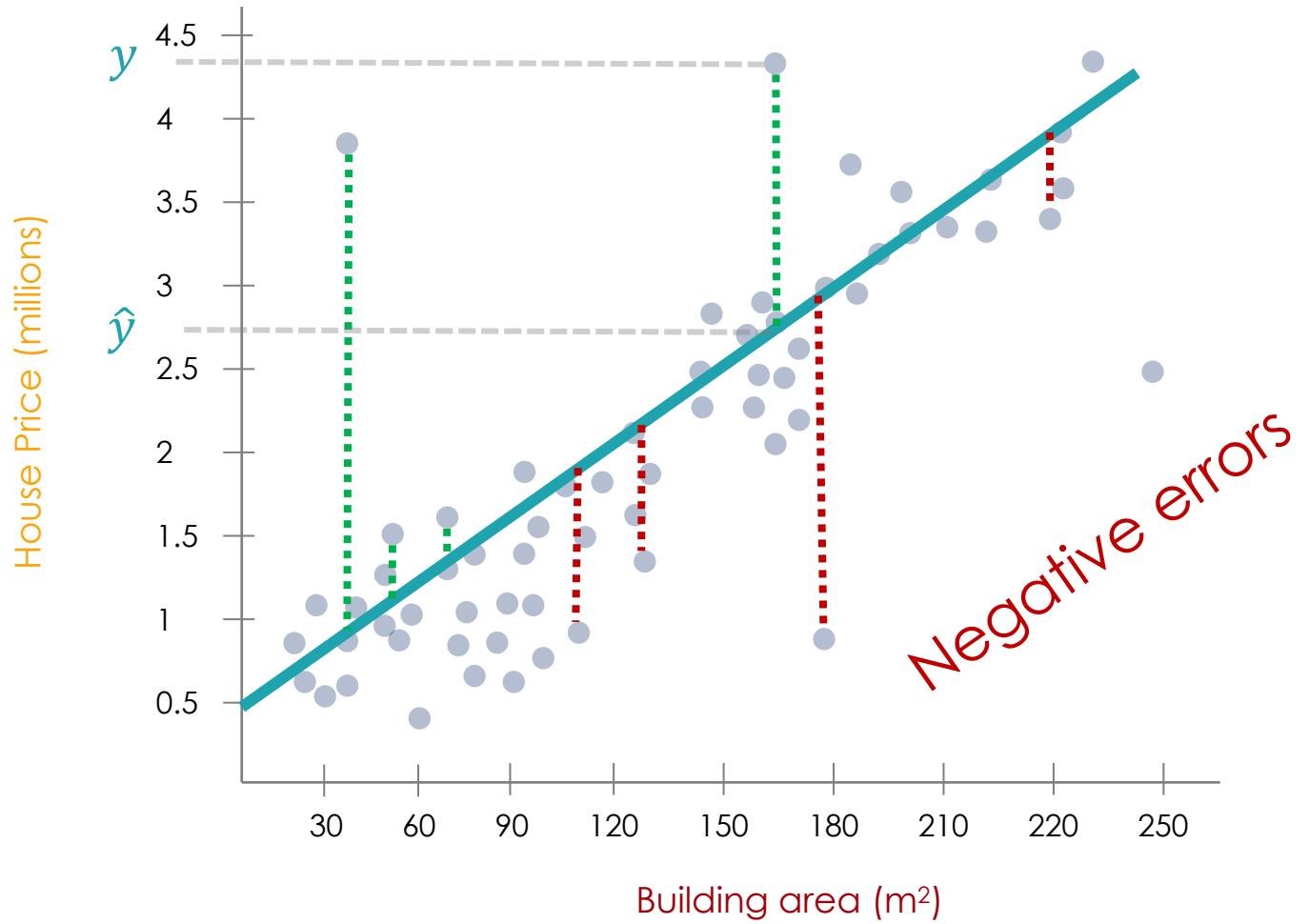
Question: *How can we find the optimal line?*

By minimizing the sum square errors (SSE)
also known as the sum of square
residuals

Errors, or residuals are the difference
between the observed and predicted
values of the data (vertical lines on the
chart)

In OLS, we square each error to remove
negative values. We then add all squared
errors together.

$$SSE = \sum (y_i - \hat{y}_i)^2$$



Example

The blue line has the following equation

$$\hat{y} = 0.7x + 0.5$$

Then errors can be calculated as:

$$y_i - \hat{y}_i = y_i - ((0.7 \times x) + 0.5) = \text{error}$$

$$y_1 - \hat{y}_1 = 0.3 - ((0.7 \times 60) + 0.5) =$$

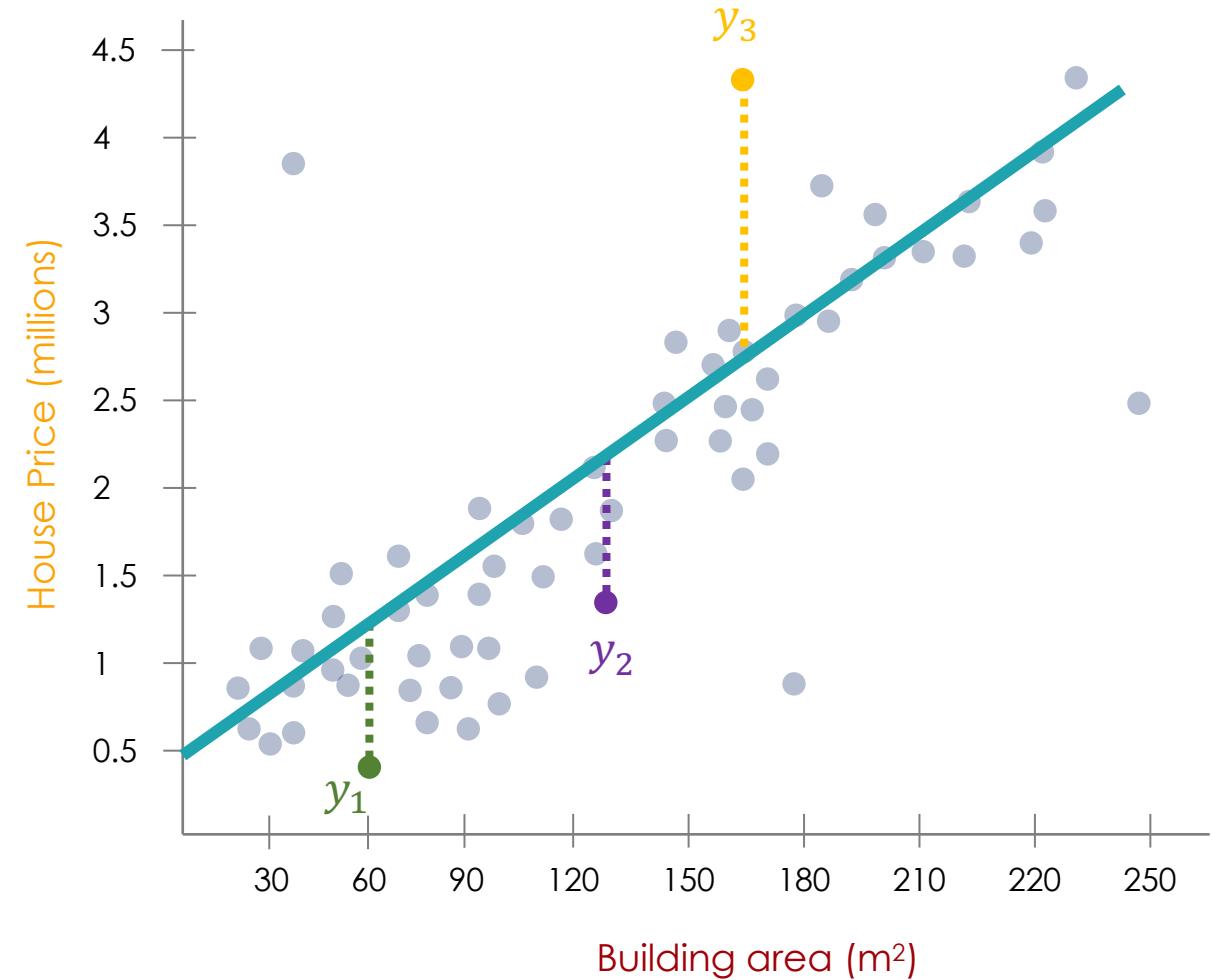
$$y_2 - \hat{y}_2 = 1.2 - ((0.7 \times 60) + 0.5) =$$

$$y_2 - \hat{y}_3 = 4.4 - ((0.7 \times 60) + 0.5) =$$

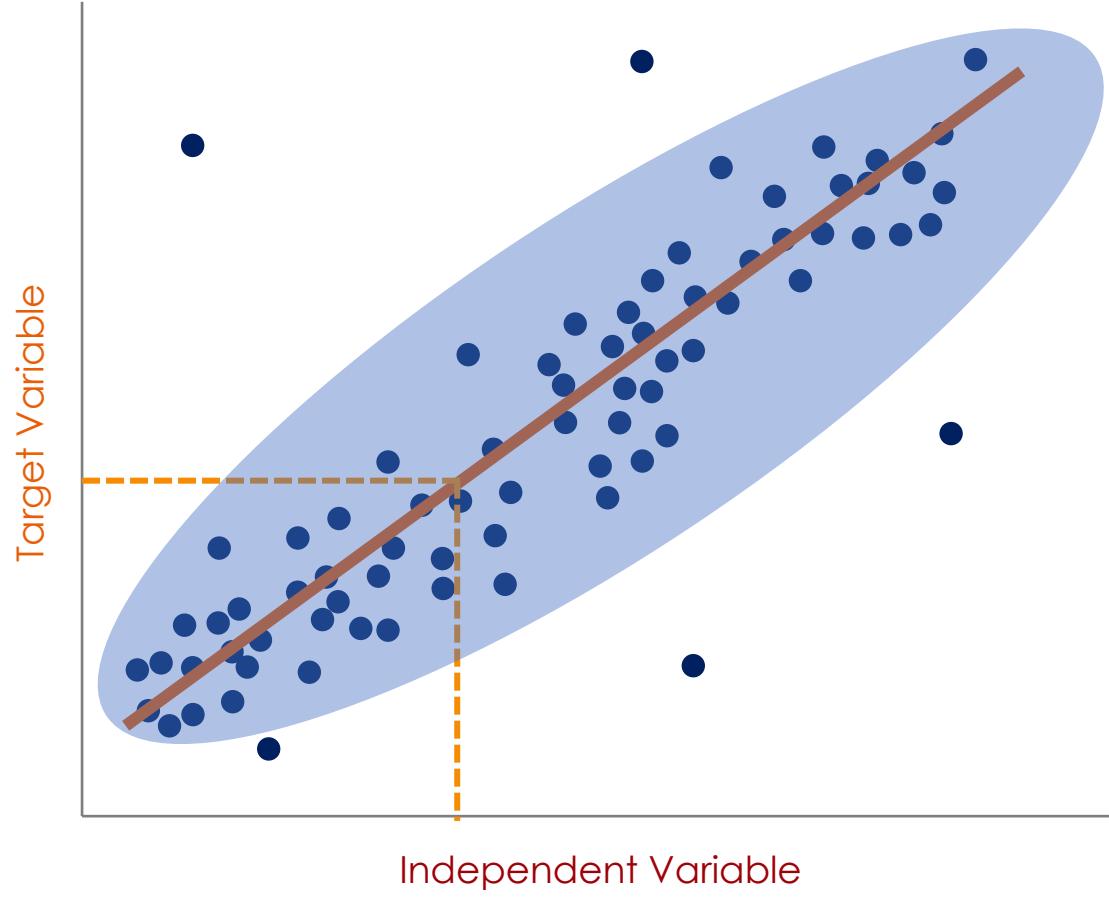
...

