



**POLITECNICO**  
MILANO 1863

# Marketing Spending Optimization

**Theoretical Background & Statistical Tools  
for Marketing Mix & Media Attribution Modeling**

AY 2024/2025 - Gloria Peggiani

# Agenda

- Marketing Mix Modeling
- Attribution Modeling

C

Candiani\_B6\_B6.3.2

02:03:30

We can start with the second part of the lecture. I.

C

Candiani\_B6\_B6.3.2

02:03:35

I hope that the people from whom can hear me.

C

Candiani\_B6\_B6.3.2

02:03:42

As I said at the very beginning of this second part of the lecture is about a very, very important topic, a problem that companies always takes that is deciding how to divide the budget on the different channels.

C

Candiani\_B6\_B6.3.2

02:04:01

So this problem is very very important and until very little time ago, there were not.

C

Candiani\_B6\_B6.3.2

02:04:13

C

Candiani\_B6\_B6.3.2

02:04:01

So this problem is very very important and until very little time ago, there were not.

C

Candiani\_B6\_B6.3.2

02:04:13

Let's say analytical approaches to answer this out. So as we said the first the very first lecture, if you remember, there was.

C

Candiani\_B6\_B6.3.2


02:04:23

The famous sentence that says.

C

Candiani\_B6\_B6.3.2

02:04:26

Alpha demony I spent in marketing is lost but the problem is that I don't know which is the alpha that is lost. This sentence is very, very famous. Because until sometime ago the typical approach was  somebody in this marketing a.

C

Candiani\_B6\_B6.3.2

02:04:46

Activities and then I see what comes back. After they didn't really measure the specific returns from the initiatives. And the main reason was that the channels that they had available were mainly offline, so they had they had the radio, they had been boards on the streets.

C

Candiani\_B6\_B6.3.2

02:05:07

So it was not easy to understand.

C

Candiani\_B6\_B6.3.2

02:05:11

Who actually had seen the beer border who have actually seen the TV and then both the the products. So because of this.

C

Candiani\_B6\_B6.3.2

02:05:22

Today we say that the approach that the companies had in the past is called spray and pray. So spray and pray means we spray some marketing effort. We put some money, even a bit random, I would say, and then we pray that this effort.

C

Candiani\_B6\_B6.3.2

02:05:43

that this effort.

C

Candiani\_B6\_B6.3.2

02:05:43

Goes in the right direction. And so I put a lot of money on TV, I create my advertising for TV and I hope to get more sales because of that. And that's it. So what they did was maybe see the sales improved like from this month.

C

Candiani\_B6\_B6.3.2

02:06:04

To the next one. But that's it that they cannot be sure that sales improved because of the TV advertising.

C

Candiani\_B6\_B6.3.2

02:06:14

This caused the situation until very, very little time ago, but now we have a digital channels and we have also some more sophisticated statistical techniques. And so nowadays we can actually try to understand the defectiveness of each channel.

C

Candiani\_B6\_B6.3.2

02:06:34

So the topic that we will see during these second part of the lecture are these two.

**How to optimally allocate marketing efforts and investment to achieve the desired level of performance?**

# Marketing Mix Modeling

01

# Marketing Mix Modeling

Quantify **the impact of marketing actions** on the outcome of interest (estimate ROI and compare channels and levers)



