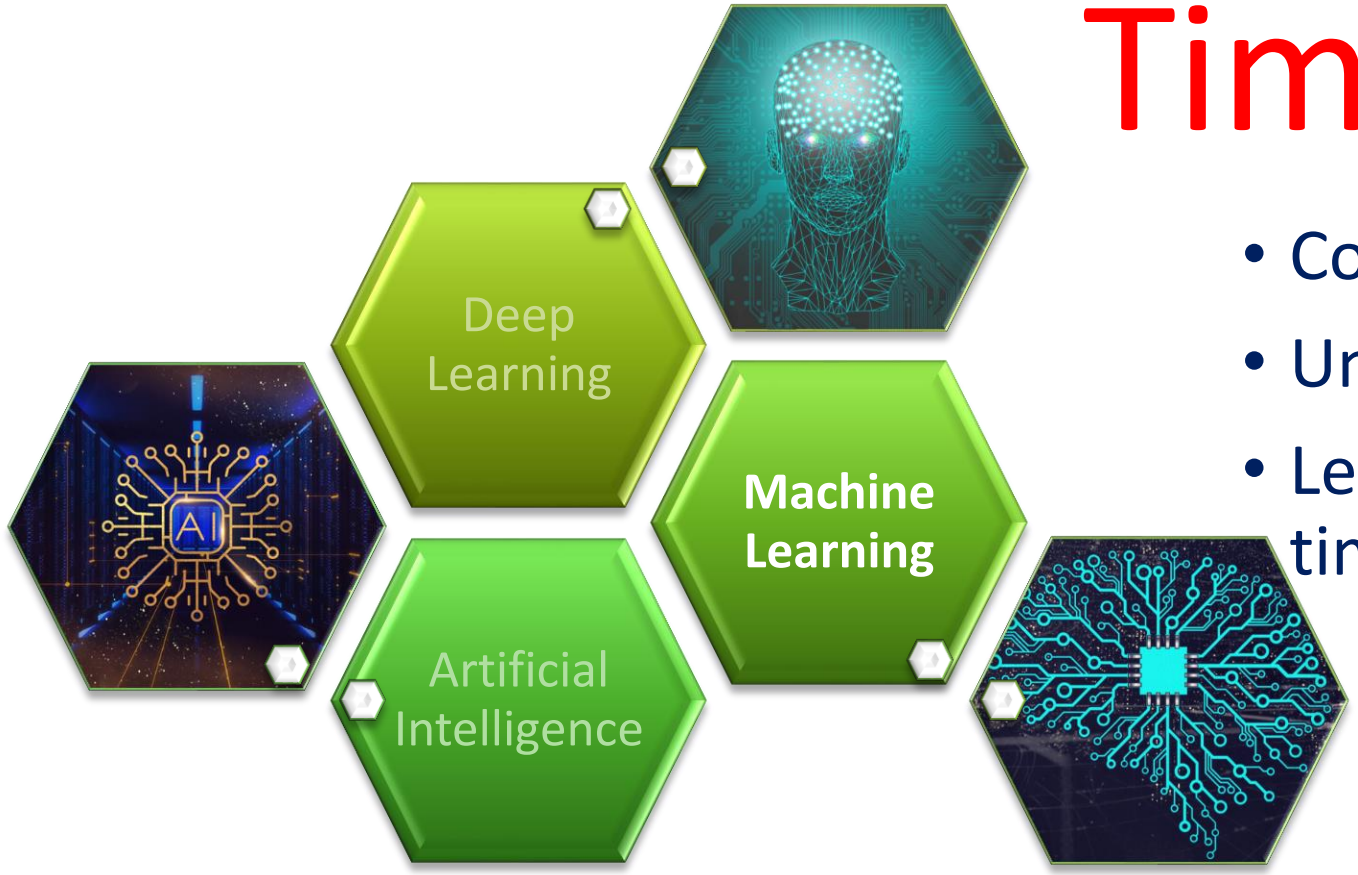


Time Series

- Course Code: CSE471
- Unit 1: **Time Series: An Introduction**
- Lecture 1: Introduction & History of time series in Diverse Applications,

Course Contents/Syllabus:

	Weightage (%)
Module I : Time Series: An Introduction History of Time series in Diverse Applications, Origin of Statistical Time Series Analysis, Origin of Machine Learning Time Series Analysis, Finding and Wrangling Time Series Data, Where to find Time Series Data, Retrofitting a Time Series Data Collection from a Collection of Tables, Data Cleaning	20%
Module II : Exploratory Data Analysis for Time Series Familiar Methods-Plotting, Histograms and Scatter Plots, Specific Exploratory Methods- Understanding Stationarity, Window Functions, Self correlation, Spurious correlations, Visualizations- 1D, 2D and 3D, Simulating Time Series Data, Storing Data- defining requirements of Live vs Stored Data, Database Solutions vs File Solutions	20%
Module III : Statistical & State Space Models for Time Series Autoregressive Models, Moving Average Models, Autoregressive Integrated Moving Average Models, Vector Autoregression, State Space Models-Plusses and Minuses, Kalman Filter, Hidden Markov Model, Bayesian Structural Time Series	20%
Module IV : Machine Learning & Deep Learning for Time Series Time Series Classification-Selecting and Generating Features, Decision Tree Methods, Clustering- Generating Features from the Data, Temporally Aware Distance Metrics, Clustering Code, Deep Learning Concepts-Programming Neural network, Feed Forward Networks- CNN and RNN	25%
Module V : Performance Measurement and Applications of Time series Models Measuring Error- How to Test Forecasts, Applications of Time Series in Healthcare, Financial Applications,	15%


I wonder if I can predict the stock prices for tomorrow!


Well, you can actually do that with Time Series forecasting

Well, you can actually
that with Time Series
forecasting

We can predict:

Daily Stock Price

Weekly interest rates

Sales figures

where the outcome (independent variable) is dependent on time

In such scenarios, we use Time Series forecasting

What is Time Series?

It is a random sequence recorded in a time ordered fashion

What is Time Series?

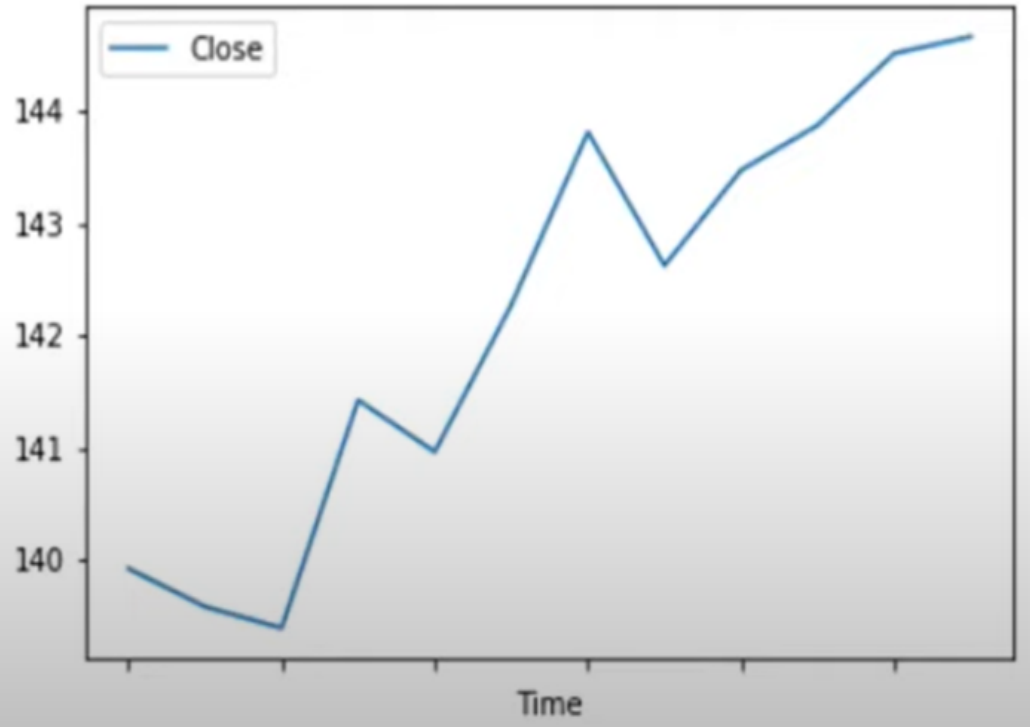
A Time Series data for stock price analysis may look like this:

	A	B
1	Date	Close
2	1/4/2017	139.92
3	2/4/2017	139.58
4	3/4/2017	139.39
5	4/4/2017	141.42
6	5/4/2017	140.96
7	6/4/2017	142.27
8	7/4/2017	143.81
9	8/4/2017	142.62
10	9/4/2017	143.47
11	10/4/2017	143.87
12	11/4/2017	144.51
13	12/4/2017	144.66

The stock prices change everyday!