Then, the sum of square errors is...

$$SSE = (\cdot)^2 +$$



To consider



Some random variation
cannot be explained

Linear problems

Non-Linear
problems

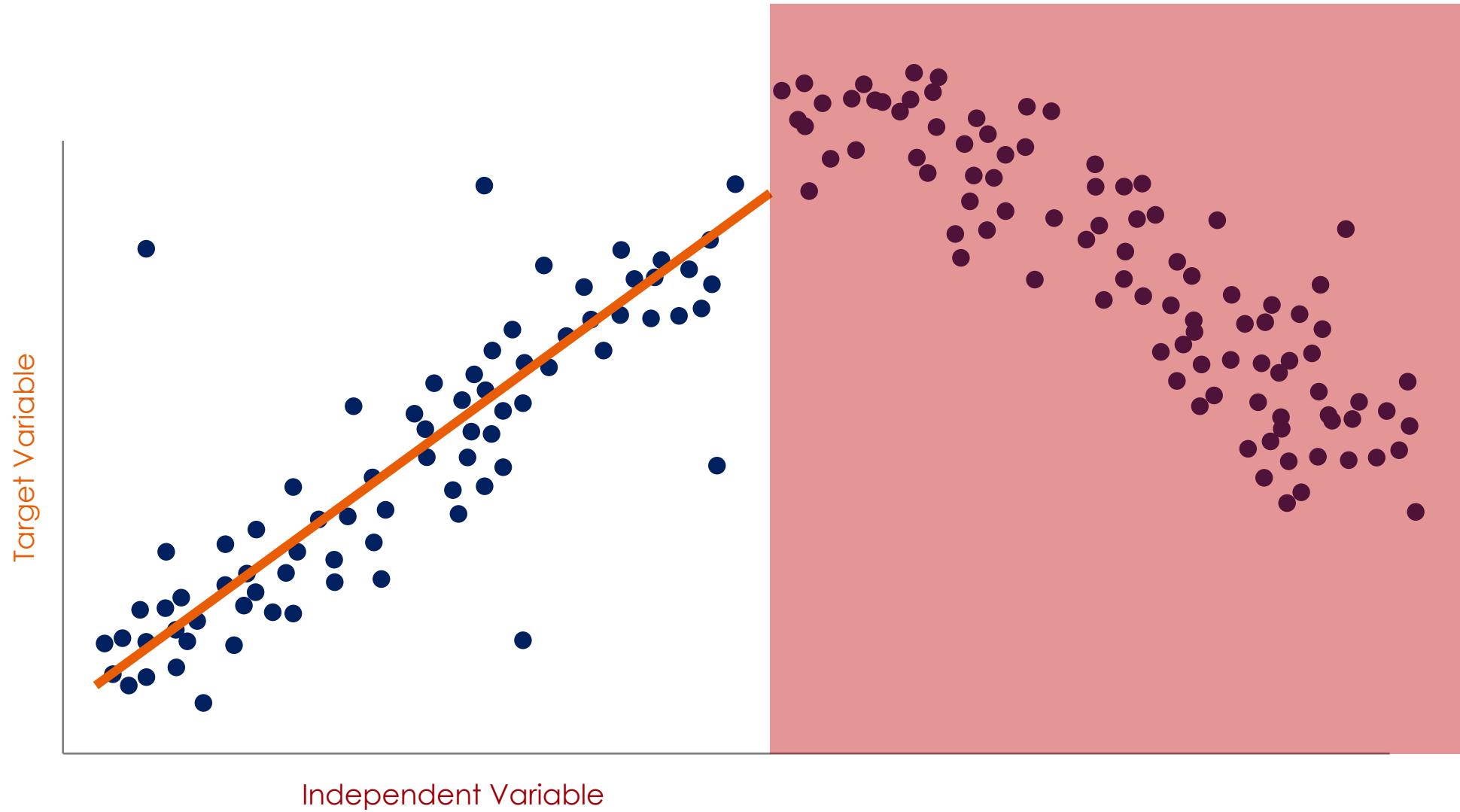
Linear problems
are the
exception!

Almost all
economics
problems are
non-linear.

Non-Linear problems

Linear problems

To consider



SECOND EDITION

WITH A NEW SECTION: "ON ROBUSTNESS & FRAGILITY"

NEW YORK TIMES BESTSELLER

THE
BLACK SWAN



The Impact of the
HIGHLY IMPROBABLE

"The most prophetic voice of all."

—GQ

Nassim Nicholas Taleb

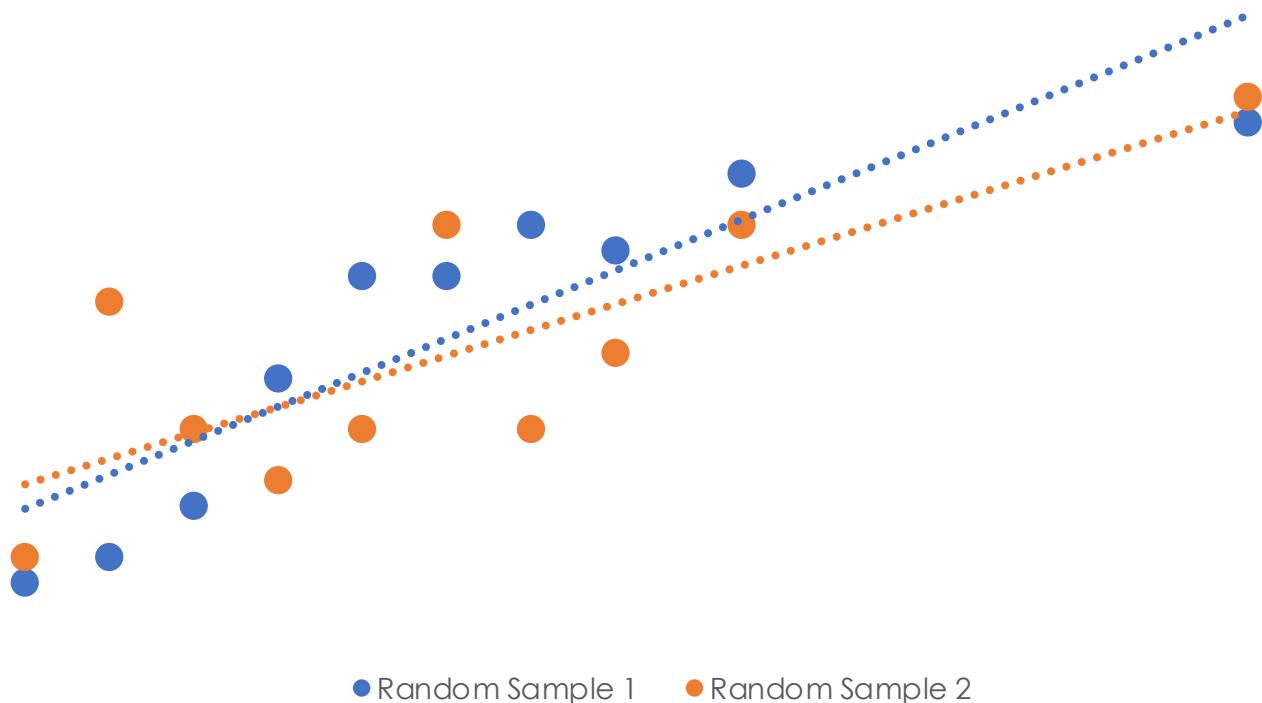
Maxims for
Thinking
Analytically



The wisdom of legendary
Harvard professor Richard Zeckhauser

Dan Levy
Foreword by Larry Summers

Sample regression function



When we cannot access to the **whole universe** of data, we use the **sample regression function** in order to estimate the population regression function

Now, we want to add more variables, to make our model more complex

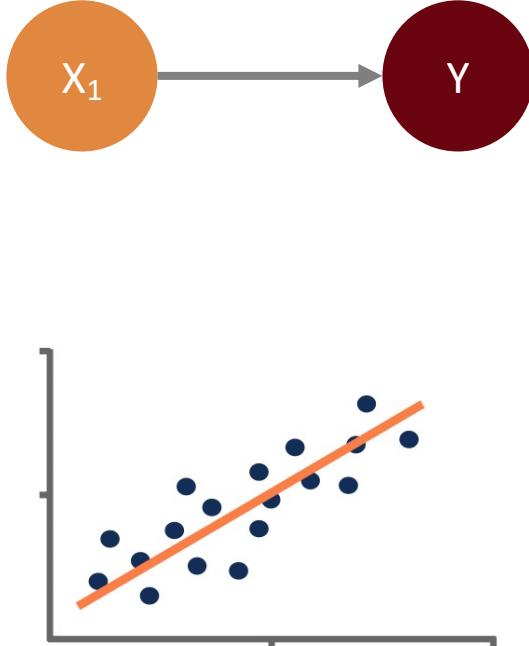
What can we do?

We use Multiple Linear Regression which is more suitable for a *ceteri paribus* analysis due to its convenience to control the rest of factors that affect simultaneously to the dependent variable

Types of linear regression?

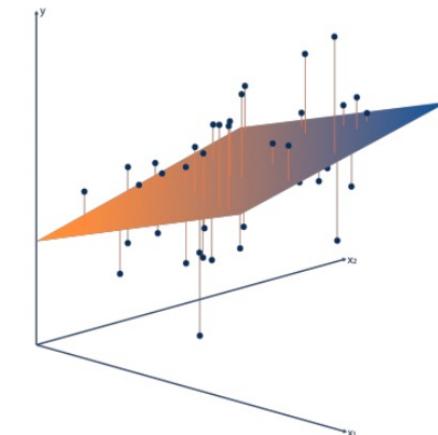
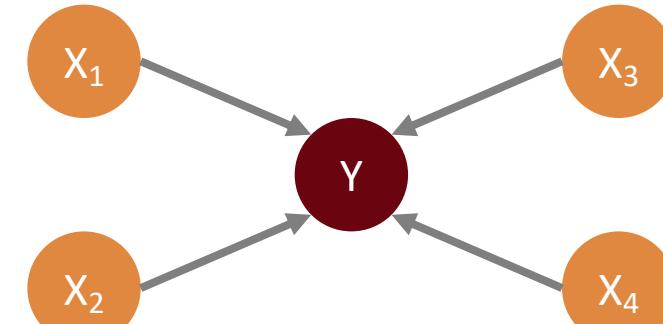
Simple Linear Regression

Independent variable predicted using only **one** independent variable



Multiple Linear Regression

Independent variable predicted using **multiple** independent variables



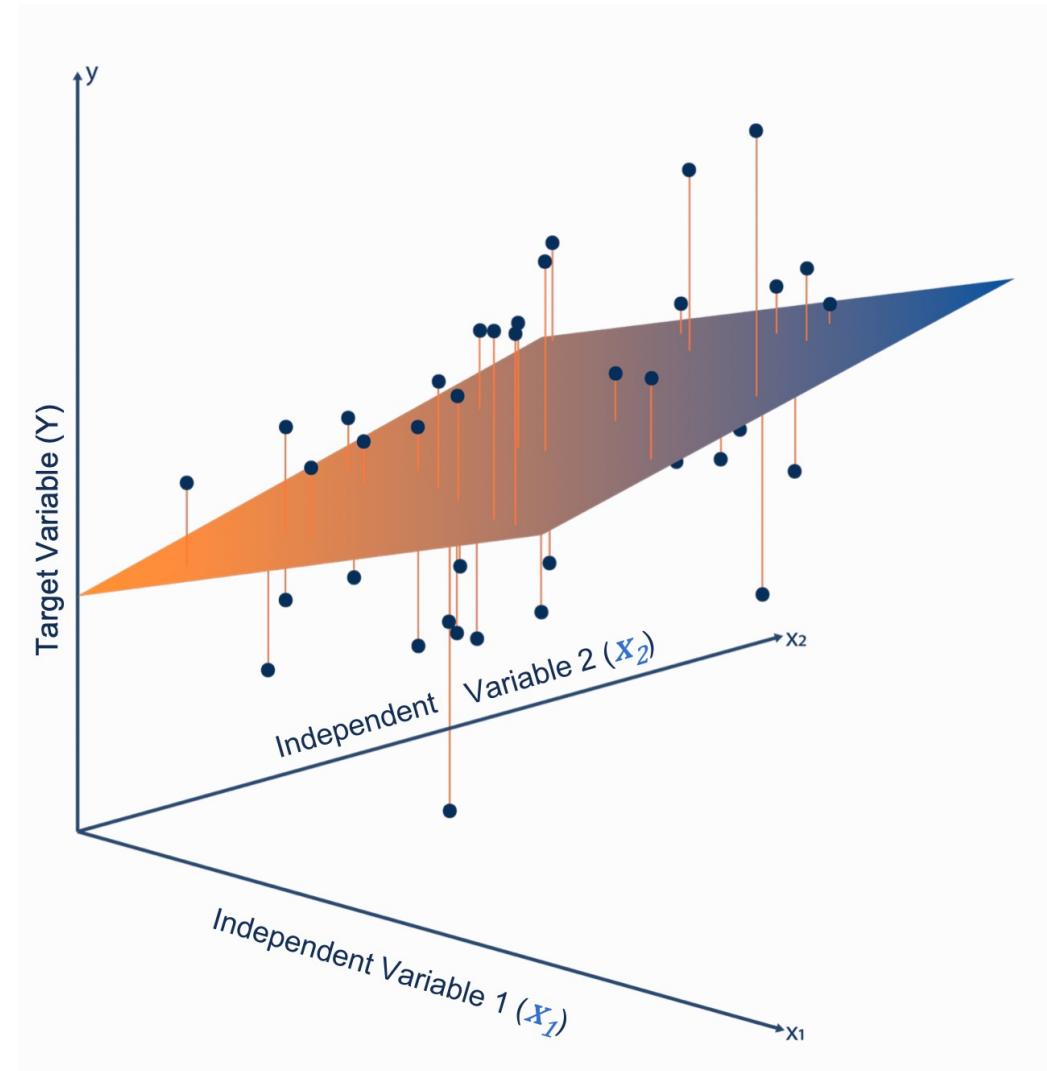
Multiple Linear Regression

Due to the **lack of explanability** that **one** variable provides, we need to use Multiple Linear Regression, using any number of independent variables