**Decomposition of sales into  
baseline and incremental**

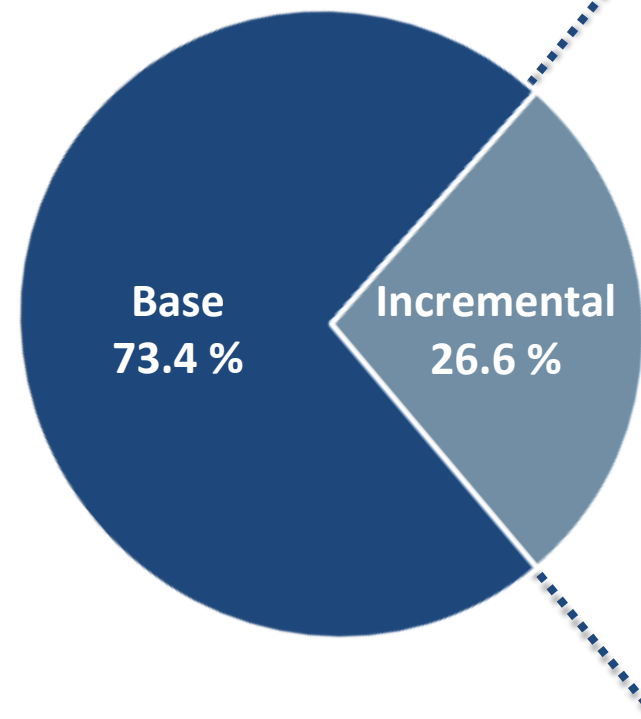
# Marketing Mix Modeling

Quantify **the impact of marketing actions** on the outcome of interest (estimate ROI and compare channels and levers)

