Regression Analysis

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Mentored 100+ people

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Agenda

- Introduction to Regression Analysis

  - What is Regression Analysis

  - Why do we need Regression Analysis in Business – Introduction to Modeling

- Introduction to OLS Regression

- Introduction to Modeling Process

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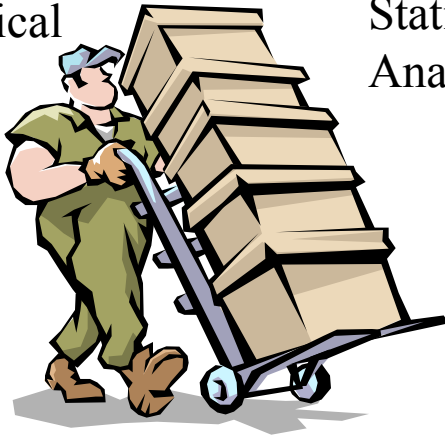# *What is Regression Analysis?*

Regression Analysis captures the relationship between one or more response variables (dependent/predicted variable – denoted by Y) and the its predictor variables (independent/explanatory variables – denoted by X) using historical observations of both.

Hence its estimates the functional relationship between a set of independent variables X_1, X_2, …, X_p with the response variable Y which estimate of the functional form best fits the historical data.
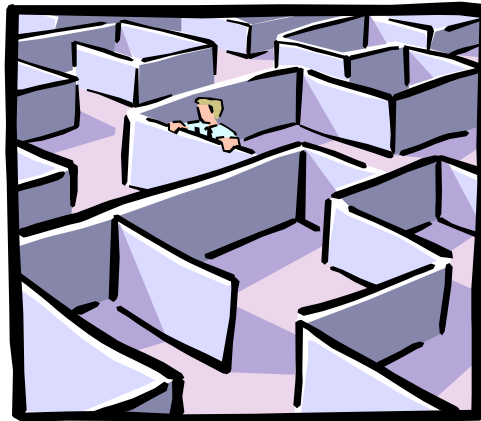
$$Y = f(X_1, X_2,.., X_p) + \epsilon$$

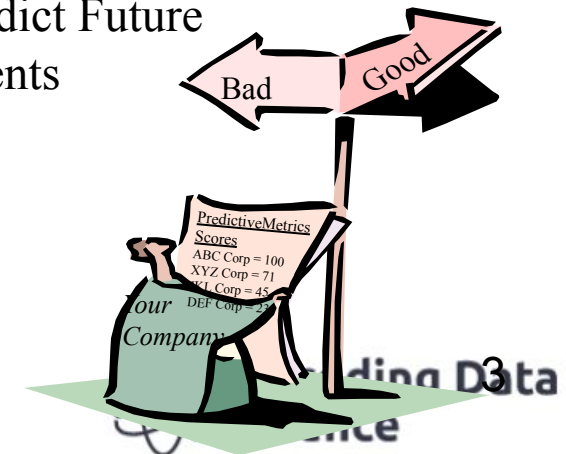where ϵ denotes the "Residual" or unexplained part of Y

Historical Data

Statistical Analyses

Predict Future Events

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Types of Regression Analysis

$$Y = f\,(X_1, X_2,..., X_p) + \epsilon$$

There are various kinds of Regressions based on the nature of : -

- the functional form of the relationship
- the residual
- the dependent variable
- the independent variables

Functional Form	Residual	Dependent Var	Independent Var
▪ **Linear** ▪ Non-Linear – *Out of scope for this presentation*	▪ Based on the distribution of the residual – normal, binomial, poisson, exponential	▪ **Single** ▪ **Continuous** ▪ **Discrete** ▪ **Binary** ▪ Multiple – *Out of scope for this presentation*	▪ Numerical ▪ Discrete ▪ Continuous ▪ Categorical ▪ Ordinal ▪ Nominal

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Types of Linear Regression

Dependent Variable Type	Residual Distribution	Types of Regression
Continuous	Normal (with constant variance)	Ordinary Least Squares (OLS)
Continuous	Normal (without constant variance)	Generalized Least Square
Binary	Binomial	Logistic Regression
Discrete	Poisson	Poisson Regression
Rational	Exponential Family of Distributions	Generalized Least Squares

Other Types of Regression Related Techniques

- Simultaneous Equation Models
  - When both X & Y are dependent on each other
- Structural Equation Modeling / Pathways
  - Captures the inter-relations between Xs i.e. captures how Xs affect each other before affecting Y
- Survival Analysis
  - Predicts a decay curve for a probability of an event
- Hierarchal Bayesian
  - Estimates a non-linear equation

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What is Modeling?