$$\hat{y} = \theta_0 + \theta_1 x_1 + \theta_2 x_2 + \cdots + \theta_p x_p$$

When we have **two independent** variables, we are fitting a **plane** to data, not a straight line

Again, we use OLS to solve **$p + 1$ simultaneous equations** using matrix algebra for the best fit parameter values



Keep it **simple**

Location

Size

Conservation

Services

Security

House Price =

Color

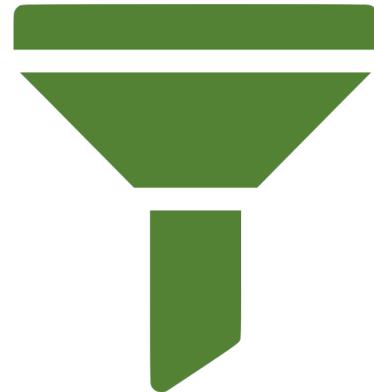
Garage

No. Bathrooms

Land

Green area

Country



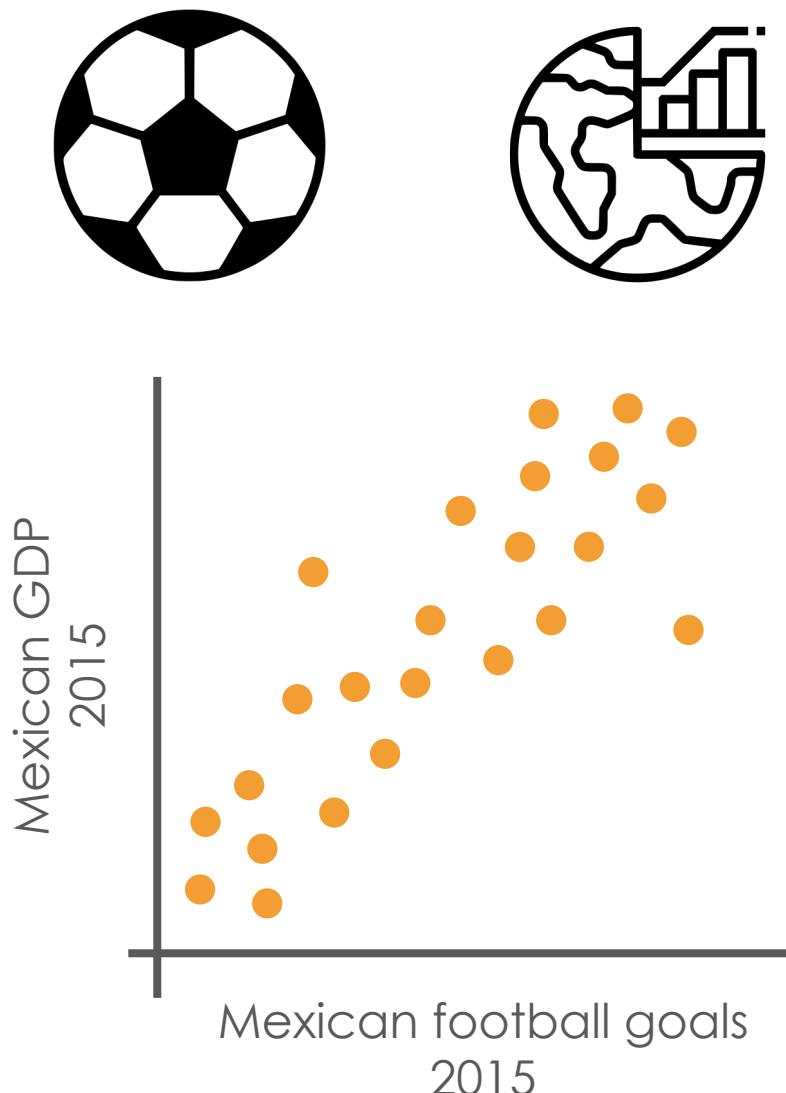
Parsimony

House Price =

Size

Conservation

Correlation **vs** Causality



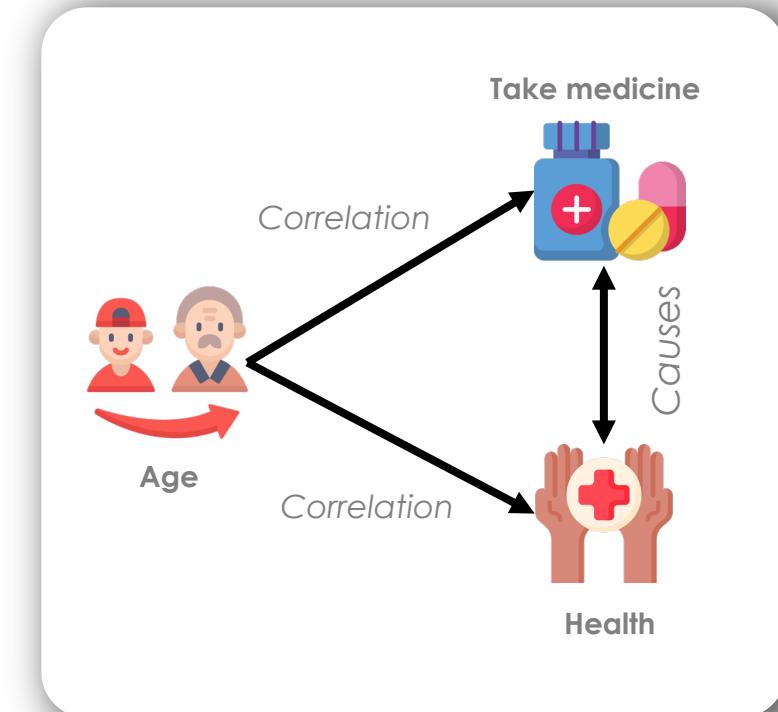
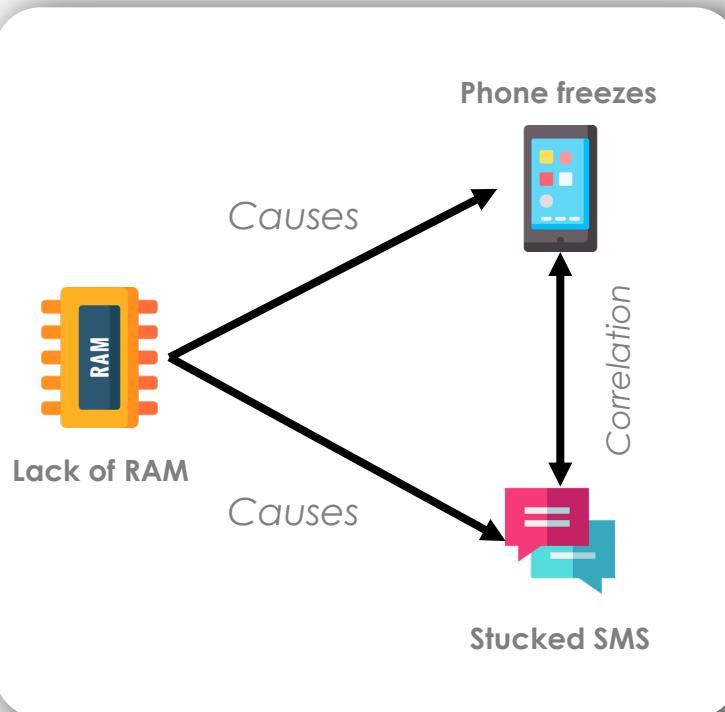
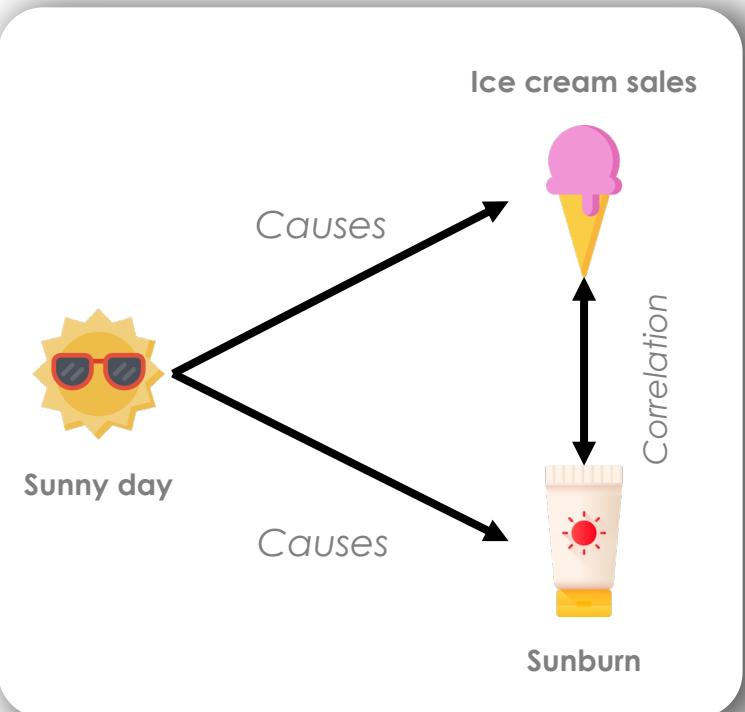
Correlation **vs** Causality