What is Time Series?

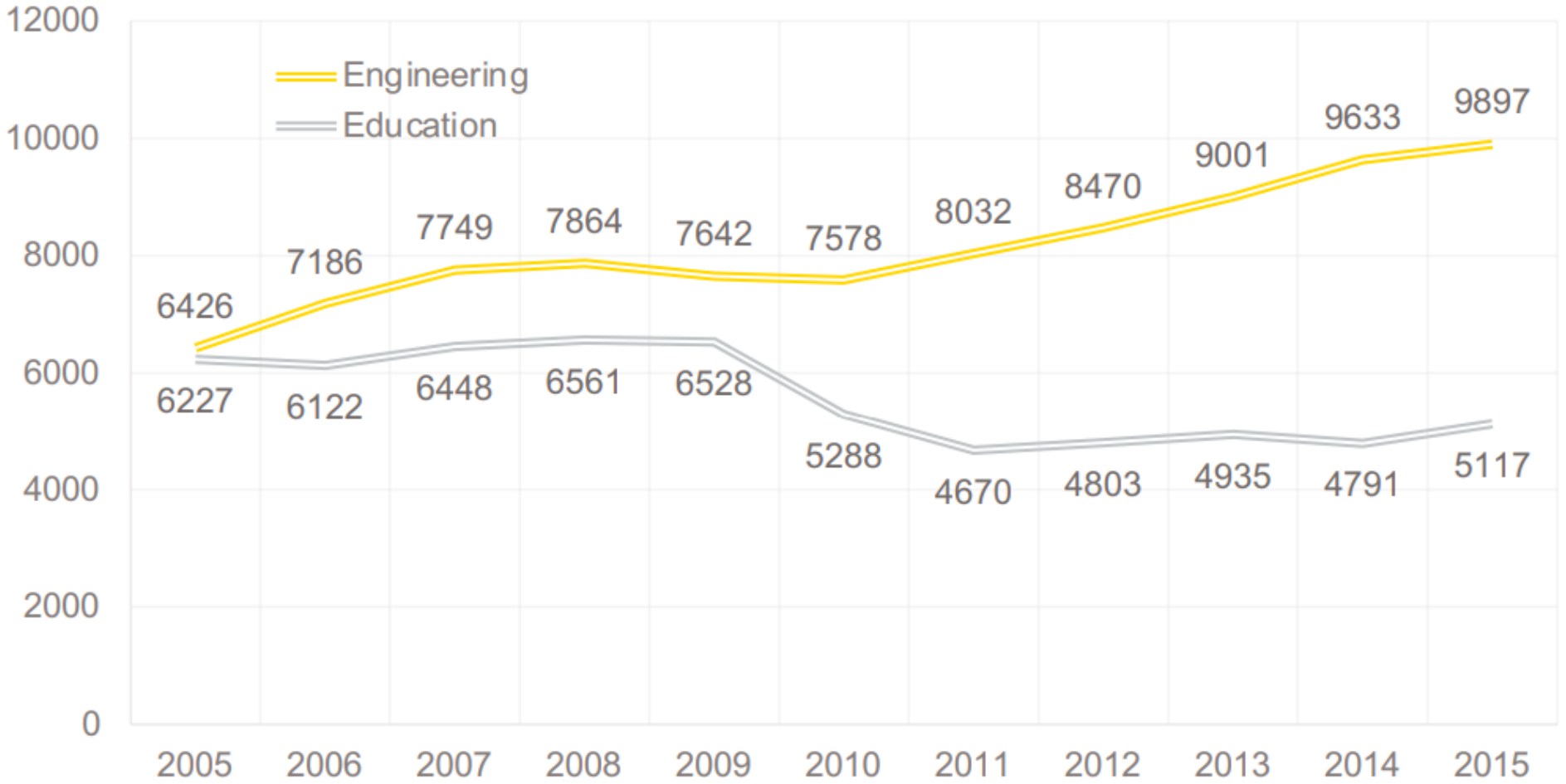
A simple plot shows that it is increasing with time!



Examples

Time series example 1

Numbers of Doctorates Awarded in US, annual data – Engineering Vs. Education



At a glance

Annual data

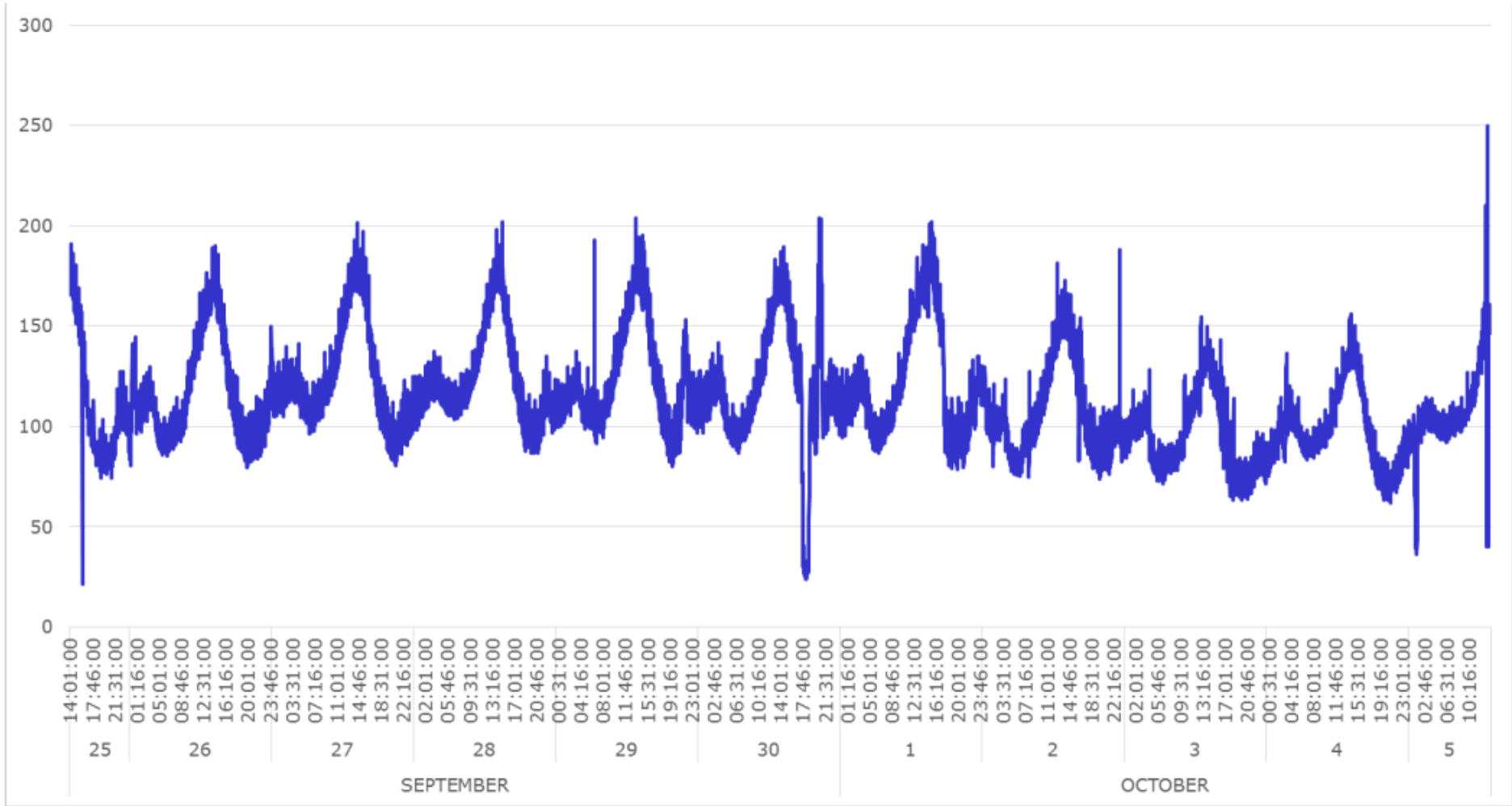
Different «directions»

