Marketing and Advertising:

Traditional methods ① outdoor display & promotions ② Print: newspaper & magazines ③ mailings: door to door ④ Radio ⑤ Television

CPM = Cost per Mille or Thousand

Rating = Households watching a program / Total no. of households with TV

Share = Households watching a program / Total no. of households watching TV

HUT = Households watching TV / Households with TV

GRP = Gross Rating Points

Reach = Households watching a program / Total TV households

Frequency = GRP / Reach

Digital Advertising: Email, Direct Messaging, Display Advertising

Digital Marketers: build campaigns, buy media, optimize media campaigns

Ad Placement systems - audience relevancy & budget allocation

Ad networks not restricted to work w only one media buying agency

2017 & 2018 search ads had highest revenue

2014 to 2018 mobile ads had more growth than desktop ads

2012 to 2018 Social media ads boom

2005 to 2019 Performance Pricing > CPM > hybrid model

Exponential Smoothing A_t = actual demand, F_t = forecast demand

$F_{t+1} = F_t + \alpha(A_t - F_t)$ where $0 \le \alpha \le 1$

Forecast Including Trend $FIT_t = F_t + T_t$

$F_t = FIT_{t-1} + \alpha(A_{t-1} - FIT_{t-1})$

$T_t = T_{t-1} + \delta(F_t - FIT_{t-1})$

Seasonality Index = Period average demand / avg demand for all periods

① realised seasonal demand in previous period ($\sim A_t$), seasonal forecast for previous period ($\sim F_t$) & smoothing constant α

② $A_t = \sim A_t / SI_t$ and $F_t = \sim F_t / SI_t$

③ $F_{t+1} = \alpha A_t + (1-\alpha) F_t$ *Mod 14 Lesson 4

④ $\sim F_{t+1} = F_{t+1} \times SI_{t+1}$

Error = actual - forecast

Mean Forecast Error (Bias) = $\frac{\Sigma(A_t - F_t)}{n}$ } Running Sum Forecast Error

Mean Absolute Deviation = $\frac{\Sigma|A_t - F_t|}{n}$

Tracking Signal TS = RSFE ÷ MAD, |TS| < 4 ideal, for evaluating models

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Methods of Digital Marketing

① Display Ads ② Search Engine Marketing ③ Social Media Marketing ④ Mobile Ads ⑤ Direct Messaging & Email Marketing

① Display Ads - on websites, fit page, good for branding, low click through rates, works better with retargeting

Tracking Data - Impressions, clicks, time of day, device/OS, region

② Search Engine Marketing

PPC (pay per click) - pay only for each click of an ad

SERP (search engine results page) - Click Through Rate - total clicks on link divided by number of times an ad link has been shown

Landing Page - first page user reaches

Vickrey Auction Model

Quality Score Factors ① Keywords ie relevance of keywords ② Ad Copy - ie relevance of ad copy to search term ③ Landing Page - relevance of the landing page to the search term ④ CTR of Ad based on history

CPC Bid × Quality Score = Ad Rank → AD position on page

(max bid) Max bid for key word; (Keyword relevance + user exp) how relevant & useful your ad is to user. Components are CTR, relevance & landing page

Profitability of ad-campaign: ① Cost per Click ② Conversion Rate ③ Sale Value ④ Profit Margin ⑤ Repeat Behaviour / loyalty / lifetime value of a customer

Conversion Rate = rate at which ppl who land on your site will go to your page, register or buy smth etc.

Awareness → interest → desire → research / comparison → purchase decision → payment → thanks → repeat

LTV (lifetime value) of customer

Break Even Point (BEP) Analysis

*PPC Conversion Cost = Avg CPC (cost per click) / Conversion Rate in Decimals

Profit margin per sale = Avg sale value × Profit Margin in decimals

BEP CPC per avg sale = Profit margin per sale × Conversion rate in decimals

BEP CPC for LTV (life time value) = n × BEP CPC per avg sale

n = avg no. of sales per cust. over lifetime

Social Media Goals

SMART: Specific, Measurable, Attainable, Relevant, Time-Bound

Recall Exploration - Exploitation

Payment Models ① CPM - Cost per Mille ② Cost Per View (CPV) ③ Cost Per Click (CPC) ④ CPA/CPL cost per acquisition or lead ⑤ CPS - Cost per sale

Display ads → size, position, duration & air time play a role in pricing

Only Search Engine Marketing considers a quality score

Digital Marketers: planning & building AD campaigns → buying media or ad placements → optimizing media campaigns.