✔ Is based on Regression Analysis

✔ It can be used for the following two distinct but related purposes

    ✔ Predict certain events

    ✔ Identify the drivers of certain events based on some explanatory variables

✔ Isolates individual effects and then quantifies the magnitude of that driver to its impact on the dependent variable

✔ It is required because

    ✔ Knowledge of Y is crucial for decision making but is not deterministic

    ✔ X is available at the time of decision making and is related to Y

Volume = Base Sales + b_2(GRPs) + b_3(Dist) … + b_n(Price)

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- **Predict the sales that a customer would contribute, given a certain set of attributes like demographic information, credit history, prior purchase behavior, etc.**

- **Predict the probability of response from a direct mail thus saving cost and acquire potential customers.**

- **Identify high responsive and high profit segments and targeting only these segments for direct mail campaigns**

- **Identify the most effective marketing levers & quantify their impact**

- **To find out what differentiates between buyers and non buyers based on their past 3 months usage of the product and the age group**

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Introduction to Ordinary Least Squares

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Introduction to Ordinary Least Squares – Simple Regression

| Advertising	Sales
$120	$1,503
$160	$1,755
$205	$2,971
$210	$1,682
$225	$3,497
$230	$1,998
$290	$4,528
$315	$2,937
$375	$3,622
$390	$4,402
$440	$3,844
$475	$4,470
$490	$5,492
$550	$4,398
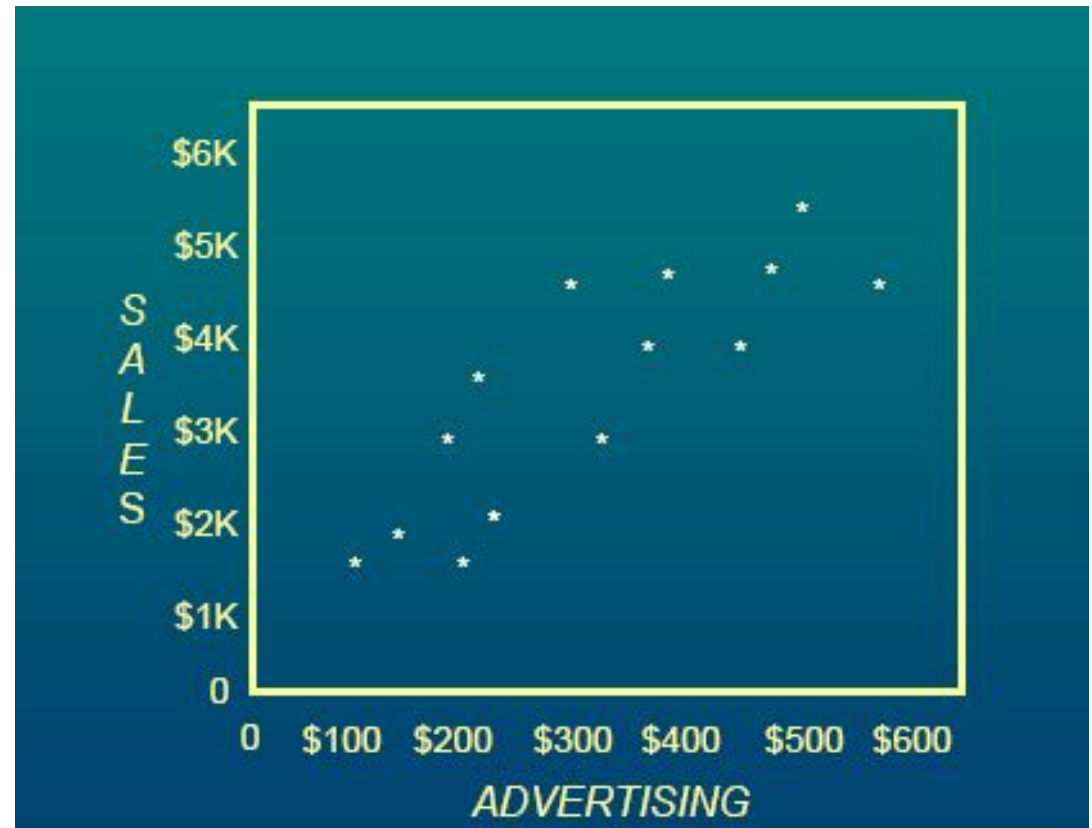
Goal: characterize relationship between advertising and sales
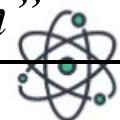
Introduction to Ordinary Least Squares – Simple Regression