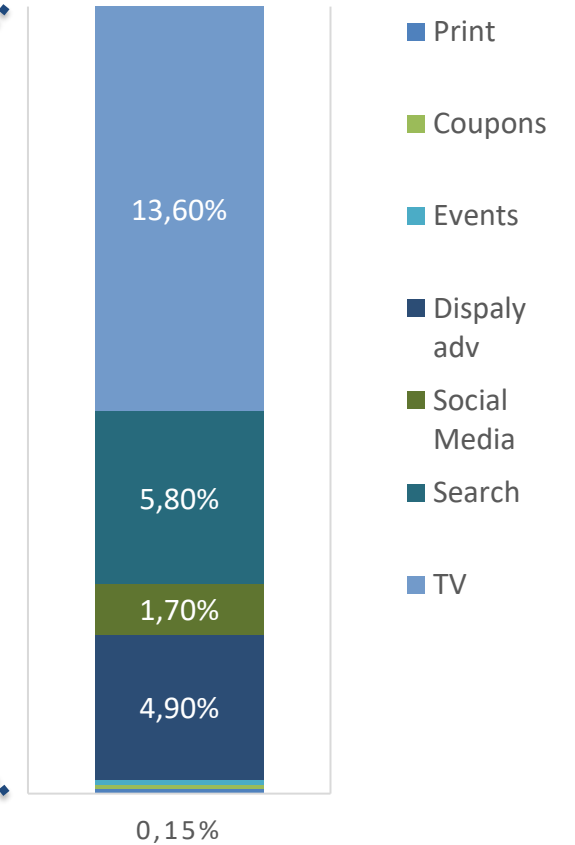


**Decomposition of sales into baseline and incremental**

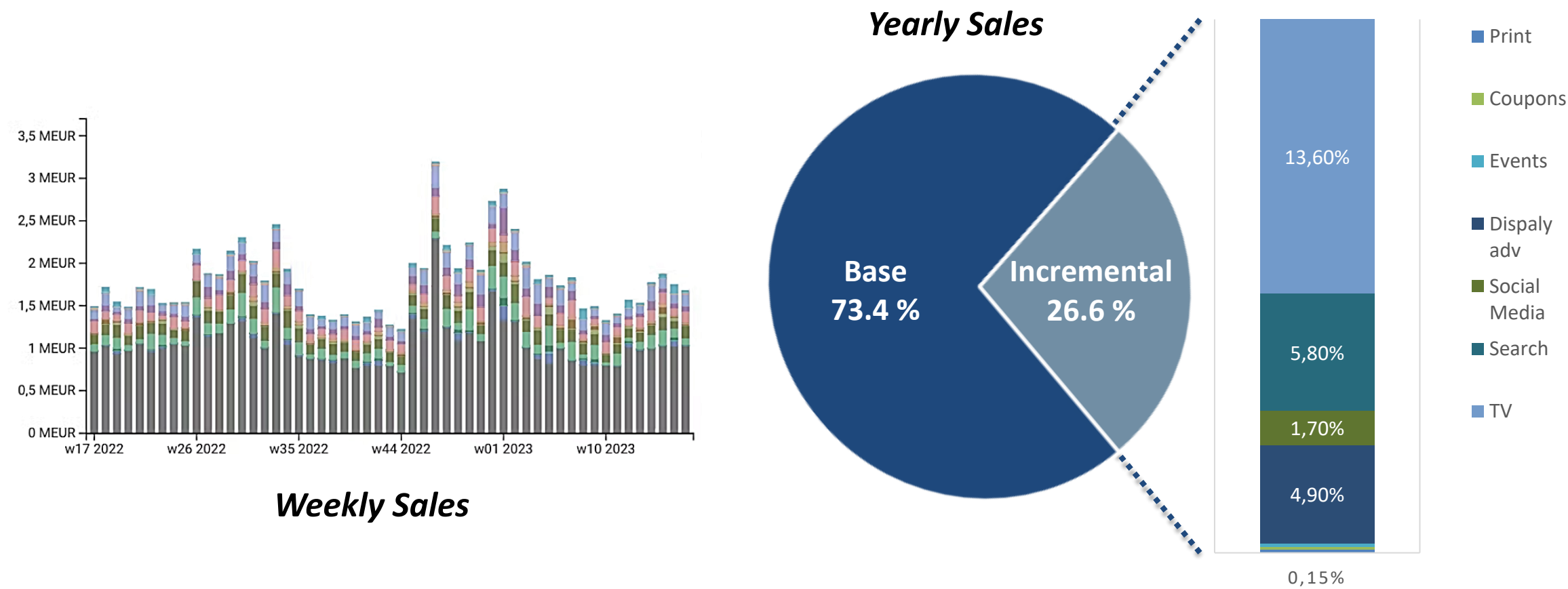
if I stop marketing, base is the sales



when we do promotion



# Marketing Mix Modeling



# Marketing Mix Modeling



very important to also to consider the comp.

**C** Candiani\_B6\_B6.3.2 02:18:58  
Competitor's activity. So every time we do this