CPS (cost per sale) payment guarantees tangible return (profits) for any money spent on ads.

Bounce Rate: gives an indication of the proportion of visitors who did not interact with the website

Conversion Rate Optimisation

Gather → Analyse → Correct → Design → Implement → Assess & Repeat

Goals: Increase Traffic, Enhance Engagement, Increase New Leads, Grow Sales, Improve Conversion to Leads & To Sales

Bounce Rate - proportion of visitors who did not interact with the website

Metrics for Google Analytics ① Users ② Bounce Rate ③ Sessions ④ Average Session Duration ⑤ % of new sessions ⑥ Pages per sessions ⑦ Page views

↓ total pageviews ÷ total no. of sessions

Advertising Steps: ① Campaign ② Ad Set ③ Ad

Ad = Audience + Creative o) Decide on an objective 1) Select an Target Audience 2) Upload the creative (of the ad)

Impt considerations for landing pages ① Heading ② offer ③ Images ④ Call to action

FB insight reporting tool Reports ① messages to page ② people engaged with content ③ Fans of a page ④ Daily & hourly activity

FB network → FB, Insta, Audience Network

Google behaviour report → shows people engaged, pages viewed, landing & exit

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Risks of running ads for advertisers from riskiest to least: cost per view, cost per click, cost per sale

Hybrid Advertisements: cost per view + cost per click model

Landing page is the first page a user reaches when clicking on a link in an online marketing campaign

Google AdWords system quality score: keywords, Ad Copy, Landing Page and CTR

An organisation that attains a higher quality score relative to their competitors can realise a lower CPC & still rank higher

Planning & Setting up a paid search campaign: establish budget, conduct keyword search, define business goals supported by market research

Reasons for supply interruptions ① Labor shortages ② Inaccurate inventory ③ Supplier failures ④ Poor Forecasting.

Large impacts on supply chain operations ① Autonomous Vehicles ② Robotics ③ AI ④ 3D Printing

Process Capability (Cp) Ratio Week 10 Mod 13 Lesson 7

$C_p = (\text{upper specification} - \text{lower specification}) / 6\sigma$

$C_p \ge 1.0$ indicates a process is capable

Process Capability Index (Cpk)

$C_{pk} = \min[\{(\text{upper specification} - \bar{\bar{x}}) / 3\sigma\}, \{(\bar{\bar{x}} - \text{lower specification}) / 3\sigma\}]$

$C_{pk} = 1$ ⇒ process meets specifications

$C_{pk} < 1$ ⇒ does not meet specifications

$C_{pk} > 1$ ⇒ outperform specifications

Operations Management

Improve efficiency, effectiveness, value

Queuing: Strategic, Tactical, Operational

Customer Pop'n → Arrival → Queue → Service → Exit

Arrival Rate λ - mean arrival rate

Exponentially distributed interarrival time $f(t) = \lambda e^{-\lambda t}$ OR

Poisson Distributed arrivals per unit time $P_T(n) = \frac{(\lambda T)^n e^{-\lambda T}}{n!}$

Service Rate (μ) → how many channels & how many phases?

Exponentially distributed service time $f(t) = \mu e^{-\mu t}$

λ = arrival rate, μ = service rate (M/M/1)

Utilization = $\rho = \frac{\lambda}{\mu}$

Avg # of customers in system = $\frac{\lambda}{\mu - \lambda} = L_s$

Avg # of customer in queue $L_q = \frac{\lambda^2}{\mu(\mu - \lambda)} = L_s \times \rho$

Avg time a customer spends in the system in hours $W_s = \frac{1}{\mu - \lambda} = \frac{L_s}{\lambda}$

Avg time a customer spends in the queue in hours $W_q = \frac{\lambda}{\mu(\mu - \lambda)} = \frac{L_q}{\lambda}$