Correlation
does **not imply**
causation

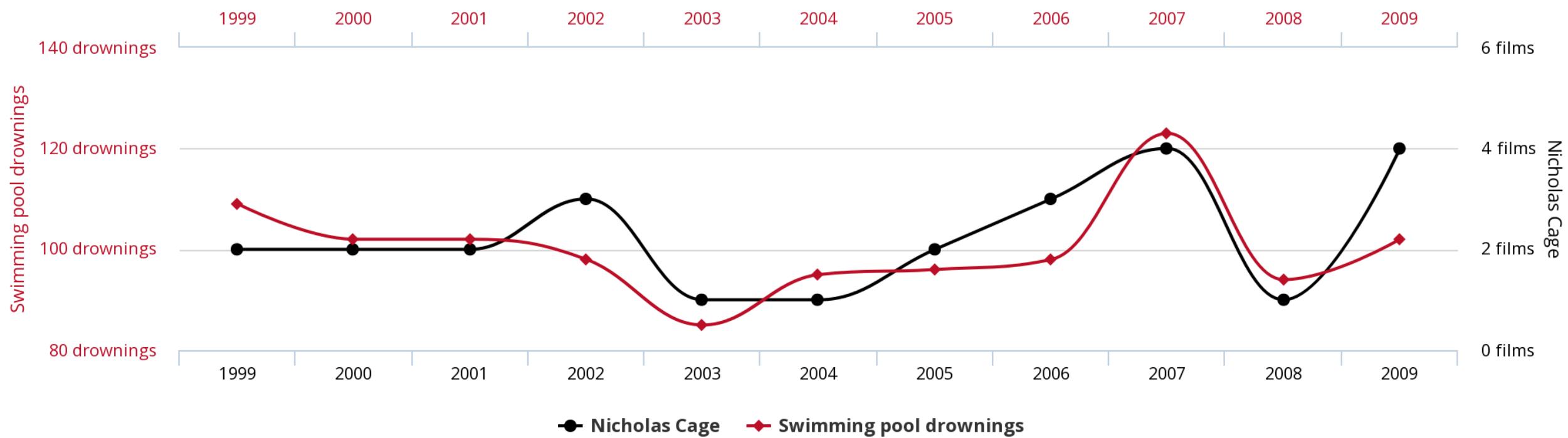
Cum hoc ergo propter hoc

Correlation vs Causality



Spurious correlations

Number of people who drowned by falling into a pool correlates with Films Nicolas Cage appeared in

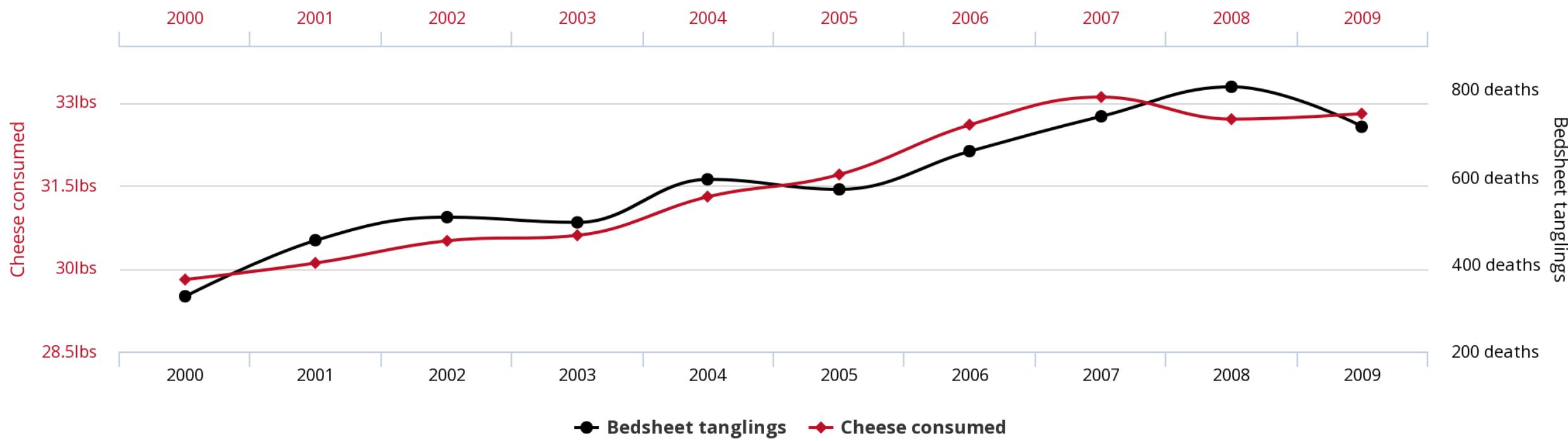


Spurious correlations

Per capita cheese consumption

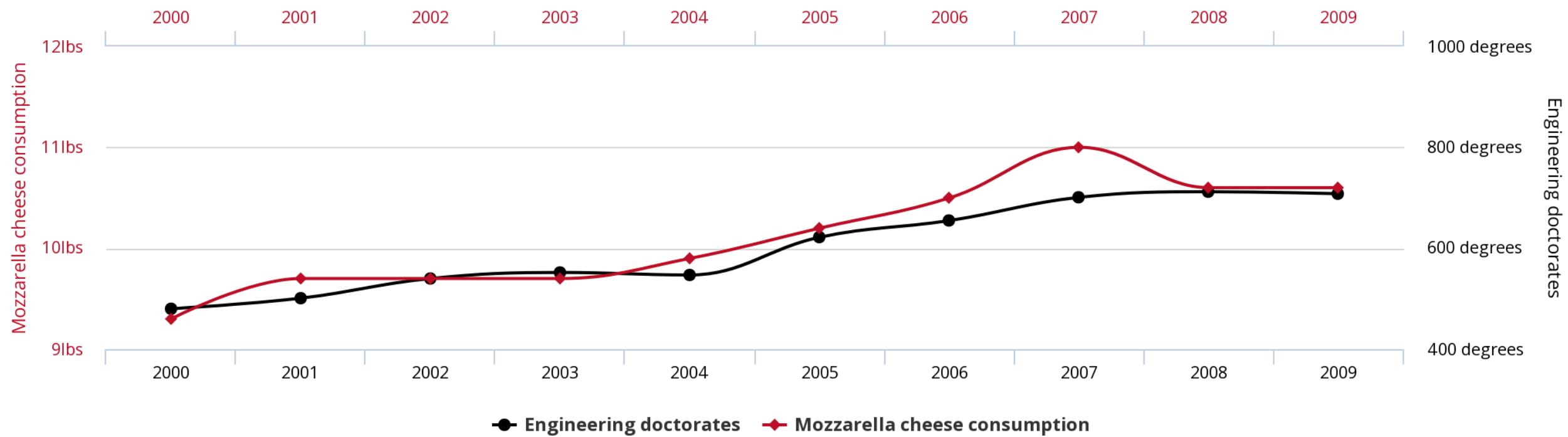
correlates with

Number of people who died by becoming tangled in their bedsheets



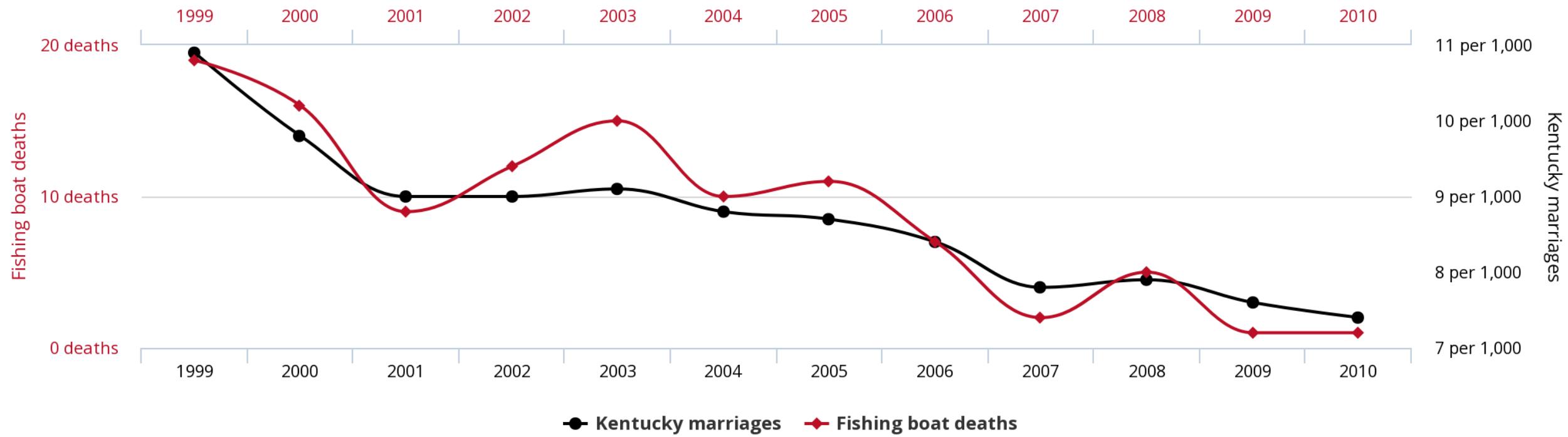
Spurious correlations

Per capita consumption of mozzarella cheese correlates with Civil engineering doctorates awarded

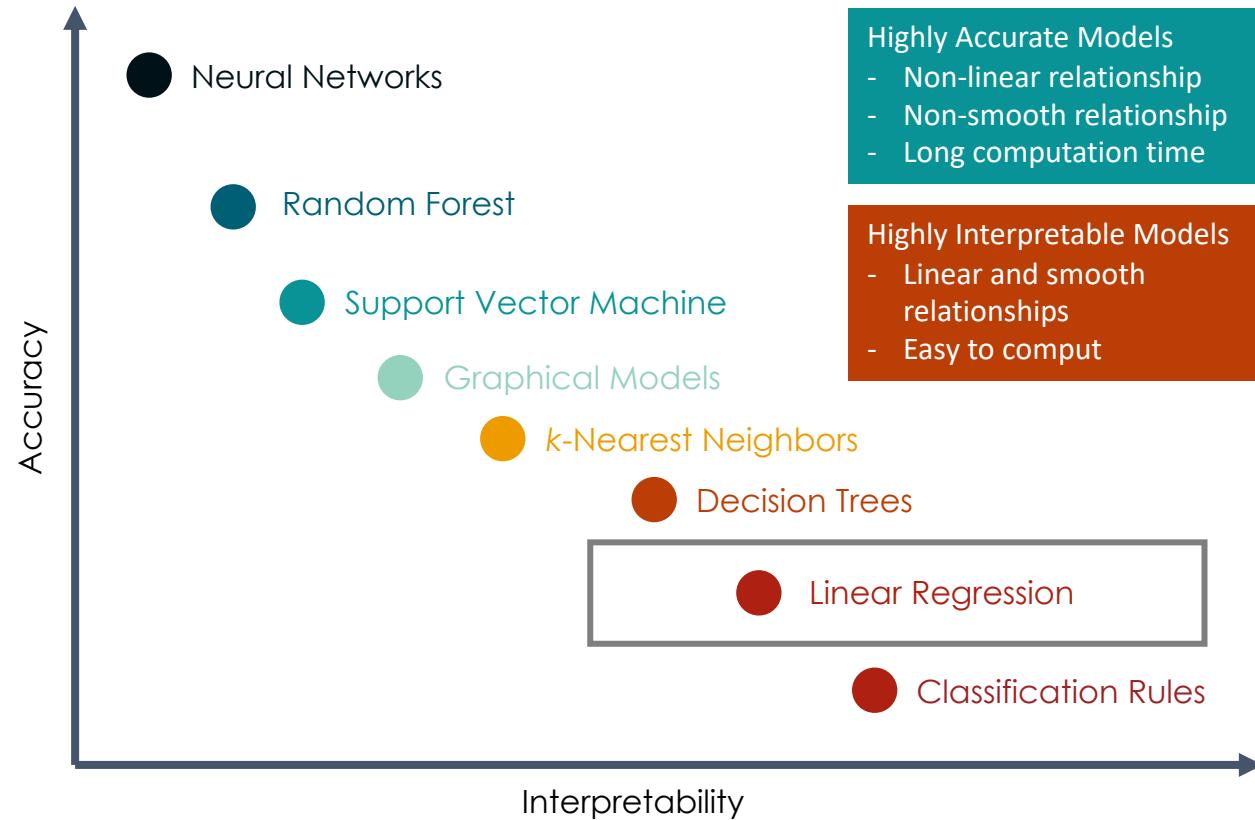


Spurious correlations

People who drowned after falling out of a fishing boat correlates with Marriage rate in Kentucky



Why models fail?



Do you remember
that we said we
love testing?

The important task is not to obtain it because a software can easily make it for you but to interpret it. This is the next step right after running your regression.

The smaller the p.value the more evidence we have against H_0

Hypothesis testing

The **smaller** the p.value the **more evidence** we have against H_0

or

If p.value is "**very small**", then we have more evidence to reject the null hypothesis

Hypothesis testing

All depends on the
significance level, which you
may have heard about...