kind of model, we see the baseline, we see the incremental sales, new to our marketing activities, and we see the effects of environmental factors and the competitors activities.



# Marketing Mix Modeling

Analyze the impact of **external factors** on  
the outcome of interest



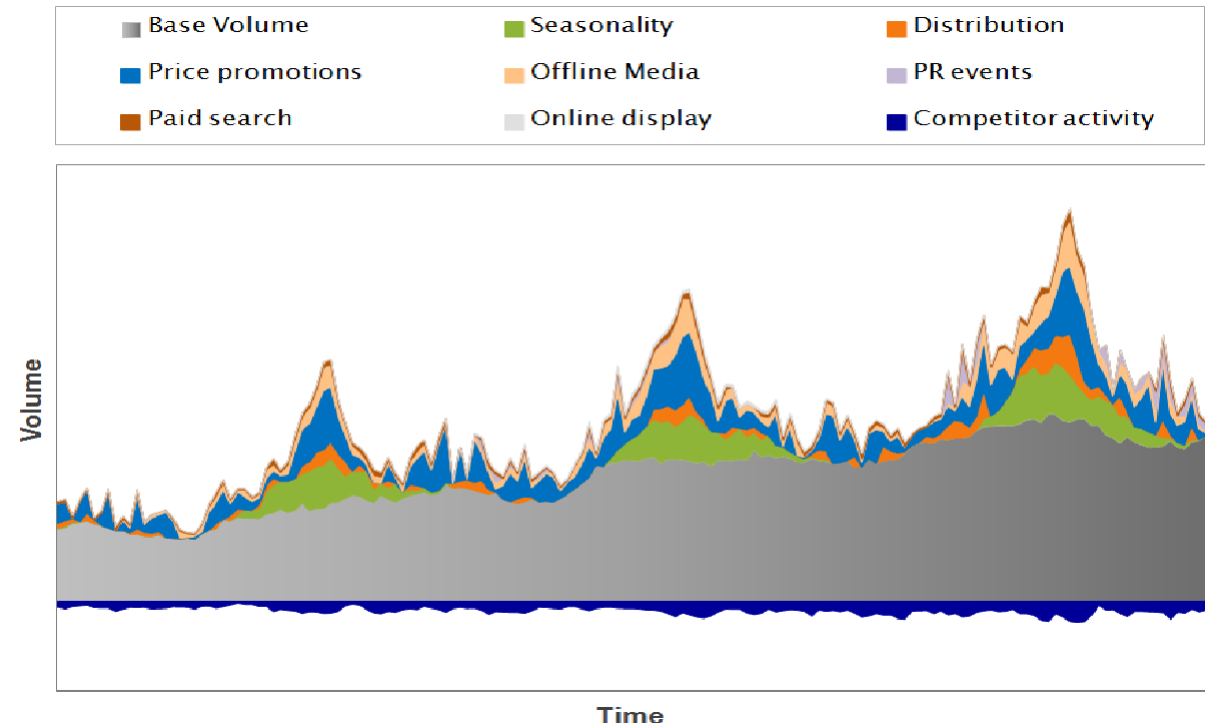
**Quantify the effect of competitors actions  
and exogeneous events**