Result: equation that predicts sales dollars based on advertising dollars spent
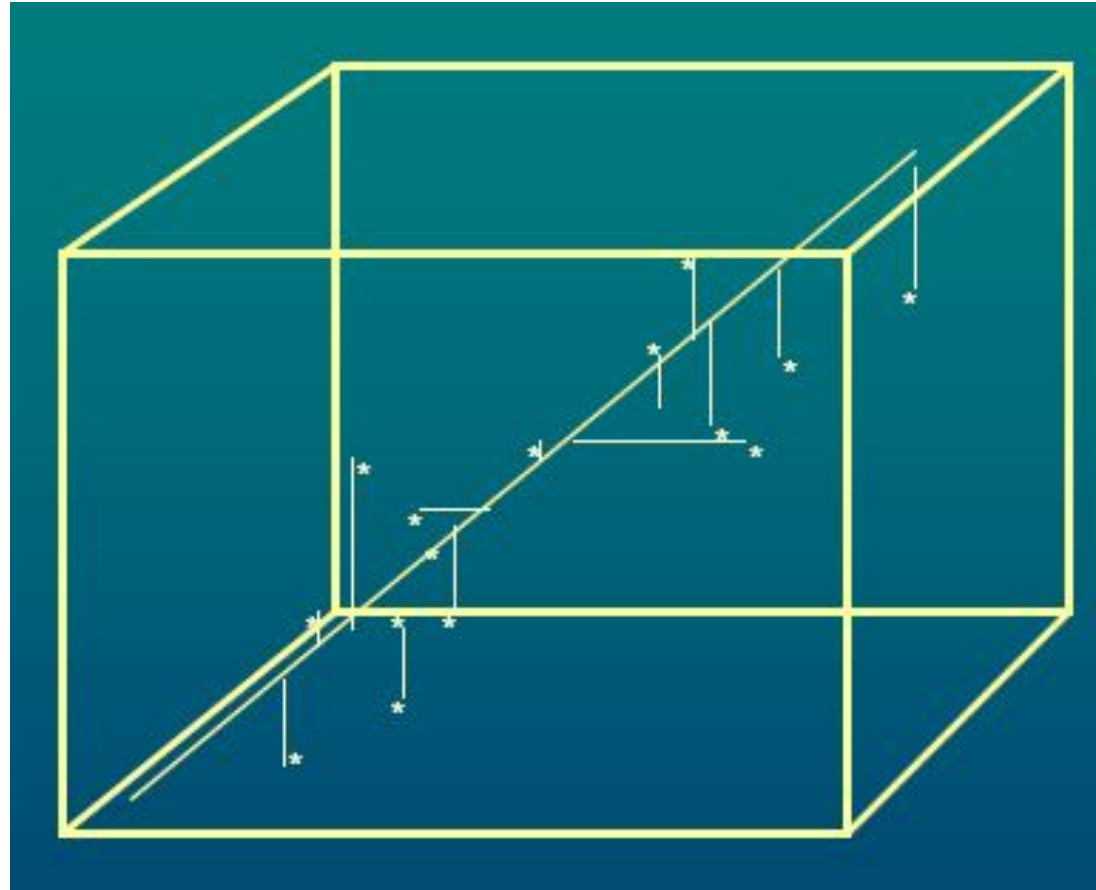
$$Sales = B_0 + B_1 * Adv.$$