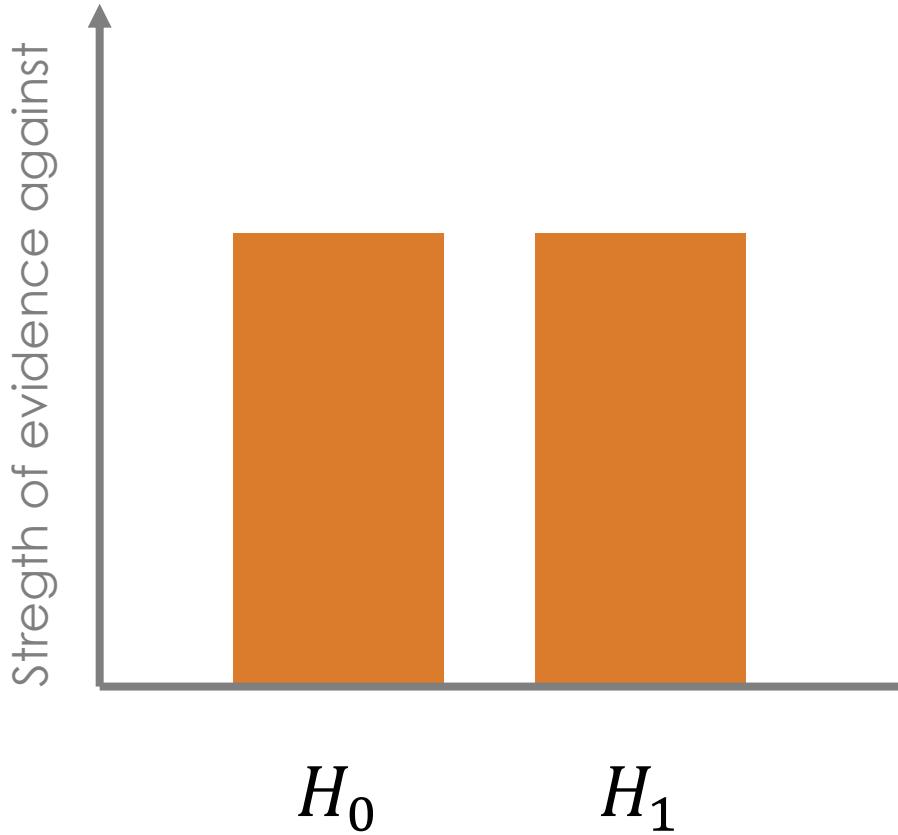
That number you always
declare

10%

5%

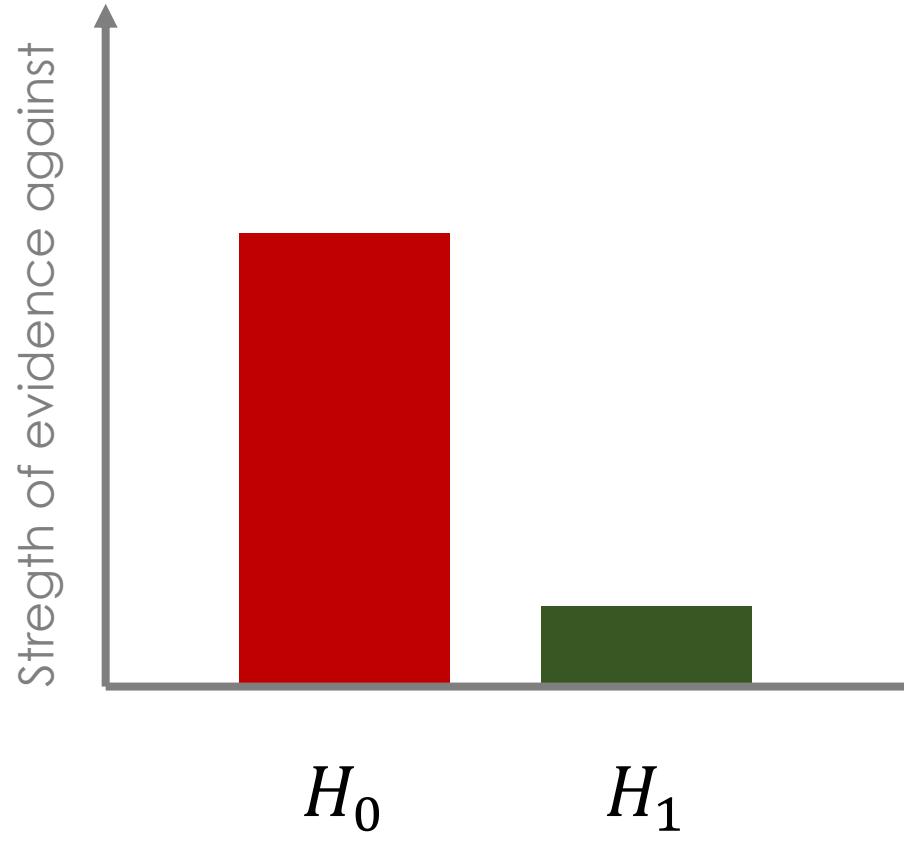
1%

Hypothesis testing



Suppose that your software outputs a **p.value** of 0.0001 and you have a **significance level** of 5%

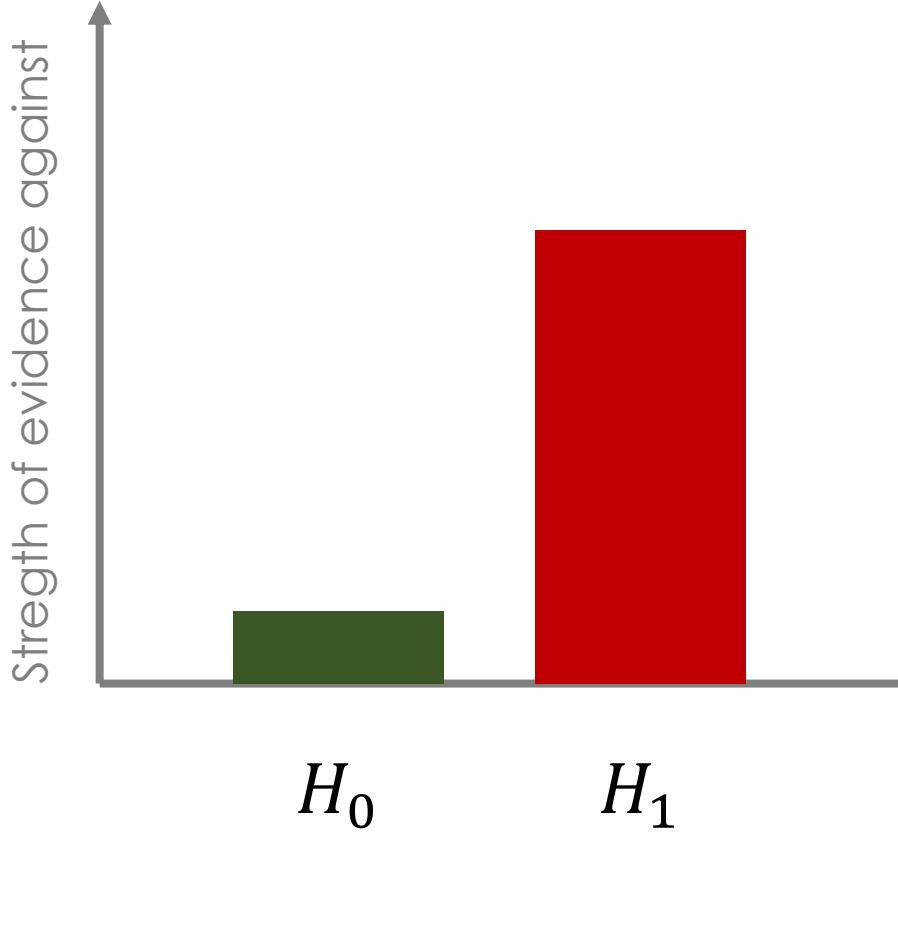
Hypothesis testing



Suppose that your software outputs a **p.value** of 0.0001 and you have a **significance level** of 5%

Your p.value is “**small**” or at least less than the significance level value then your evidence against the null hypothesis **increases** (you **accept** the alternative one)

Hypothesis testing



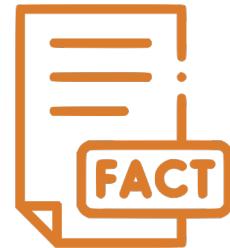
Now suppose that your software outputs a `p.value` of 0.07 and you have a significance level of 5%

Your `p.value` is not “small” or at least it is more than the significance level value. Then your evidence against the null hypothesis **decreases** (you do not accept the alternative one)

Hypothesis testing

You can state your own
hypothesis testing

Information you already
have and you want to
reject


$$H_0$$

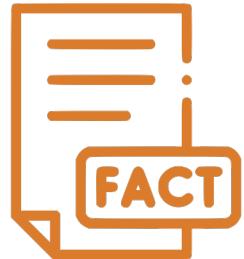
What you desire


$$H_1$$

And then you state your significance level

Hypothesis testing

Example



A school report shows
that the average age
in a class is 12

but...



You suspect it is
less than 12

$$H_0: \mu \geq 12$$

$$H_1: \mu < 12$$

p.value outputs 0.06 and we have a significance value of 5%, then we do not have enough evidence to reject the null hypothesis, so it is clear that school is right

Statistical tests

We now that you may have heard about **z-test**, **t-test**, **R²** and all that stuff, and that those may be **confusing**

We want you to **memorize** this **table**

Normally Distributed?	Variance known?	Small Sample?	Large Sample?
Yes	Yes	z	z
Yes	No	t	t or z
No	Yes	n/a	z
No	No	n/a	t or z

Type I & Type II Errors

	Null hypothesis is TRUE	Null hypothesis is FALSE
Reject null hypothesis	Type I Error (False Positive)	Correct! (True Positive)
Fail to reject null hypothesis	Correct! (True Negative)	Type II Error (False Negative)

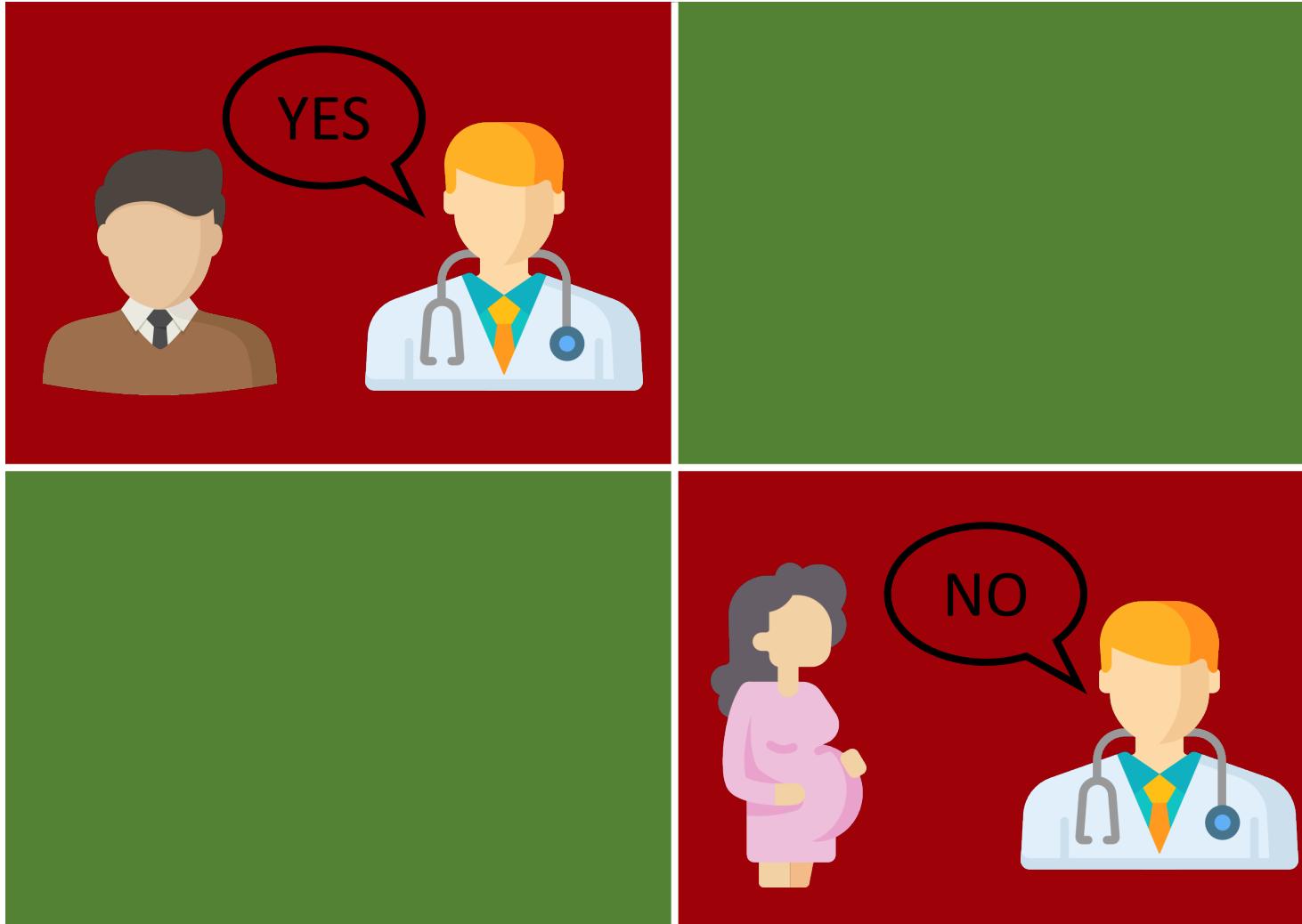
Are you **pregnant**?