Prob. of n units in the system

$P_n = (1 - \frac{\lambda}{\mu})(\frac{\lambda}{\mu})^n = (1 - \rho)(\rho)^n$

Eg. customers arrival 15 per hour, staff can service customers 1 every 3 mins

$\lambda = 15/h$, $\mu = 20/h$

Utilization: $\rho = \frac{\lambda}{\mu} = \frac{15}{20} = 75\%$

Avg # of customers in the system: $L_s = \frac{\lambda}{\mu - \lambda} = \frac{15}{20-15} = 3$ cust

$L_q = \frac{\lambda^2}{\mu(\mu - \lambda)} = L_s \times \rho = 3 \times 0.75 = 2.25$ cust

$W_s = \frac{1}{\mu - \lambda} = \frac{L_s}{\lambda} = 3/15 = 0.2h = 12min$

$W_q = \frac{\lambda}{\mu(\mu - \lambda)} = \frac{L_q}{\lambda} = \frac{2.25}{15} = 0.15h = 9min$

Eg. Ensure with 95% confidence (or service level) that no more than 3 cars will be in the system at any time. What confidence exists currently for no more than 3 cars?

$P_n = (1 - \frac{\lambda}{\mu})(\frac{\lambda}{\mu})^n = (1 - \rho)(\rho)^n$, $\rho = \frac{15}{20}$

$P_3 = (1 - 0.75)(0.75)^3 = 0.105$

$P_2 = (1 - 0.75)(0.75)^2 = 0.141$

⋮

$P_0 + P_1 + P_2 + P_3 = 0.25 + 0.186 + 0.141 + 0.105 = 0.684 \to 68.4\%$

For 95% service level we want:

$P_0 + P_1 + P_2 + P_3 = 0.95$

$1 - \rho^4 = 0.95 \Rightarrow \rho = 0.47$

$\rho = \frac{\lambda}{\mu} \Rightarrow 0.47 = \frac{15}{\mu} \Rightarrow \mu = 32$ ppl per hour

Quality - Price Tradeoff | Queuing System

① Line Length ② Queue Discipline ③ Service rate ④ Arrival Rate

M/M/1 model

① Random Arrivals ② Single Line ③ ∞ customer pop'n ④ FCFS

Single - Phase queuing mean only one service facility

$S_n = \frac{a(1 - r^n)}{1 - r}$ *SA9

Garvin 8 Dimensions of Product Quality ① Performance ② Functionality ③ Durability ④ Reliability ⑤ Conformance to Specifications ⑥ Serviceability ⑦ Aesthetics ⑧ Perceived Quality.

Dimensions of Service Quality ① Consistency ② Courtesy ③ Convenience ④ Communication ⑤ Accuracy / Reliability ⑥ Timeliness / Responsiveness ⑦ Credibility / Trustworthiness ⑧ Security.

Cost of Quality ① Appraisal Cost ② Prevention Cost ③ Internal Failure Cost ④ External Failure Cost

Costs of Good Quality → ① & ②

Costs of Bad Quality → ③ & ④

Statistical Process Control monitoring a Variable ① Collect Data ② Calculate $\bar{R}$ ③ Calculate UCL_R and LCL_R ④ Plot R-chart ⑤ Calculate $\bar{\bar{x}}$ ⑥ Calculate $UCL_{\bar{x}}$ and $LCL_{\bar{x}}$ ⑦ Plot $\bar{x}$-chart

*Week 12 Mod 13: Lesson 6 + Lesson 1

$UCL_R = D_4 * \bar{R}$, $LCL_R = D_3 * \bar{R}$

$UCL_{\bar{x}} = \bar{\bar{x}} + A2 * \bar{R}$, $LCL_{\bar{x}} = \bar{\bar{x}} - A2 * \bar{R}$

Variation: random / common causes, assignable / special causes

With only common causes of variation, variable will be Normally Distributed.