Minimize Squared Error
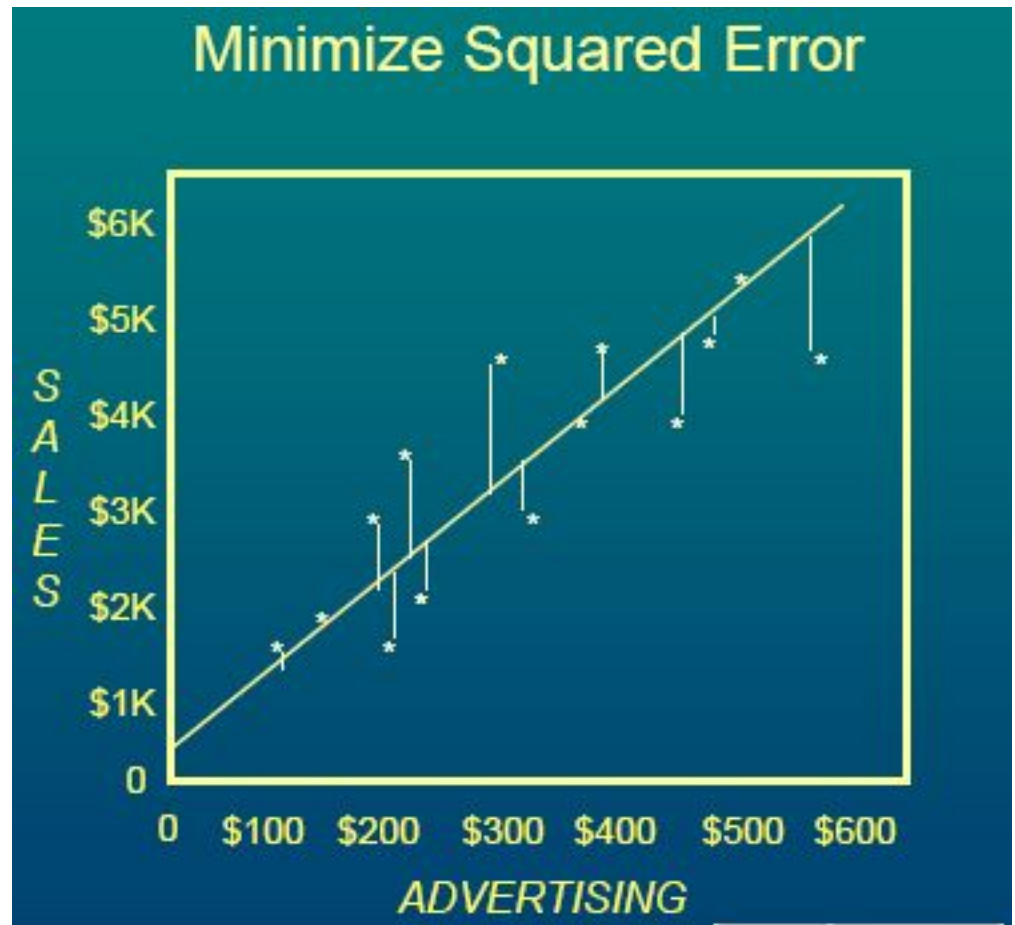
Minimizes Error sum of squares ,Hence the name

"Ordinary Least Square Regression"

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Introduction to Ordinary Least Squares – Multiple Regression

- Credit card balances
  - payment amount
  - years
  - gender (0/1)
- Minimizes squared error in N-dimensional space

Balances = 2.1774 +.0966*Payment + 1.2494*Months + .4412*Gender

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OLS Model Assumptions

1. **Linearity**

   Model is linear in parameters

   $$Y_i = a + b_1 X_{1i} + b_2 X_{2i} + \ldots + b_p X_{pi} + e_i$$

2. **Spherical Errors**

   Error distribution is Normal with mean 0 & constant variance

   $$e_i \sim Normal(0, \sigma^2)$$

3. **Zero Expected Error**

   The expected value (or mean) of the errors is always zero

   $$E(e_i) = 0 \text{ for all } i$$

4. **Homoskedasticity**

   The errors have constant variance

   $$Variance(e_i) = constant \text{ for all } i$$

5. **Non-Autocorrelation**

   The errors are statistically independent from one another. This implies the data is a random sample of the population

   $$corr(e_i, e_j) = 0 \text{ for all } i \neq j$$

6. **Non-Multicollinearity**

   The independent variables are not collinear

   $$Covariance(X_i, X_j) = 0$$

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Steps in OLS Regression

Assume all OLS assumptions hold

Run regression in software (R/Python)

Check if assumptions really hold

Check if Fit is good

Check Hypothesis testing results
i.e. variable significance

Iterate to make "BEST" model

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Applications of OLS Regression in Business

Sales Prediction Models	Marketing Effectiveness Models	Ad. Effectiveness Models	Profitability Models
Capital Expenditure Model	Claims Forecasting Models	Chare-off Prediction Models	Macro Economic Models

Just a few of them

Thank You!
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