No big fluctuations

Examples

Time series example 4

Number of photos uploaded on the Instagram every minute (regional sub-sample)



At a glance

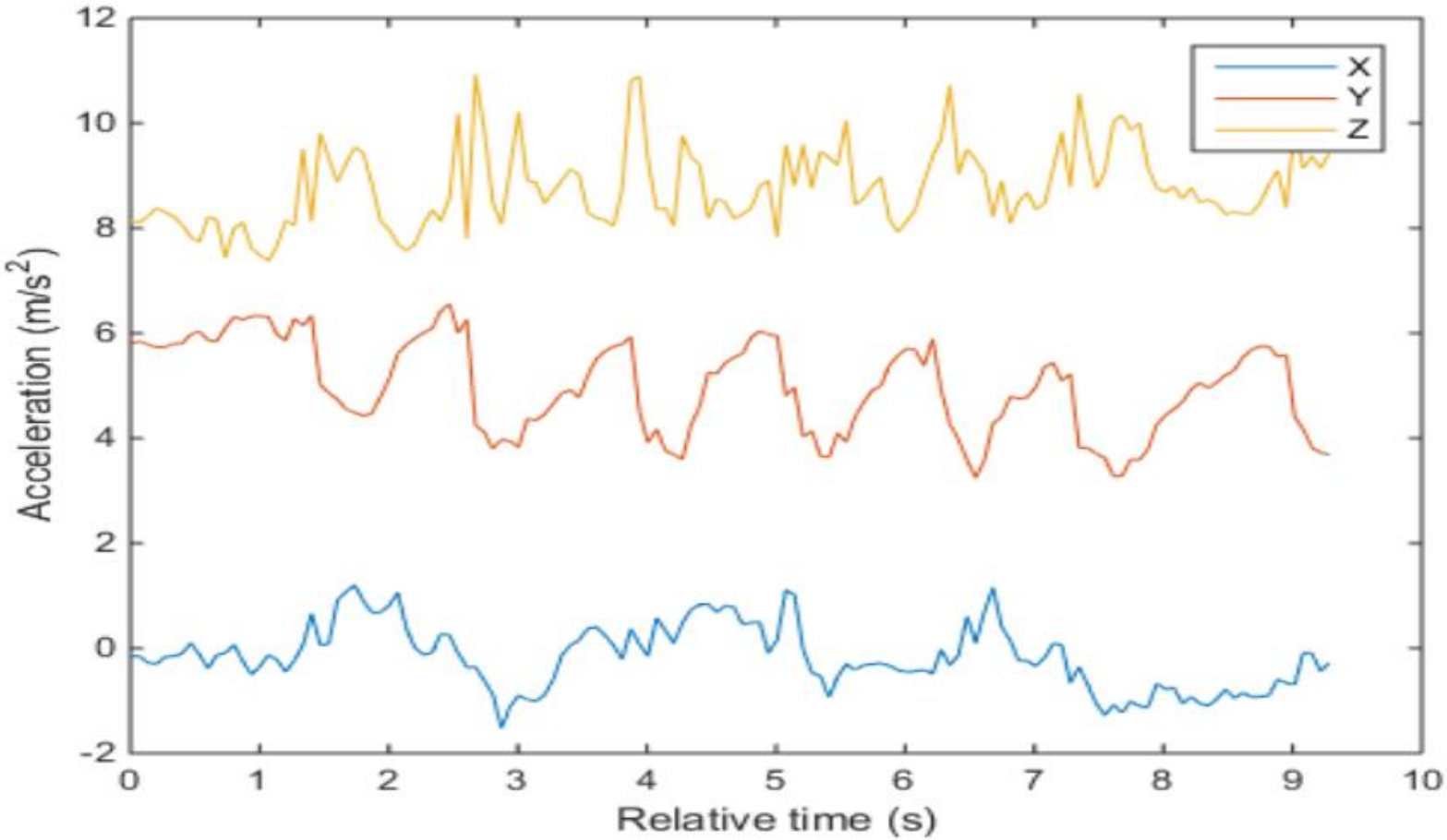
Minute basis data

Almost regular daily pattern but with some anomalies and spikes

Examples

Time series example 5

Acceleration detected by a smartphone sensors during a workout session (10 seconds)



At a glance

Milliseconds basis data

Each sensor has its own dynamics

What is Time Series?