UCL & LCL are based on common causes of variation

Investigate causes of variation when ① A point outside of UCL & LCL band ② 2 plots near upper control ③ Erratic

Regression

Total Deviation = Explained Deviation + Unexplained Deviation/Residual/Error

$y_i - \bar{y} = (\hat{y}_i - \bar{y}) + (y_i - \hat{y}_i)$

$SSE = \Sigma_i (y_i - \hat{y}_i)^2 = \Sigma_i (y_i - (b_0 + b_1 x_i))^2$

SST = SSE + SSR

$\sum_i (y_i - \bar{y})^2 = \sum_i (y_i - \hat{y}_i)^2 + \sum_i (\bar{y} - \hat{y}_i)^2$

$R^2 = 1 - (SSE/SST) = SSR/SST$

Adjusted $R^2 = 1 - \{SSE/(n-p-1)\}/\{SST/(n-1)\}$

p = no. of independent variables

n = no. of observations

ANOVA table the SSE is Residuals

$F = \frac{R^2/p}{(1-R^2)/(n-p-1)}$ | Adjusted R^2: $1 - \frac{(1-R^2)\times(n-1)}{(n-p-1)}$

Compare two models $F = \frac{(R_2^2 - R_1^2)/(p_2 - p_1)}{(1-R_2^2)/(n-p_2-1)}$ | $0 \le R^2 \le 1$, $-1 \le R \le 1$

Assumptions of Linear Regression ① Linearity Assumption ② Error terms are i.i.d with mean zero and constant variance σ^2 ③ Predictor variables in multiple regression are assumed to be linearly independent

Common Problems ① Nonlinear relationship between response & predictor. Check linearity using residuals vs fitted values ② Correlation of error terms. An impt assumption we have is that error terms are uncorrelated. If they are correlated we have autocorrelation ③ Heteroskedasticity (non constant error variance) we need to transform the Y variable ④ Outliers ⑤ High-leverage points

→ Residuals vs Fitted (check linearity)

→ Normal QQ (check if normally distributed)

→ Scale Location

→ Residuals vs Leverage (find influential point, if any, with $C_i > 1$)

⑥ Multicollinearity: check using VIF or corr matrix. regress predictor X_j against other predictor (X). The resulting $R^2 = R_j^2$. $VIF_j = 1/(1-R_j^2)$. VIF > 5 mean there is multicollinearity

R^2 will increase with new variables or stay same if interaction term does not improve model. Adjusted R^2 may go up or down

OLS to reduce SSE. Indicator = Dummy

For n factors, n-1 are hot encoded

Purpose of log transformation - make distribution more normal and get better fit (like a higher R^2)

Indicator Variables and Interaction Terms

Eg. $AgeMid = \{1, \text{if Age = middle}; 0, \text{o/w}\}$

$AmtSpent = b_0 + b_1 * AgeMid + b_2 * AgeOld$

$AmtSpent = -c.12 + 0.002\,Salary - 4.81\,AgeMid + 23.28\,AgeOld$

At the same salary level, old customers spend more than young customers

Categorical variable w/ M values, you will need M-1 indicator (dummy) variables

$AmtSpent = b_0 + b_1 Salary + b_2 Far$

If Far = 1, Relevant slope = $b_1 + b_3$ | $+ b_3\,Salary\,Far$

$Price = b_0 + b_1 Capacity + b_2 Private + b_3 House + b_4 Private*Cap + b_5 House*Cap$. $b_4 + b_1$ is slope for private. $b_1 + b_5$ is slope for house | Interaction term = Synergy

linear-linear $Y = b_0 + b_1 X$. If X increase by 1 unit, Y changes by b_1 units

linear-log $Y = b_0 + b_1 \ln X$. If X increase by 1%, Y changes by $(b_1/100)$ units or $0.01 \times b_1$ units. Because $\ln(1.01x) = \ln 1.01 + \ln x = 0.01 + \ln x$

log-linear $\ln Y = b_0 + b_1 X$

Y changes by $(100 \times b_1)$% for 1 unit increase in X. Proof $y = e^{(b_0 + b_1 x)}$

$\frac{dy}{dx} = b_1 e^{b_0 + b_1 x} = b_1 y \Rightarrow \frac{dy}{y} = b_1 dx$

$100\,dy/y = 100 b_1 dx$, let $dx = 1$. Accurate % change in $Y = (e^{b_1} - 1) * 100$ for one unit change in X

log-log $\ln Y = b_0 + b_1 \ln x$

Y changes by b_1% for 1% increase in x

Proof: $b_0 + b_1 \ln(1.01x) = b_0 + b_1 \ln 1.01 + b_1 \ln x = b_0 + b_1 \ln x + b_1(0.01) = \ln y + b_1(0.01)$

Elasticity: % change in Y when X ↑ by 1%. b_1 captures elasticity in log-log.