Null hypothesis is **TRUE**

Null hypothesis is **FALSE**

Reject null hypothesis

Fail to reject null hypothesis

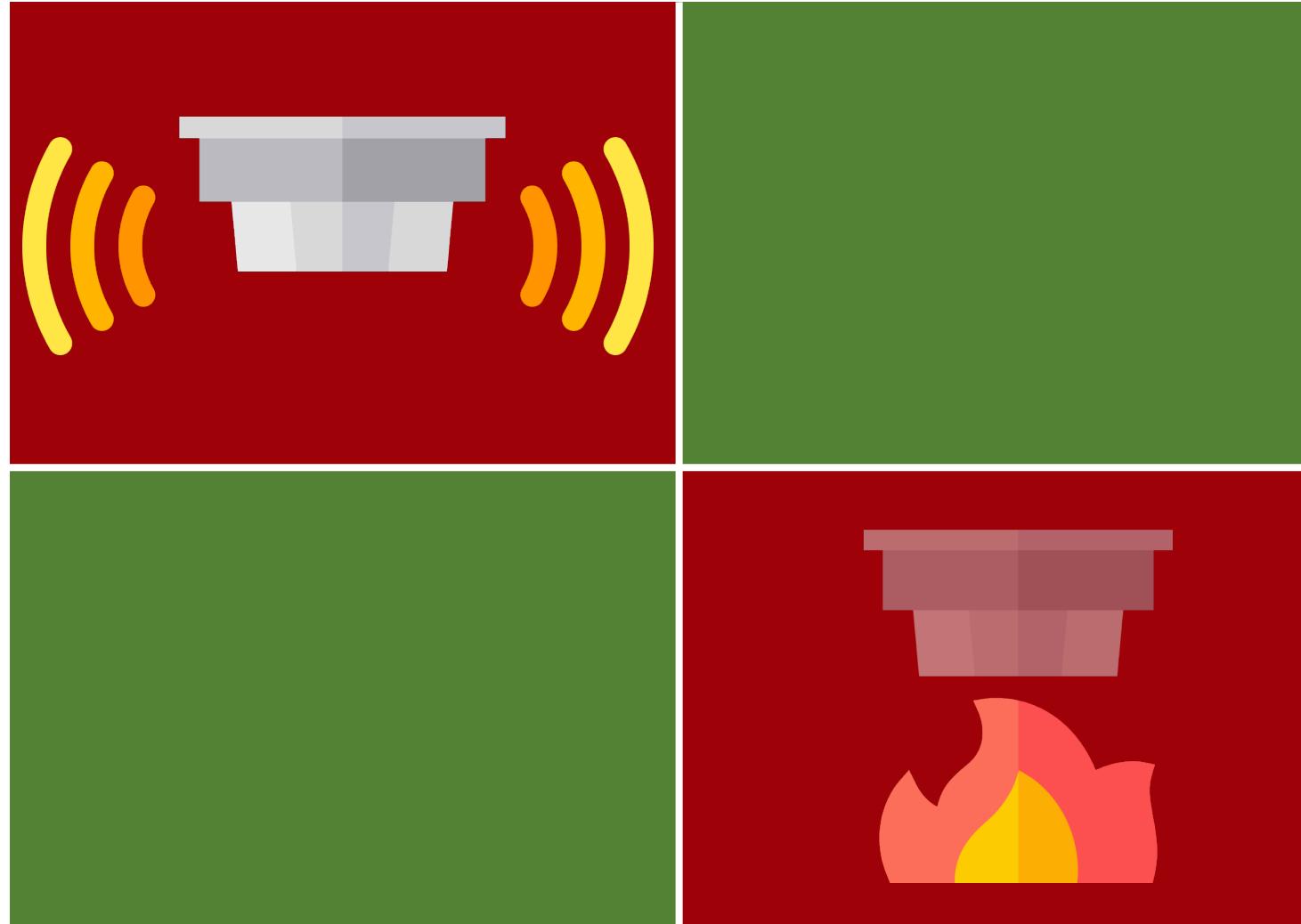


Are you **pregnant**?

Null hypothesis is **TRUE**

Null hypothesis is **FALSE**

Reject null hypothesis



Statistical tests

$$t = \frac{\bar{x} - \mu}{s/\sqrt{n}}$$

where

μ population mean

\bar{x} mean from distribution

n size of sample

s standard error from size

We are going to use **t-test** because we already have the **population mean**

constant

$$H_0: a = 0$$

$$H_a: a \neq 0$$

slope

$$H_0: b = 0$$

$$H_a: b \neq 0$$

constant

$$H_0: a = 0$$

$$H_a: a \neq 0$$

slope

$$H_0: b = 0$$

$$H_a: b \neq 0$$

What do we want
to **reject**?

We want to reject the **null hypothesis** and to confirm that coefficients are **significative** (it means that are different from zero)

Statistical tests

What can we do if we want to evaluate the **explanatory ability** that a group of independent variables have over the variation of dependent variable

$$F = \frac{\frac{SSR}{k}}{\frac{SSE}{n - k - 1}}$$

where

SSR Sum of squared regression

k Degrees of Freedom

SSE Sum of squared error

n total number of obs

constant

$$H_0: F = 0$$

$$H_a: F \neq 0$$

constant

$$H_0: F = 0$$

$$H_a: F \neq 0$$

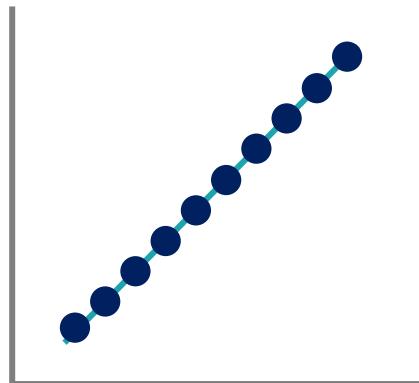
What do we want
to **reject**?

We want to reject the **null hypothesis** and to confirm that our model fits the data **better** than using **only the intercept** (the null hypothesis states that the model with no independent variables fits the data well)

Statistical tests

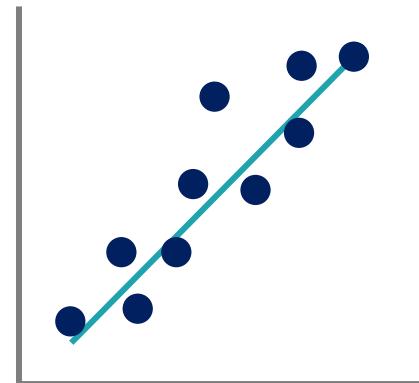
Finally, in order to know **how well** our model is when putting it inside reality, we use **R²** which is the **proportion of variance** in the dependent variable given a bunch of independent variables (or maybe just one)

$$R^2 = 1$$



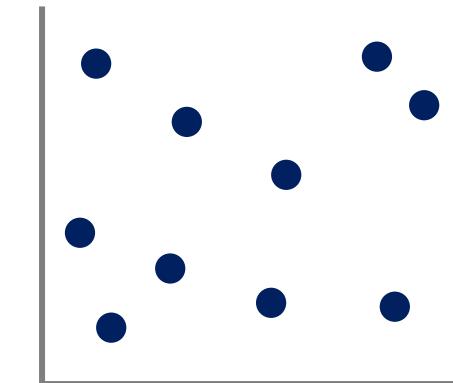
X fully explain Y

$$R^2 = 0.86$$



X fully explain 86%
of change in Y

$$R^2 = 0$$



X cannot explain Y

Statistical tests

Coefficient of Determination

$$R^2 = 1 - \frac{SSE}{TSS}$$

SSE/TSS show how much variance there is in our model as a fraction of the total variation in the target

Note that independent variables in models with high R^2 explain **most of the variance present in data**

R^2 will never decrease by adding new variables, but it can lead to **overfitting**

Adjusted R^2

$$\bar{R}^2 = 1 - \frac{SSE/(n-p-1)}{TSS/(n-1)}$$

n number of datapoints

p number of independent variables

Adjusted R^2 **only increases** when a **new variables is added** and improves the model by more than would be expected due to **random chance**

Adjusted R^2 **decreases** when an added variable **does not improve** model

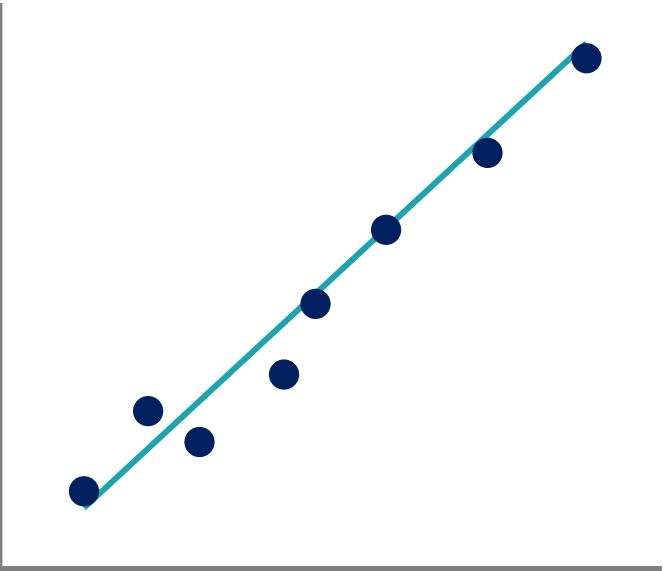
Adjusted $R^2 < R^2$

It allows **comparison between models** with different numbers of independent variables

Does higher R²
mean a significant
p.value?