A Time Series is a sequence of data being recorded at specific time intervals

These data points (past values) are analyzed to forecast a future

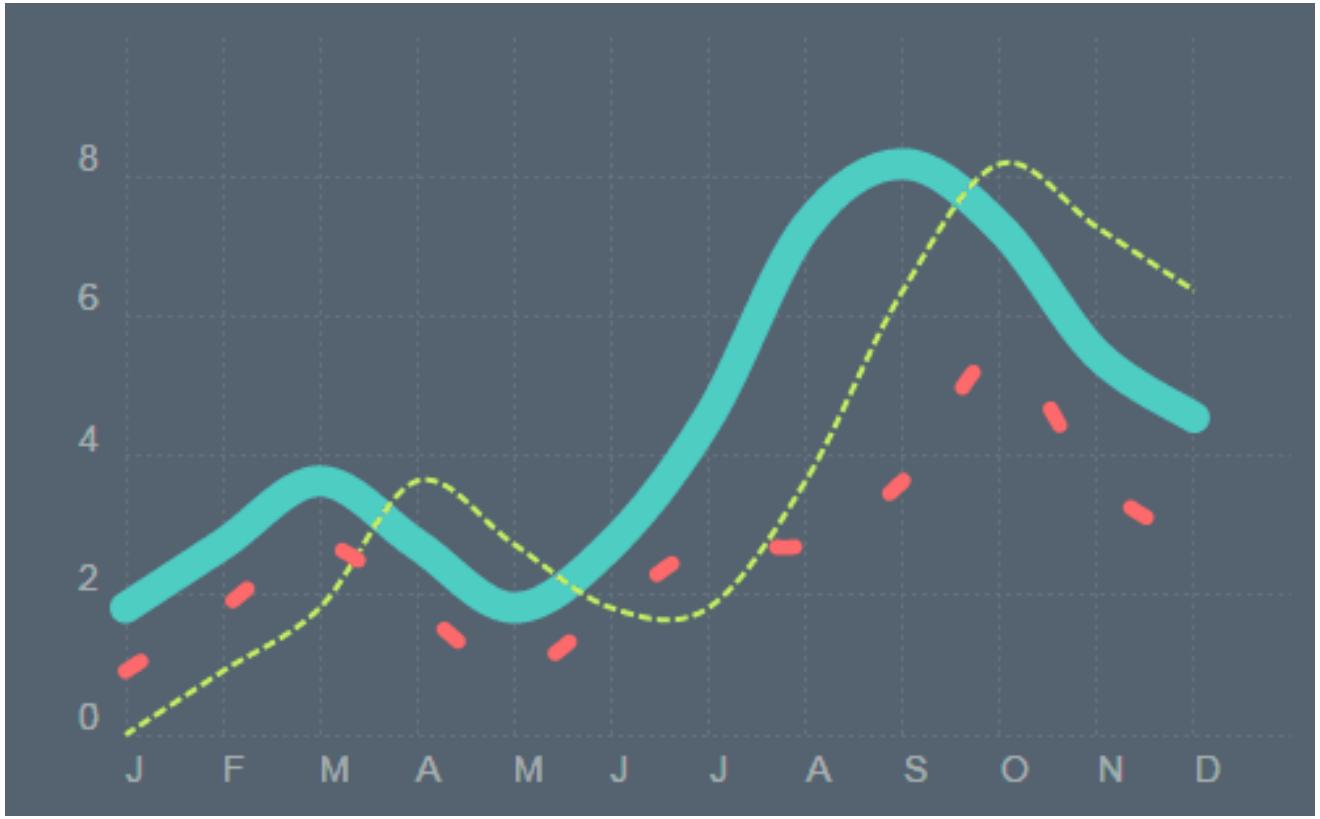
It is time-dependent

What is time Series Analysis

- Time series analysis is the endeavor of extracting meaningful summary & statistical information from points arranged in temporal order.
- It is to diagnose past behavior to make predictions about future behavior.
- The most common concerns of time series analysis are forecasting the future and classifying the past

What is time Series Analysis

- Time Series Analysis and Forecasting helps us to analyze and forecast or compute the probability of an incident, based on data stored with respect to changing time



History Time series in Diverse Application

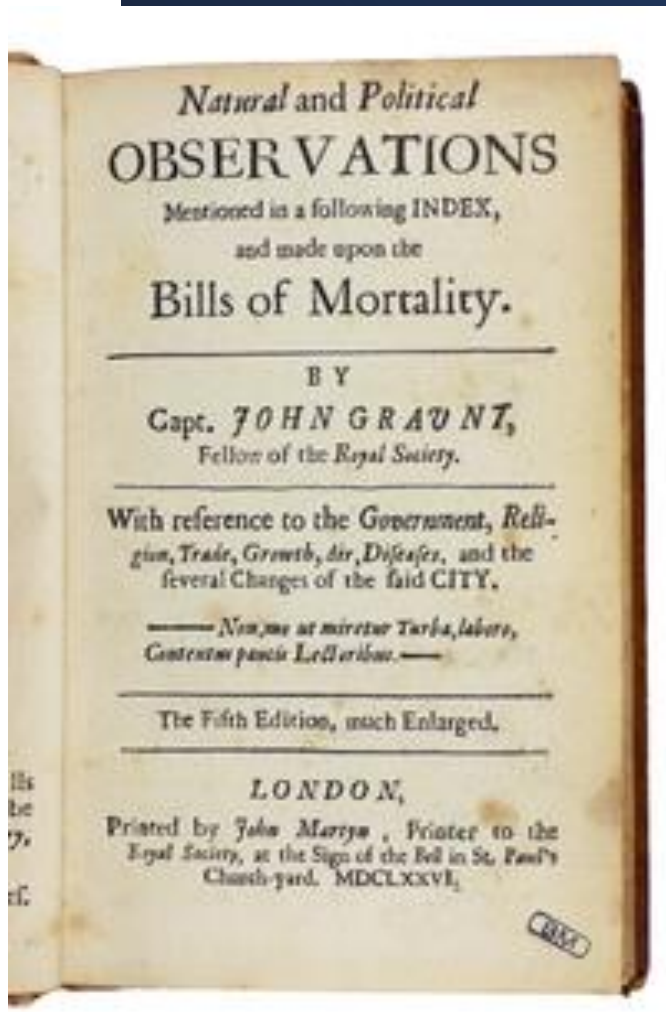
Time series analysis includes questions of causality: how did the past influence the future?

Earlier Often such problems, and their solutions, go unlabeled as time series problems.

History Time series in Diverse Application

1. Medicine as a time series analysis

- John Graunt's actuarial tables were one of the first results of time series style thinking applied to medical questions



Natural and *Political*

OBSERVATIONS

Mentioned in a following INDEX,

and made upon the

Bills of Mortality.

BY

Capt. JOHN GRAUNT,

Fellow of the *Royal Society*.

With reference to the *Government, Religion, Trade, Growth, Air, Diseases*, and the several Changes of the said CITY.

——*Non me ut miretur Turba, laboro,*
Contentus paucis Lectoribus.——

The Fifth Edition, much Enlarged.

LONDON,

Printed by *John Martyn*, Printer to the *Royal Society*, at the Sign of the Bell in St. *Paul's* Church-yard. MDCLXXVI.

History Time series in Diverse Application

1. Medicine as a time series analysis

- its way into medicine even before the standardization of the randomized control study over a century ago, when electrocardiograms3 (ECGs) were invented in 1903.

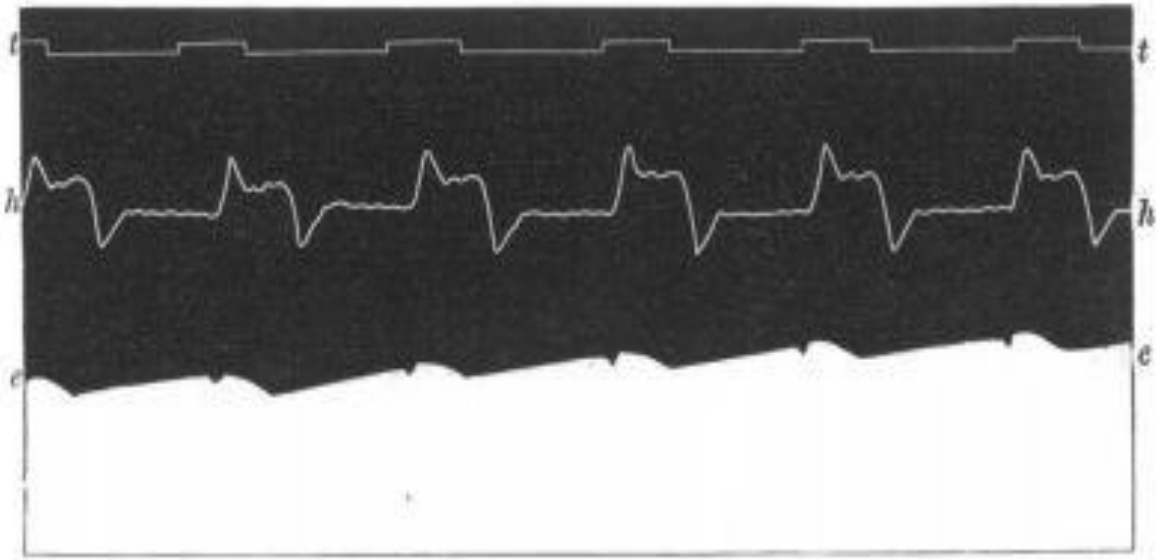
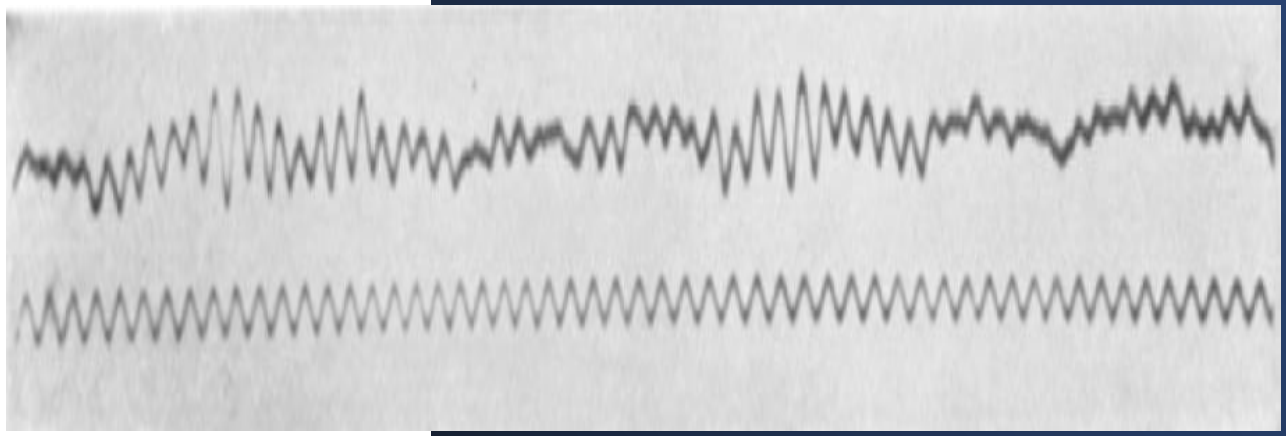