# Marketing Mix Modeling

Analyze **the impact of external factors** on the outcome of interest



**Quantify the effect of competitors actions and exogeneous events**



# Marketing Mix Modeling

**Optimizing the allocation of the  
marketing resources**



**Individual response functions can be  
estimated** (=curves that describe the  
relationship between the incremental sales  
and the invested budget)

# Marketing Mix Modeling

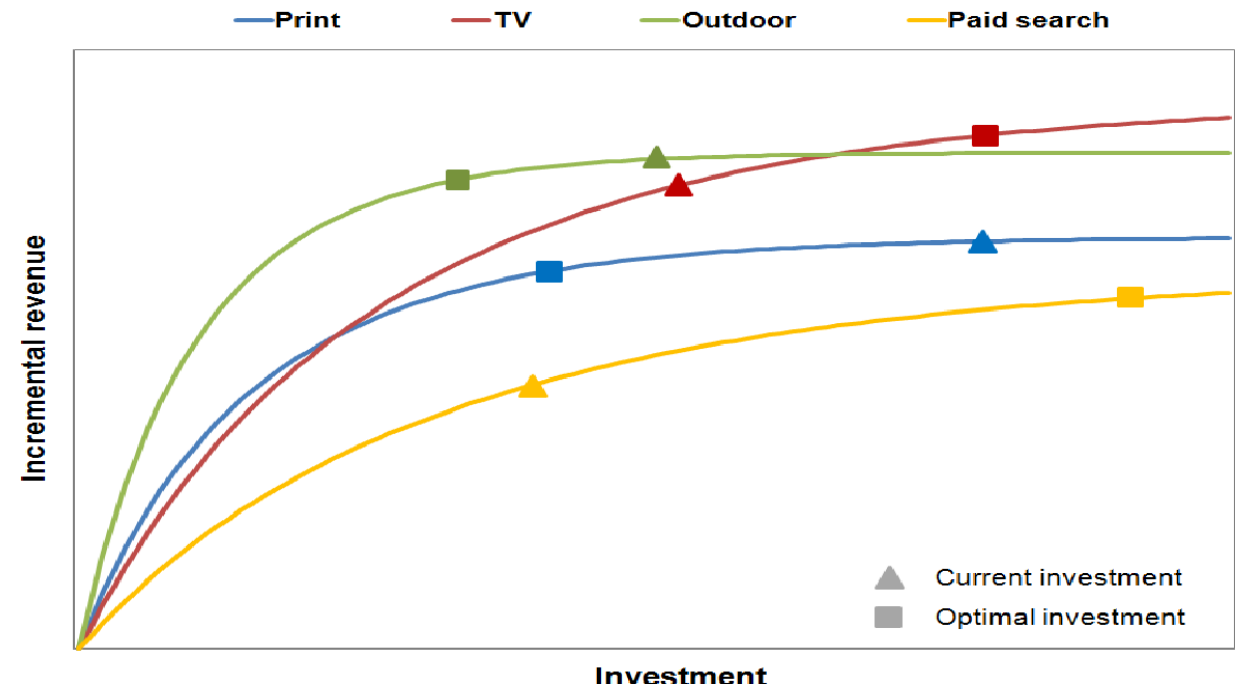
third characteristics?