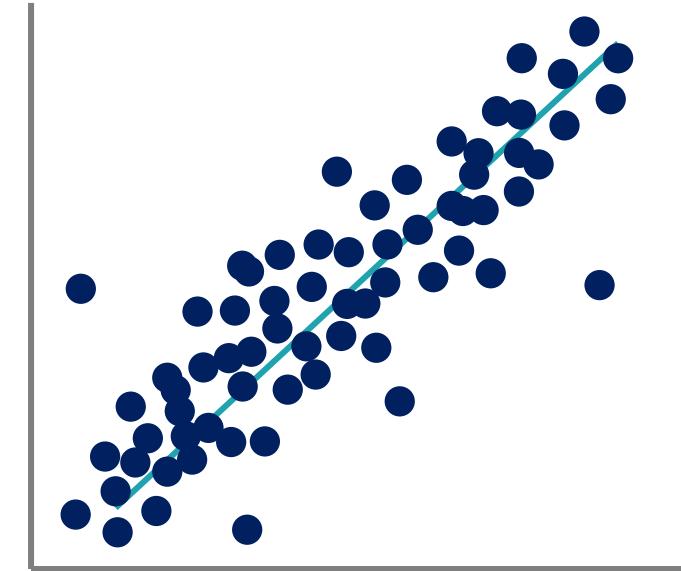


p.value vs R^2



Higher R^2

Probably **not** a significant
p.value (High probability for
prediction to be a random
chance)



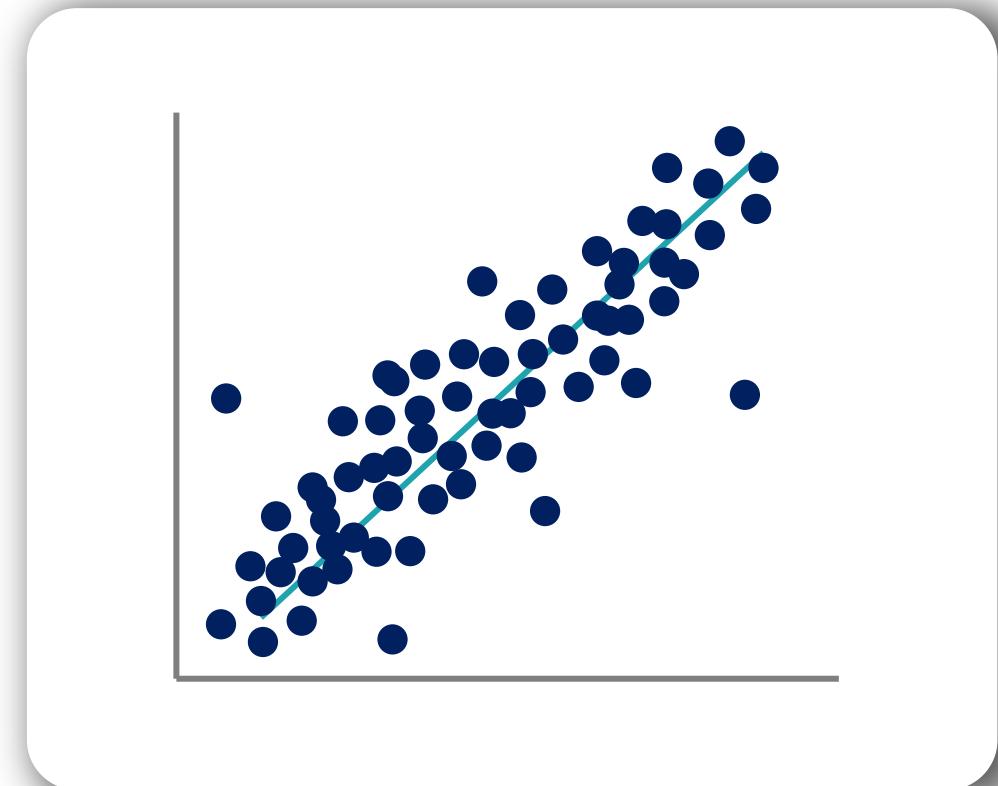
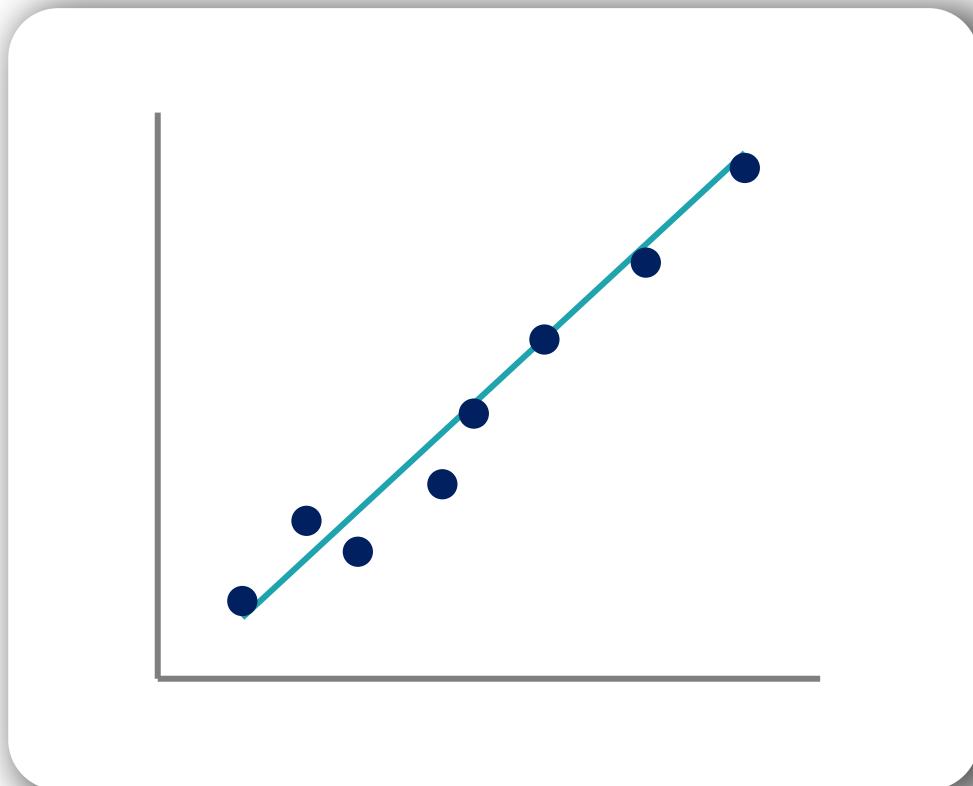
Descent R^2

Probably a **significant**
p.value

p.value vs R²

In conclusion, a significant p.value **does not necessarily imply** a high R² and **viceversa**

R² looks at the **variability around the fitted line**, while p.value tests the **fitted line itself**



How to read **regression** coefficients

$$P = 77000 + 80X_1 + 9200X_2$$

P – House price

X₁ - Building area

X₂ - House condition

- There is a **base price** of \$77,000
- On **average**, for every extra m² we **add**, the house price increases by \$80
- For every **condition point** we **add**, the house price increases by \$9,200

How to read **regression** coefficients

We can **scale independet variables** before running regression in order to compare cofficients, like standarization, which follows a normal distribution with **mean zero** and **unit variance**.

$$Z = \frac{x_i - \bar{x}}{\sigma}$$

$$P = 11320 + 41766X_1 + 30047X_2$$

P – House price

X₁ - Building area

X₂ - House condition

How to read **regression** coefficients

$$P = 11320 + 41766X_1 + 30047X_2$$

P – House price

X_1 - Building area

X_2 - House condition

Now, we can compare which variable contributes more for predicting house price for a single unitless increment in the independent variable, such as building area

Linear Regression Analysis Study

Khushbu Kumari, Suniti Yadav

Department of Anthropology, University of Delhi, New Delhi, India

Abstract

Linear regression is a statistical procedure for calculating the value of a dependent variable from an independent variable. Linear regression measures the association between two variables. It is a modeling technique where a dependent variable is predicted based on one or more independent variables. Linear regression analysis is the most widely used of all statistical techniques. This article explains the basic concepts and explains how we can do linear regression calculations in SPSS and excel.

Keywords: Continuous variable test, excel and SPSS analysis, linear regression

INTRODUCTION

The concept of linear regression was first proposed by Sir Francis Galton in 1894. Linear regression is a statistical test applied to a data set to define and quantify the relation between the considered variables. Univariate statistical tests such as Chi-square, Fisher's exact test, *t*-test, and analysis of variance (ANOVA) do not allow taking into account the effect of other covariates/confounders during analyses (Chang 2004). However, partial correlation and regression are the tests that allow the researcher to control the effect of confounders in the understanding of the relation between two variables (Chang 2003).

In biomedical or clinical research, the researcher often tries to understand or relate two or more independent (predictor) variables to predict an outcome or dependent variable. This may be understood as how the risk factors or the predictor variables or independent variables account for the prediction of the chance of a disease occurrence, i.e., dependent variable. Risk factors (or dependent variables) associate with biological (such as age and gender), physical (such as body mass index and blood pressure [BP]), or lifestyle (such as smoking and alcohol consumption) variables with the disease. Both correlation and regression provide this opportunity to understand the "risk factors-disease" relationship (Gaddis and Gaddis 1990). While correlation provides a quantitative way of measuring the degree or strength of a relation between two variables, regression analysis mathematically describes this relationship. Regression analysis allows predicting the value

of a dependent variable based on the value of at least one independent variable.

In correlation analysis, the correlation coefficient "*r*" is a dimensionless number whose value ranges from -1 to +1. A value toward -1 indicates inverse or negative relationship, whereas towards +1 indicate a positive relation. When there is a normal distribution, the Pearson's correlation is used, whereas, in nonnormally distributed data, Spearman's rank correlation is used.

The linear regression analysis uses the mathematical equation, i.e., $y = mx + c$, that describes the line of best fit for the relationship between *y* (dependent variable) and *x* (independent variable). The regression coefficient, i.e., r^2 implies the degree of variability of *y* due to *x*.^[1-8]

SIGNIFICANCE OF LINEAR REGRESSION

The use of linear regression model is important for the following reasons:

- Descriptive – It helps in analyzing the strength of the association between the outcome (dependent variable) and predictor variables
- Adjustment – It adjusts for the effect of covariates or the confounders

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10.4103/jpcs.jpcs_8_18

How to read a paper

Abstract

Linear regression is a statistical procedure for calculating the value of a dependent variable from an independent variable. Linear regression measures the association between two variables. It is a modeling technique where a dependent variable is predicted based on one or more independent variables. Linear regression analysis is the most widely used of all statistical techniques. This article explains the basic concepts and explains how we can do linear regression calculations in SPSS and excel.

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CONCLUSION

The techniques for testing the relationship between two variables are correlation and linear regression. Correlation quantifies the strength of the linear relationship between a pair of variables, whereas regression expresses the relationship in the form of an equation. In this article, we have used simple examples and SPSS and excel to illustrate linear regression analysis and encourage the readers to analyze their data by these techniques.

Begin with:

Abstract

Keywords

Authors

Introduction

Conclusion

Note:

- **Reset your expectations**, do not worry if you do not understand the first time

- f. All the values of “y” are independent from each other, though dependent on “x.”

Table 6: Summary output

Regression statistics	Values	Explanation
Multiple R	0.96332715	Correlation coefficient: 1 means perfect correlation and 0 means none
R ²	0.927999198	Coefficient of determination: How many points fall on the regression line. Here, 92% points fall within the line
Adjusted R ²	0.891998797	Adjusted R ² : Adjusts for multiple variables, use with multiple variables
SE	516.3490153	
Observations	7	

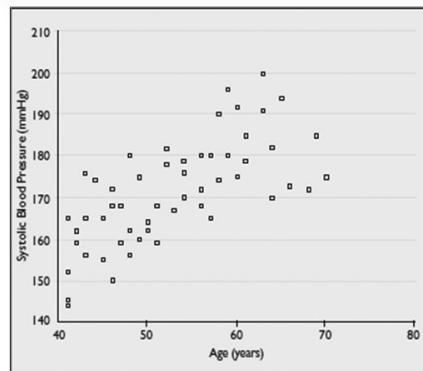


Figure 1: Scatter plot of systolic blood pressure versus age.

Table 4: SPSS equation variables

Model	Coefficients*					
	Unstandardised coefficients		Standardised coefficients	<i>t</i>	Sig.	95% Confidence interval for B
	B	Std. error	Beta			
I (Constant)	115.706	7.999	0.696	14.465	0.000	99.662 131.749
Age (years)	1.051	0.149		7.060	0.000	0.752 1.350

*Dependent variable: Systolic blood pressure (mmHg)

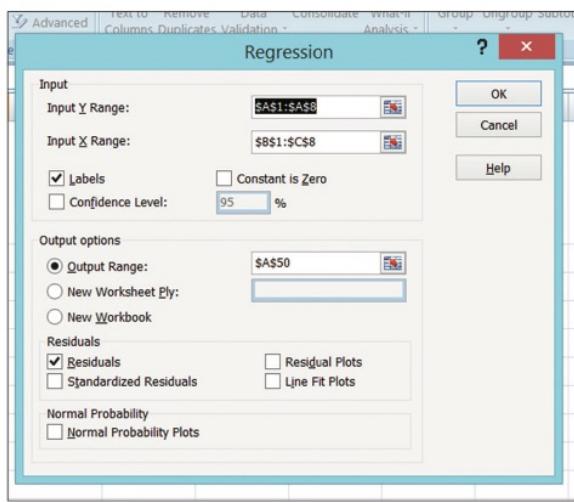


Figure 4: The regression screen. Choose Data > Data Analysis > Regression. Input y Range: A1:A8. Input X Range: B1:C8. Check Labels, Residuals, Output Range as A50.