FIG. 1. Man. Heart led off to electrometer from front and back of chest (front to Hg; back to H_2SO_4).
e.e. electrometer. *h.h.* cardiograph. *t.t.* time in seconds.

History Time series in Diverse Application

1. Medicine as a time series analysis
   - The first human EEG (electroencephalogram) recording, from 1924



History Time series in Diverse Application

2. Forecasting Economic Growth

- The US federal government funds many government agencies and related non-profits who record vital statistics as well as formulating economic indicators. This is the table of statistics about business cycles provided by the National Bureau of Economic Research.

BUSINESS CYCLE REFERENCE DATES		DURATION IN MONTHS			
Peak	Trough	Contraction	Expansion	Cycle	
Quarterly dates are in parentheses		*Peak to Trough*	*Previous trough to this peak*	*Trough from Previous Trough*	*Peak from Previous Peak*
	December 1854 (IV)	--	--	--	--
June 1857(II)	December 1858 (IV)	18	30	48	--
October 1860(III)	June 1861 (III)	8	22	30	40
April 1865(I)	December 1867 (I)	32	46	78	54
June 1869(II)	December 1870 (IV)	18	18	36	50
October 1873(III)	March 1879 (I)	65	34	99	52
March 1882(I)	May 1885 (II)	38	36	74	101
March 1887(II)	April 1888 (I)	13	22	35	60
July 1890(III)	May 1891 (II)	10	27	37	40
January 1893(I)	June 1894 (II)	17	20	37	30
December 1895(IV)	June 1897 (II)	18	18	36	35
June 1899(III)	December 1900 (IV)	18	24	42	42
September 1902(IV)	August 1904 (III)	23	21	44	39

History Time series in Diverse Application

2. Forecasting Economic Growth

- “AI” thinking of the 1980s”

Richard Dennis

The Once and Futures King

By DONALD R. KATZ

I first heard of Richard Dennis six years ago while standing amid the din of the shimmering deco lobby underneath the trading floor of the Chicago Board of Trade. A circle of brightly jacketed commodities traders were naming those few among their closed fraternity who traded futures contracts in such voluminous quantities that they no longer could afford to deal in the hand-to-hand combat of the pits. The mere rumor that one of these men was on the floor of the exchange caused markets to bend all out of shape. Fear of being on the wrong side of one of these biggest-of-the-big traders was such that markets setting a world price for food, ore, and financial instruments would literally seize up if one of them was spotted moving toward a trading pit. Thus, the monster traders preferred to trade their daily millions of bushels, boxcars, and bonds as quietly as possible. They operated through floor brokers, trading by remote control from yachts or mountain retreats or from tiny offices a few blocks from the exchange. Some of them hadn't been seen in years. But they were there in the markets... like myths.

One of the titans, I heard that day in 1980, was little more than thirty years old. It was said that he was a painfully shy, overweight kid who wore thick glasses and polyester pants and until recently still lived at home with his mom and dad. Richie Dennis was the hermit-wizard of the trade, a local street kid up from the old neighborhoods of the Southwest Side who was given to dubious political opinions by the standards of most money-market men, and who was probably the single most gifted speculator of his own generation and possibly a degree or two better than any traders of the generation before him.

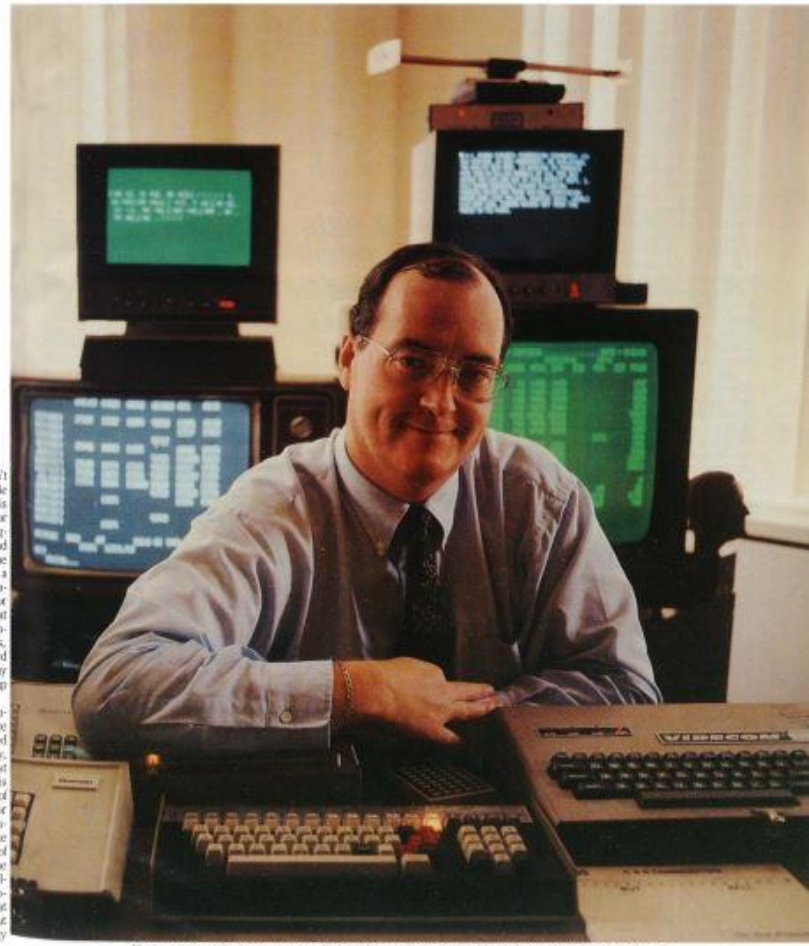
Richard Dennis was already obsessed with the ways of money and markets before he was twelve. While he was still a teenager, his father agreed to come up with the $1,400 needed to purchase a trading badge at the small MidAmerica Commodity Exchange, and his brother offered a $400 grub stake culled from his pizza-delivery savings, but because Rich wasn't yet twenty-one, he wasn't allowed to trade on the floor. He managed to persuade his father—who worked a blue-collar job for the city and possessed a healthy workingman's skepticism for speculation and speculators—to stand in for him on the floor and trade, while he directed from a seat on the sidelines. Upon reaching majority, Rich retired his father from floor trading. For a while Dennis Sr. would, at the end of each day, inquire of his introverted son how he'd fared in the markets, but eventually the figures he heard ceased to have meaning. "Let's just say Richie ran that four hundred bucks up pretty good," he says now.