Optimizing the allocation of the marketing resources

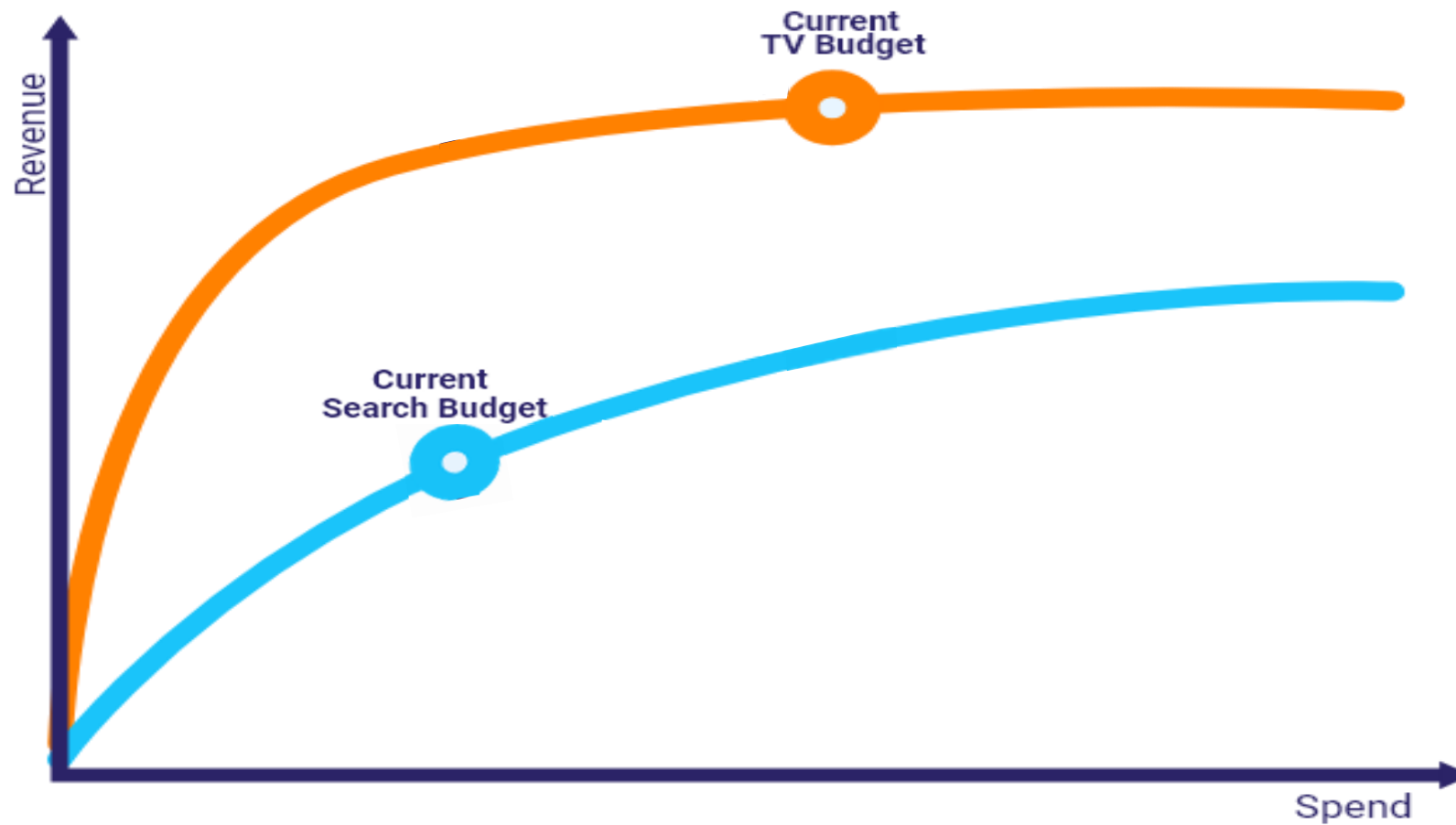


Individual response functions can be **estimated** (=curves that describe the relationship between the incremental sales and the invested budget)