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How to read a paper

When you master that
keep up with:

Technical language

Diagrams/graphs

Tables (data)

Results

Software

References

Note:

- Highlight key concepts
- Look through references

HOW TO CALCULATE LINEAR REGRESSION?

Linear regression can be tested through the SPSS statistical software (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.) in five steps to analyze data using linear regression. Following is the procedure followed Tables 1-4:

Click Analyze > Regression > Linear > then select Dependent and Independent variable > OK (enter).

Example 1 – Data ($n = 55$) on the age and the SBP were collected and linear regression model would be tested to predict BP with age. After checking the normality assumptions for both variables, bivariate correlation is tested (Pearson's correlation = 0.696, $P < 0.001$) and a graphical scatter plot is helpful in that case [Figure 2].

Now to check the linear regression, put SBP as the dependent and age as the Independent variable.

This indicates the dependent and independent variables included in the test.

Pearson's correlation between SBP and age is given ($r = 0.696$). $R^2 = 0.485$ which implies that only 48.5% of the SBP is explained by the age of a person.

The ANOVA table shows the “usefulness” of the linear regression model with $P < 0.05$.

Finally:

Read it more than once

Check details

Replicate it

Note:

- Look for technicalities you don't understand

How to read a **paper**

Read the paper
titled “How to Read
a Paper”

How to Read a Paper

S. Keshav

David R. Cheriton School of Computer Science, University of Waterloo
Waterloo, ON, Canada
keshav@uwaterloo.ca

How to read a **paper**

You can search for **free papers** in several websites,
but you may know the **characteristics between them**

Scientific papers



- Author (well-known)
- Long process to be accepted and published
- Peer reviewed (peer to peer)

White papers



- Author (Anonymity)
- Anyone can submit a paper
- Community review

How to read a **paper**

White papers

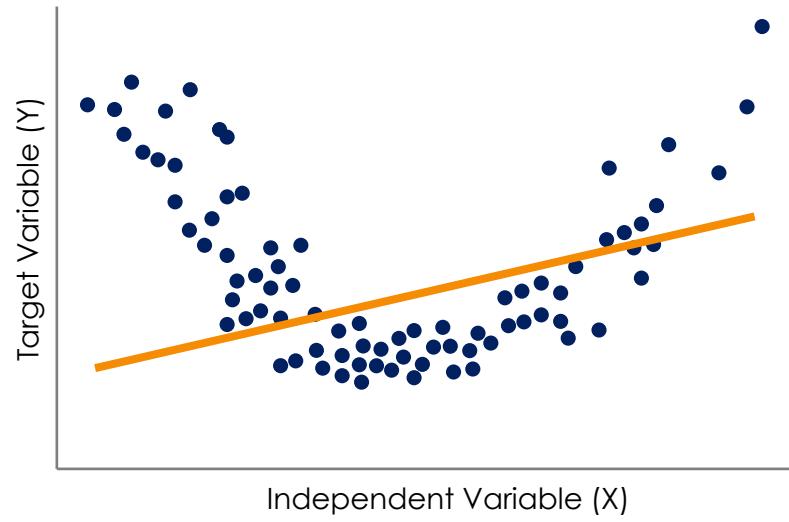


Even when the article or paper is not peer to peer review that **does not** mean there is no quality in them

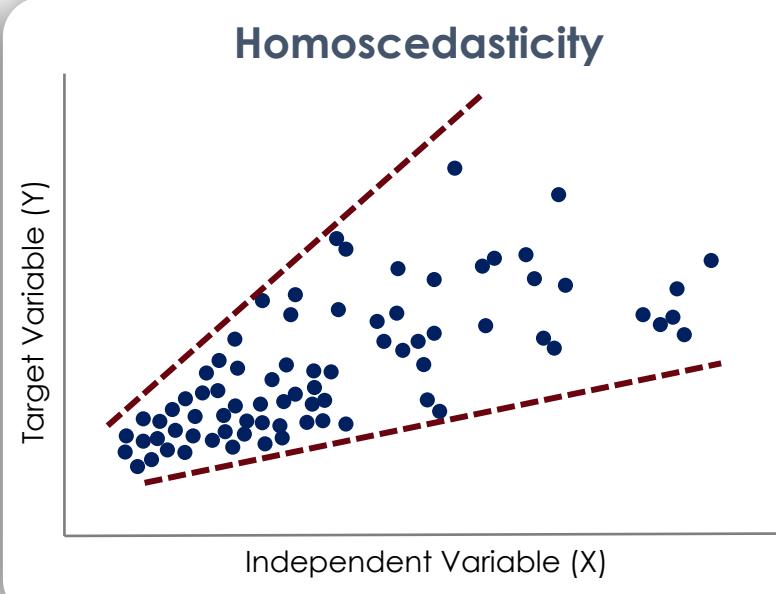
Gregory Perelman submitted an article in ArXiv with the resolution of the **Poincaré conjecture** (one of the millennium problems)

OLS Assumptions

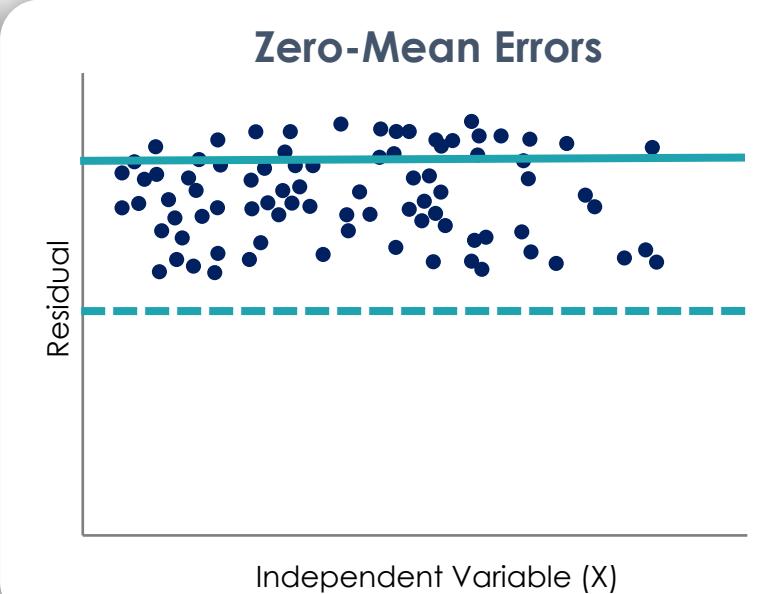
Linearity



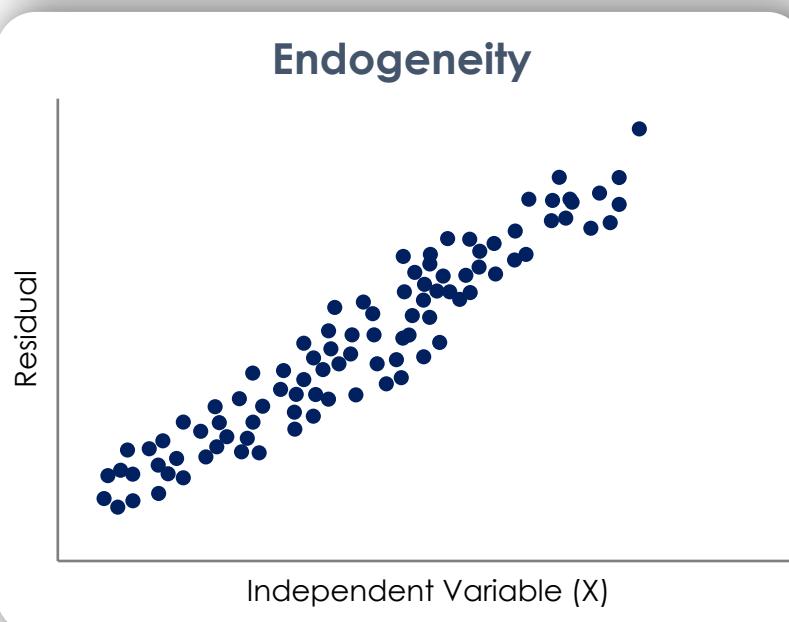
Homoscedasticity



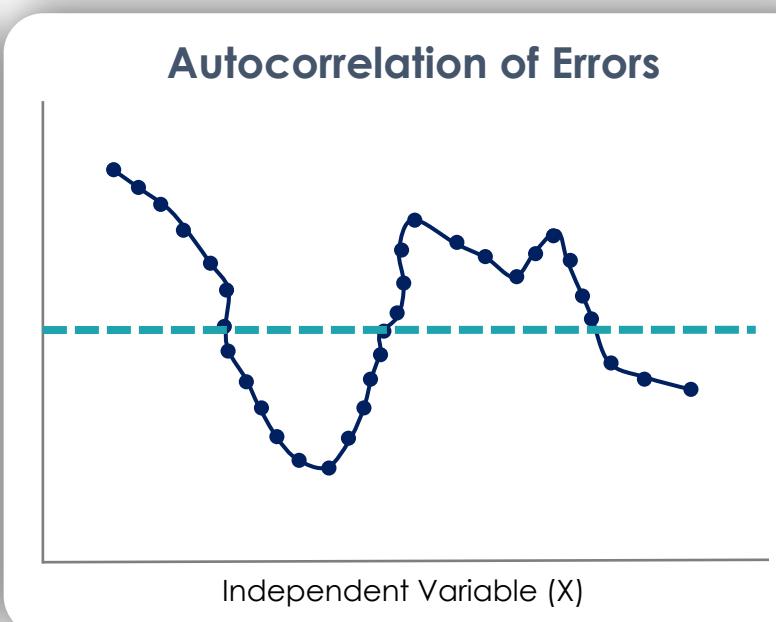
Zero-Mean Errors



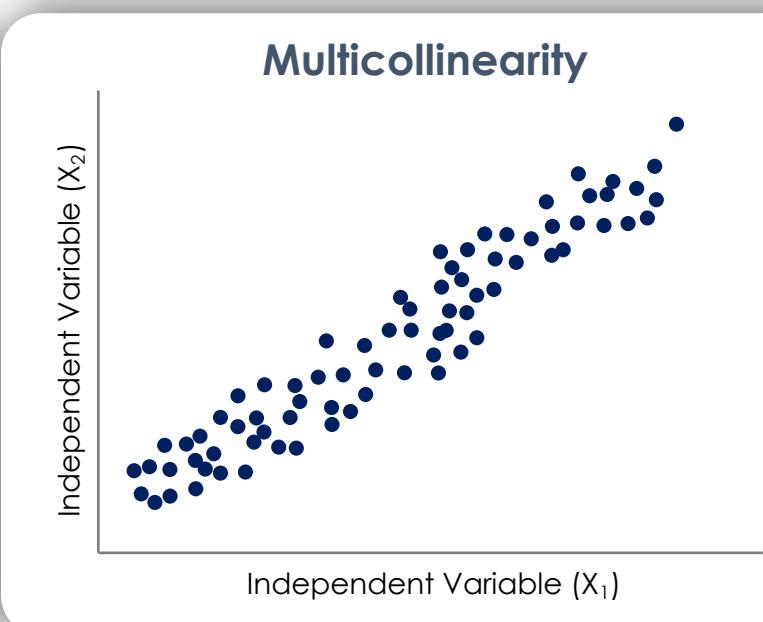
Endogeneity



Autocorrelation of Errors



Multicollinearity



Terminology

y

Dependent variable

x

Explanatory variable

Explained variable

Independent variable

Predictand

Predictor

Regressand

Regressor

Response

Stimulus

Endogenous

Exogenous

Outcome

Convariate

Controlled variable

Control variable

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