Rich attempted to step away from the futures markets in order to accept a graduate scholarship to Tulane, where he intended to refine his deep interest in philosophy, but after a week at Tulane, spending most of his time in phone booths monitoring his trades, he decided to give in to the pull of the pits, and henceforth to apply his feel for philosophical conjecturing to the metaphysics of financial markets. An associate would ask him later if his application of philosophy to trading had changed since he turned pro. "At first, I thought that intelligence was reality and price the appearance," Dennis answered in that subdued, almost laconic voice of his, "but after a while I saw that price is the reality and intelligence is the appearance."

BUSINESS & INDUSTRY

RICHARD DENNIS
Commodities trader
Chicago, Ill.
b. 1/9/49

By most accounts, the largest and most successful individual commodities trader in the world. Increasingly turning his resources to politics. Started and now bankrolls the Roosevelt Center for American Policy Studies. Has backed such candidates as Mayor Harold Washington and Adlai Stevenson III.

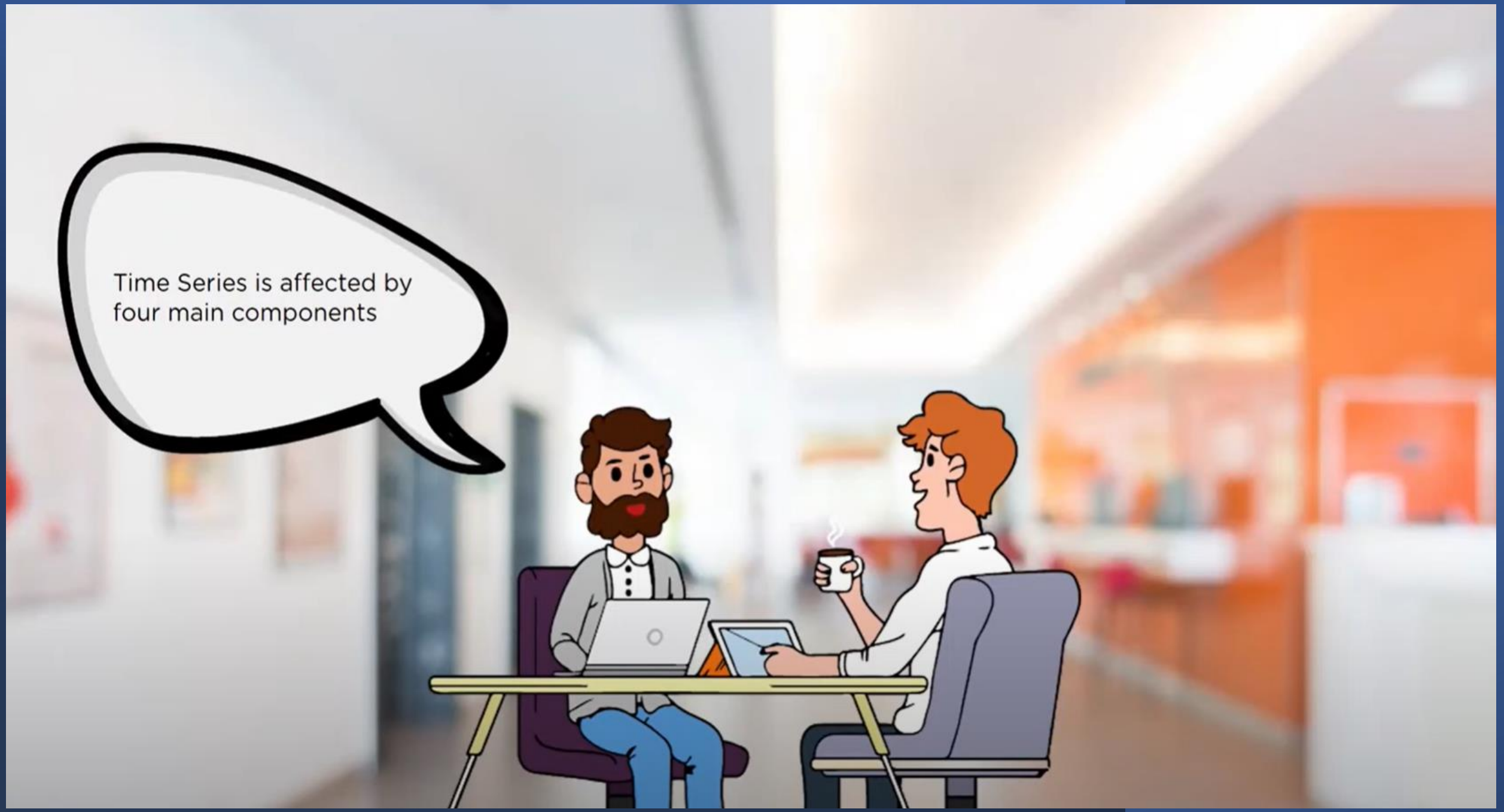


Having mastered the futures market, Richard Dennis hopes to extend his influence from the pits to the polls.

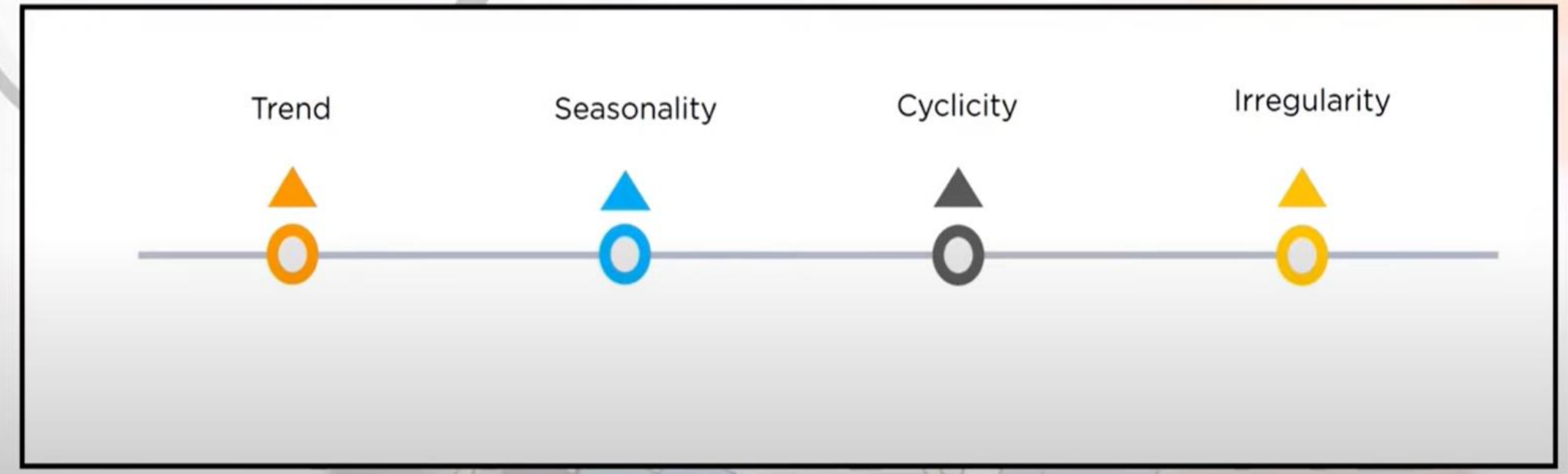
History Time series in Diverse Application

3. Weather Forecasting.

- “Predicting the weather remains fundamentally a time series problem where past measures are used to predict future ones, both with physical reasoning and also with statistical assumptions.”