## Media Saturation



# Marketing Mix Modeling

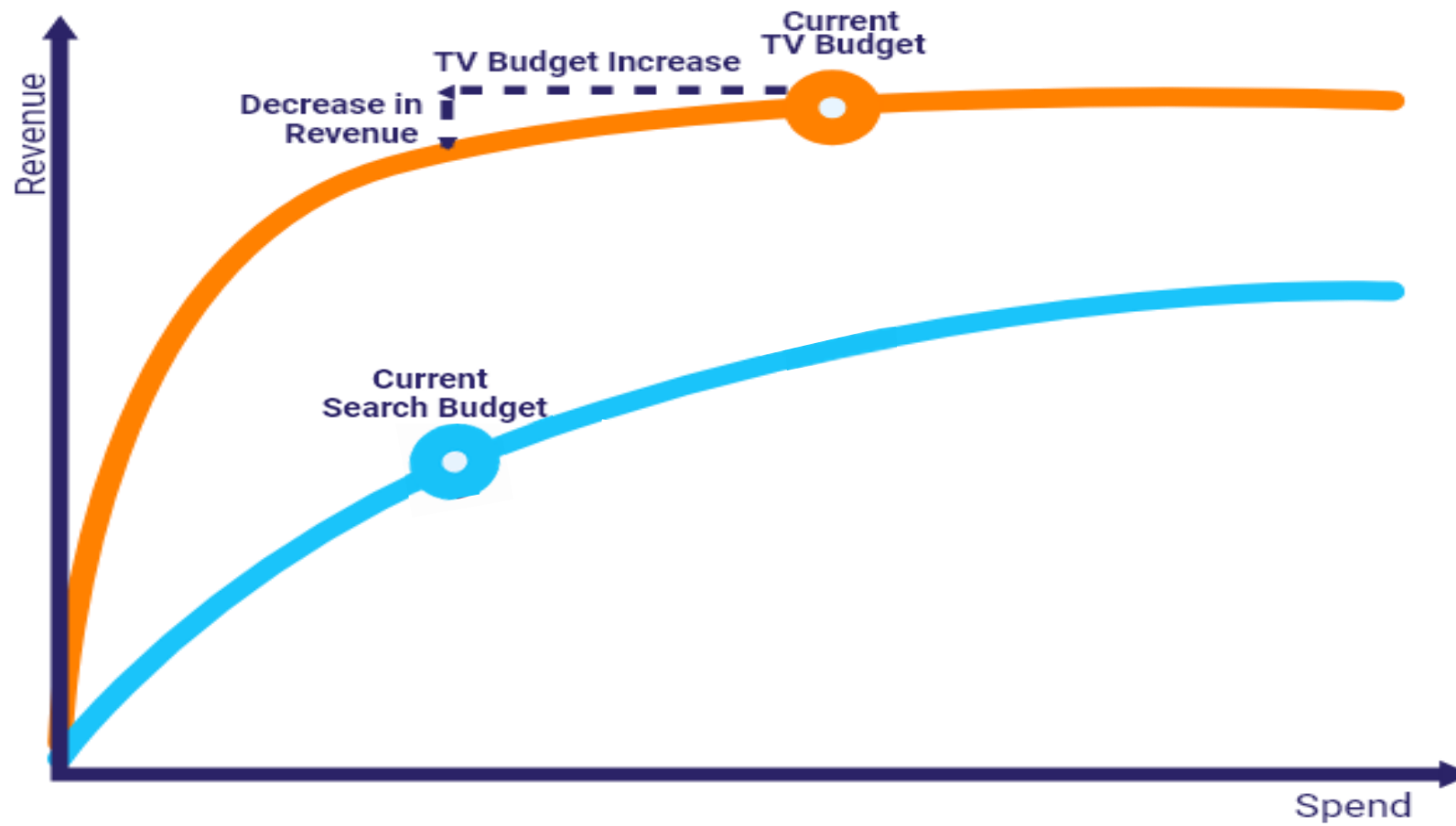


## *Media Saturation*

Are these curves estimated prior to the budget allocation? if yes, how? is there any particular way?