Reasons for log transformation: ① Achieve more linear r/s ② make distribution more normal ③ Make variance more constant ④ Get better fit ↑ R^2

Quadratic Model

$price = b_0 + b_1\,lotsize + b_2\,lotsize^2$

$\frac{d(price)}{d(lotsize)} = b_1 + 2 b_2\,lotsize$

- Clear signal of non linearity ① residuals vs. fitted values indicate heteroscedasticity ② QQ plot shows nonlinearity ③ Residuals not normally distributed

$\ln n + \ln m = \ln mn$ | $\ln m^n = n \ln m$

$\ln n - \ln m = \ln(\frac{n}{m})$

Polynomial regression does not allow for an isolated interpretation of coefficients of non-linear variables.

Poly regression provides better approx. of relationship between dependent & independent variables. Outliers can greatly affect fitted model more reliable when built on larger n

QQ plot is standardised residuals against theoretical quantiles

Odds Against: P(won't happen) > P(will happen)

Odds For: P(will happen) > P(won't happen)

Odds For $= \frac{P}{1-P}$, $P = \frac{\text{odds for}}{1 + \text{odds for}}$

$P(x) = \frac{e^{b_0 + b_1 x}}{1 + e^{b_0 + b_1 x}}$, $1 - P = \frac{1}{1 + e^{b_0 + b_1 x}}$

$\frac{P}{1-P} = e^{b_0 + b_1 x}$, $\ln \frac{P}{1-P} = b_0 + b_1 x$ (logit(p))

x ↑ by 1 unit, log odds ↑ by b_1 ie odds ↑ by factor $e^{b_1} \approx 100 \times b_1$ %

↑ cutoff value True -ve ↑ & False +ve ↓

↑ cutoff value False -ve ↑ & True +ve ↓

Sensitivity (recall) $= \frac{\text{true +ve}}{\text{true +ve + false -ve}}$

Specificity $= \frac{\text{true -ve}}{\text{true -ve + false +ve}}$

ROC Curve Plot Sensitivity against 1-specificity

Type 1 Error: null hyp rejected when it should not be rejected ie true (false +ve)

Odds against $= \frac{1-P}{P}$

Type 2 Error: Failing to reject the null hypothesis when it is false (false -ve)

null hypothesis represents the default position or assumption of no effect or no relationship between variables.

Precision $= \frac{TP}{TP + FP}$ ↑ cutoff ⇒ precision ↑ & specificity ↑ recall/sensitivity ↓

Orthogonality Assumption $Cor(X, \epsilon) = 0$ where $Y = a + bX$ is model & ϵ error term

Selection Bias: ① Self Selection ② Voluntary Response Bias ③ Non Response

$Y = b_0 + b_1 X + \epsilon$

$b_{OLS} = \frac{Cov[X,Y]}{Cov[X,X]} = b_1 + \frac{Cov[\epsilon, X]}{Cov[X,X]}$

Orthogonality Assumption: $Cov[\epsilon, X] = 0$

When X is a dummy variable

$b_{OLS} = b_1 + \frac{Cov[\epsilon, X]}{Cov[X,X]} = b_1 + (\bar{\epsilon}_1 - \bar{\epsilon}_0)$

b_1 = treatment effect. $(\bar{\epsilon}_1 - \bar{\epsilon}_0)$ = selection bias

Natural Experiments: A treatment/event that just happened, not intentionally designed as an experiment

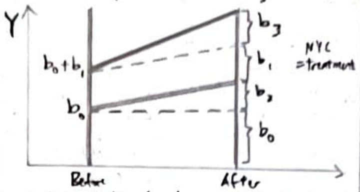
Difference In Difference

	Before	After	Difference
Control	A	C	C-A
Treatment	B	D	D-B

Diff-in-Diff $= (D-B) - (C-A)$

$= (D-C) - (B-A) = (D-C) - (B-C) = D-E$

$Sales = b_0 + b_1 NYC + b_2 After + b_3 NYC \cdot After$



Diff in Diff is b_3 coeff of treatment X after

Analyze treatment effect using DID Estimator

DID is coefficient of interaction term

Diff estimator $= \frac{Cov(y_1, y_0)}{Cov(y_0, y_0)} = mean(y_1) - mean(y_0)$

y_0 is set of obs in control group & y_1 is set of obs in treatment group

Natural Experiment = no intervention or manipulation by researchers.