Time Series is affected by
four main components

Time Series is affected by
four main components



Time Series is affected by four main components

Trend

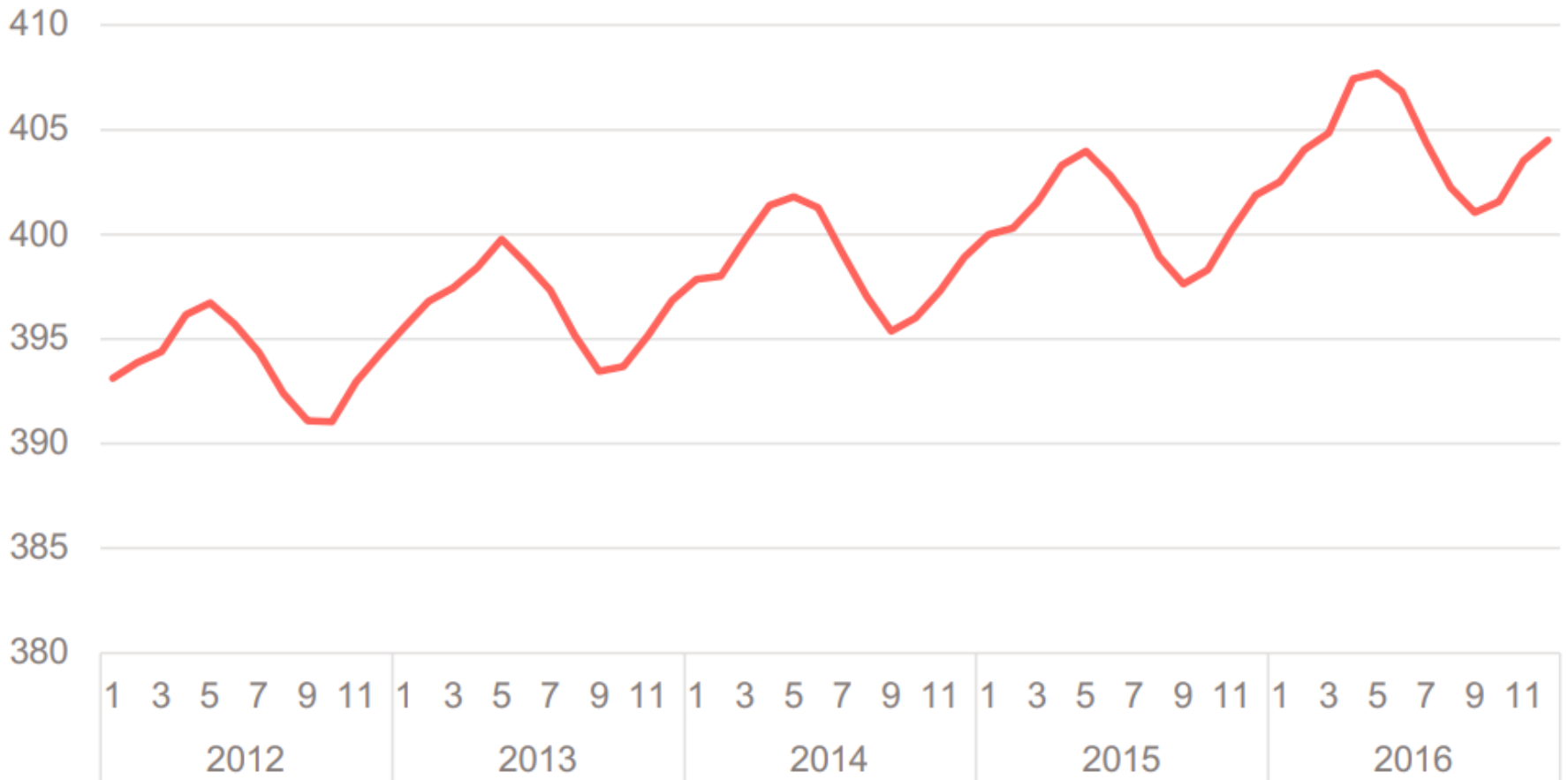
Trend is the increase or decrease in the series over a period of time, it persists over a long period of time

Example: Population growth over the years can be seen as an upward trend

Examples

Time series example 2

Monthly carbon dioxide concentration (globally averaged over marine surface sites)



At a glance

Monthly basis data

Regular pattern

Constant fluctuations

Average value increases year by year

Time Series is affected by four main components

Seasonality

Regular pattern of up and down fluctuations
It is a short-term variation occurring due to seasonal factors

Example: Sales of ice-cream increases during summer season

season

Time Series is affected by four main components

Cyclicity

It is a medium-term variation caused by circumstances, which repeat in irregular intervals

Example: 5 years of economic growth, followed by 2 years of economic recession, followed be 7 years of economic growth followed by 1 year of economic recession

Time Series is affected by four main components

Irregularity

- It refers to variations which occur due to unpredictable factors and also do not repeat in particular patterns
- Example: Variations caused by incidents like earthquake, floods, war etc.

Examples

Time series example 3

LinkedIn daily stock market closing price

At a glance

Daily basis data

Very irregular dynamic

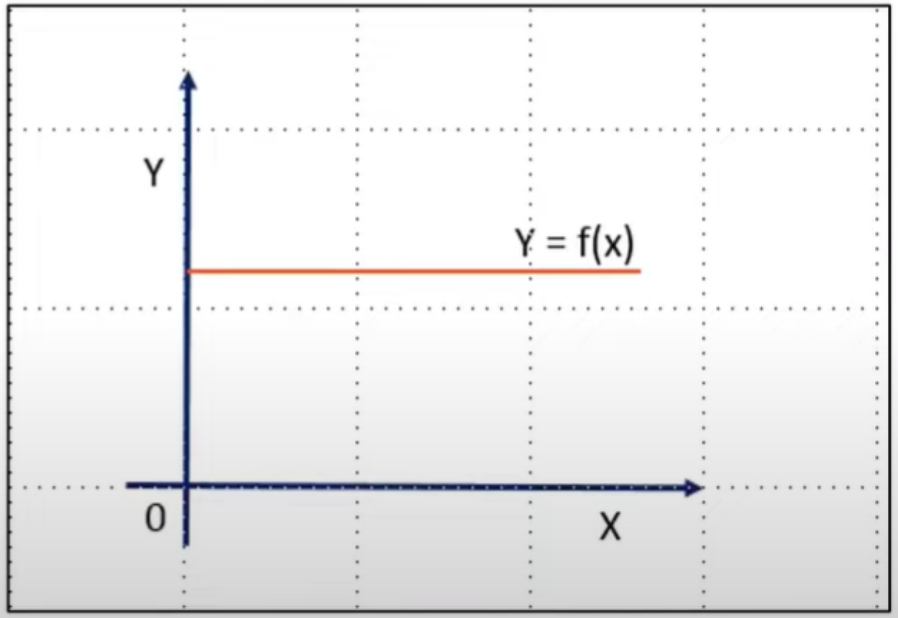
Many sudden changes


Are there conditions where we shouldn't use Time Series?

When NOT to use Time Series Analysis?

There are various conditions where you should not use Time Series:

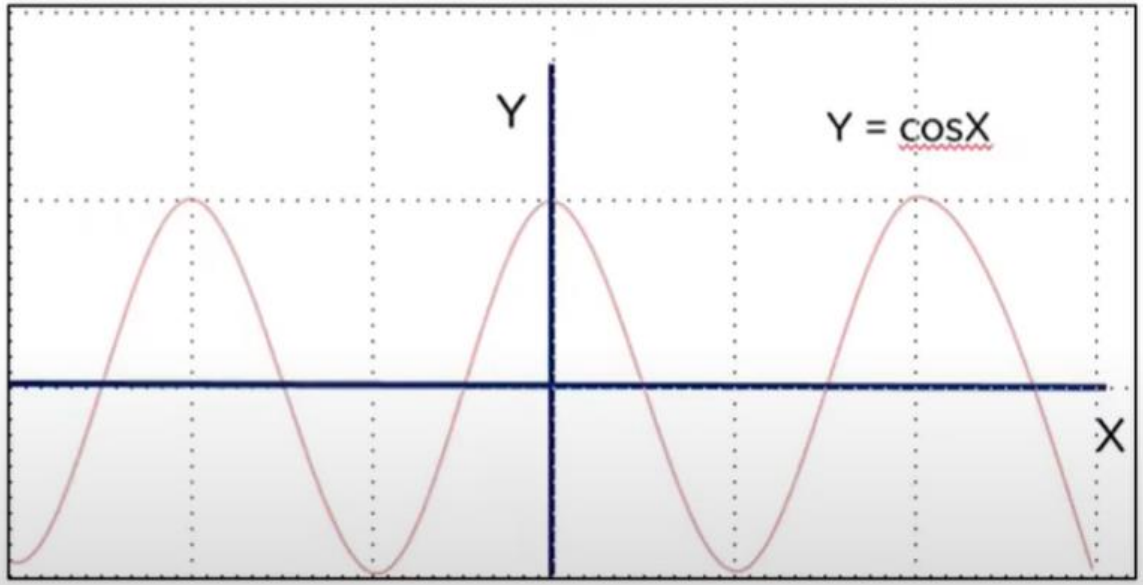
1. When the values are constant over a period of time:



When NOT to use Time Series Analysis?