DID ~~compare absolute values & not average~~ | We regress the indicator variable on the other control variables & check if there are any significant coefficients. Random assignment is present if coefficients of the regression model are insignificant

Estimate causal impact of treatment, compare treatment outcome to the counterfactual. | Avoid selection bias

① Randomized Control Experiments ② Natural Experiment ③ Adj Control

DID is comparison of the average change over time of dependent var for treatment vs control

$returns_t = \frac{price_t (factor_t) - div_t}{price_{t-1}} - 1$

$factor_t$ = stock split adjustment factor

Eg. 3 for 2 split ⇒ factor = 3/2 = 1.5

Compound Return $= \left[\prod_{i=1}^{n} (r_i + 1)\right] - 1$

$SD = \sqrt{\frac{\Sigma (x_i - \bar{x})^2}{n-1}}$ ↑ sd means ↑ risk

sd: total risk = firm specific + market wide

↑ stocks in portfolio ⇒ firm specific ↓ which means SD falls

$r_i = \alpha + \beta r_m + \epsilon$, r_m = market return

β = stock sensitivity to overall market movements

R^2 = measure % of fund's performance that occurs as a result of the market

High beta ⇒ high market risk

$DD_t = \frac{HWM_t - P_t}{HWM_t}$

Sharpe Ratio $= \frac{R - R^f}{\sigma(R - R^f)}$ | $R - R^f$ = excess of portfolio above risk free rate

$\sigma(R - R^f)$ = sd of excess returns

↑ sharpe ratio = ↑ reward / unit risk

Treynor Ratio $= \frac{R - R^f}{\beta}$ ↑ treynor → ↑ reward/unit risk

Jensen's Alpha

$r_{i,t} - r_f = \alpha_i + \beta_i (R_{m,t} - r_f) + \epsilon_{i,t}$

return on asset i at time t; return on market index at time t

$\alpha_i > 0$ ⇒ fund outperformed

$\alpha_i < 0$ ⇒ fund underperformed

1 basis point = 0.01% = 0.0001

Types of fees: ① Commissions ② Bid Ask Spread ③ Delay cost

Efficient Capital Market is one where stock prices fully reflect available info

① Weak Form: security prices reflect all info found in past prices & volume

② Semi-strong: security prices reflect all publicly available info

③ Strong: prices reflect all info public & private

Behavioural Biases ① Overconfidence ② Loss Aversion ③ Recency ④ Anchoring

Ask price: what seller is willing to sell at ie a buy order will be executed at the ask

Bid price: what buyer is willing to buy at.

Stock split does not change market value of the firm

5 for 3 stock split means 3 stocks become 5 stocks

① Size Effect ② Value Effect ③ Momentum Effect ④ Profitability Effect ⑤ Risk Effect

① Size effect → smaller firms have higher returns than larger firms on average size measured by market cap

② Value effect → inexpensive stocks tend to outperform expensive stocks expensiveness ⇒ book/market ratio

③ Momentum Effect → stocks that perform well in the past year tend to continue to perform well

④ Profitable stocks tend to outperform unprofitable stocks

⑤ Risk Effect → low beta assets outperform high beta assets (volatility effect)

Factor Regression

Market Beta $r^m - r^f$, Size SMB, Value HML, Momentum MOM, Risk BAB, Quality QMJ

$r_t^{fund} - r_t^f = \alpha + \beta(r_t^m - r_t^f) + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 MOM_t + \beta_5 BAB_t + \beta_6 QMJ_t + \epsilon_t$

+ve & significant coefficient indicates that the fund manager has outperformed

low Book/Market ratio ⇒ stock inexpensive

low B/M ratio ⇒ Value stock

-ve coefficient on HML ⇒ fund tilted towards growth stocks

Treasury bonds have historically been the safest asset.

Value factor = book value / price

Momentum = % change in price

Coeff of Size Factor -ve & significant ⇒ Large-Cap Fund

Value Factor -ve & significant ⇒ Growth Fund