There are various conditions where you should not use Time Series:

2 When values can be represented by known functions like cosx, sinx etc:



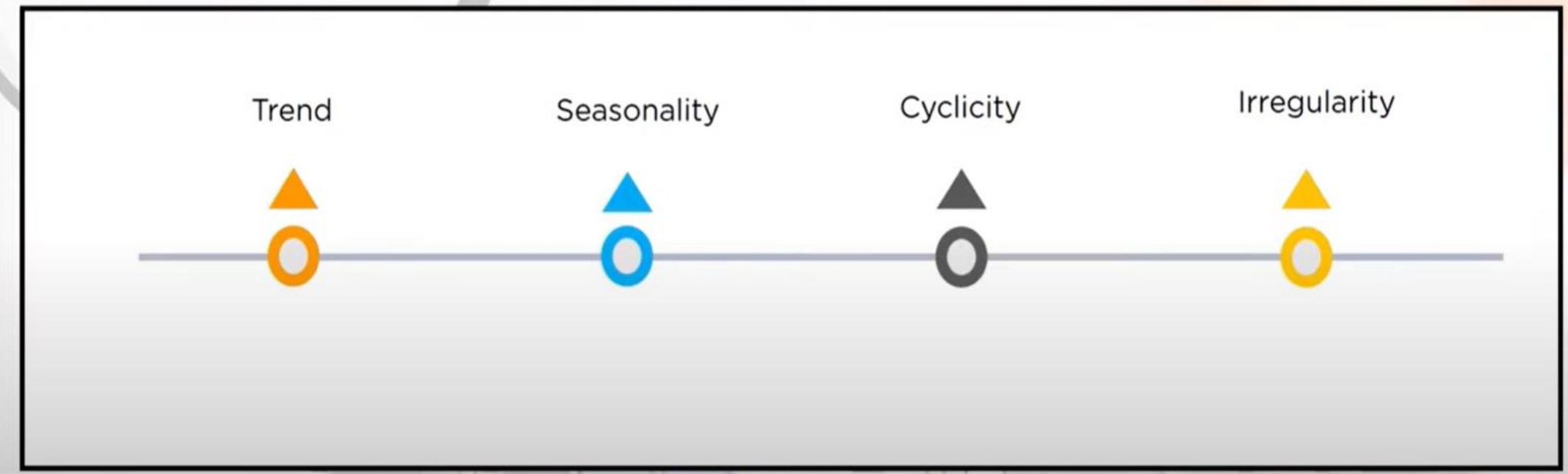

Before forecasting, you should make sure that Time Series is stationary


Why? And what do you mean by making time series stationary?


Okay, first let's understand what is Non-Stationary Time Series!


You remember the four components of Time Series?

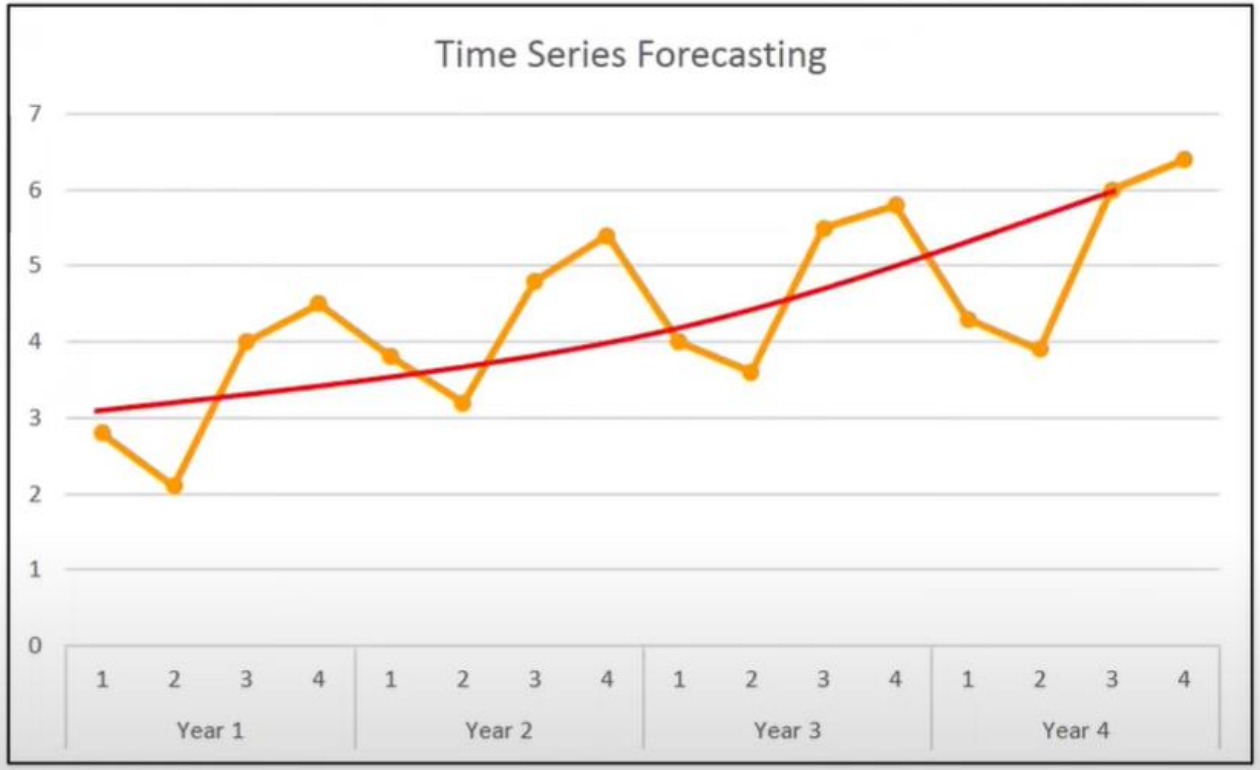
Time Series is affected by four main components




If these components are present in Time Series data, it is a Non-Stationary Time Series Data.

For example, look at this graph:

Here, the mean is non-constant and there is clearly an upward trend



Stationarity of Time Series

A Non-stationary Time Series has trend and seasonality components, which will affect the forecasting of Time Series

When a Time Series is stationary, we can identify previously unnoticed components to strengthen their forecasting

Common ways to convert time series data to stationary:

- Differencing: Differencing is a method of removing trends from time series data. This is done by subtracting the previous value from the current value.
- Logarithm transformation: The logarithm transformation is a method of transforming the data to make it more stationary. This is done by taking the logarithm of the data.
- Seasonal adjustment: Seasonal adjustment is a method of removing seasonal patterns from time series data. This is done by estimating the seasonal components of the data and then subtracting them from the original data.
- Detrending: Detrending is a method of removing trends from time series data. This is done by fitting a trend line to the data and then subtracting the trend line from the original data.
- Combination of methods: In some cases, it may be necessary to use a combination of methods to make time series data stationary.