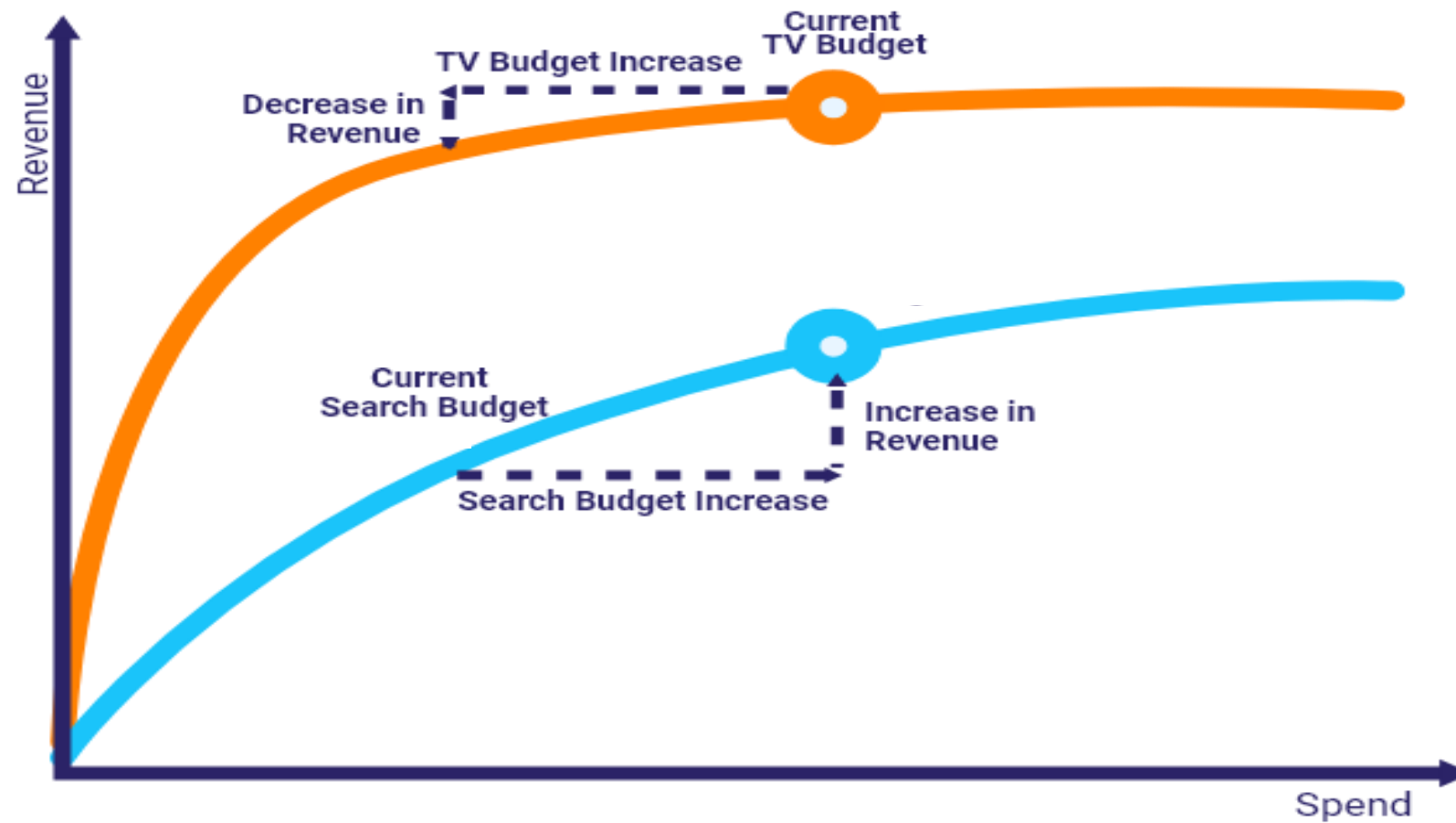
# Marketing Mix Modeling

## *Media Saturation*



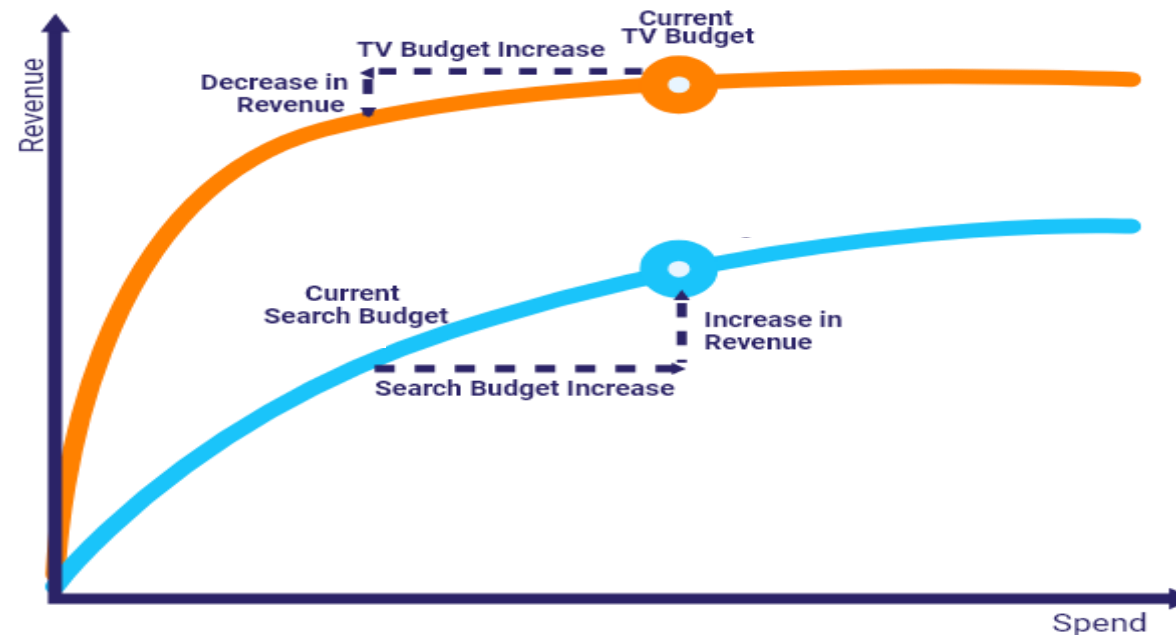
# Marketing Mix Modeling

## *Media Saturation*



# Marketing Mix Modeling

Trough classical optimization techniques it is possible to identify the optimal allocation of **minimum budget** under the constraint of the number of sales, or the **maximization of sales** and the optimal allocation of the budget under the constraint of the total budget.





#### 4th. Forecasting

# Marketing Mix Modeling

**Forecasting** revenues resulting from  
different marketing and media plans  
(what-if scenarios)



**Compare different media strategies**

# How to design a Marketing Mix Model

1

## Setting of the objectives

Measuring vs. planning vs. forecasting? What is the outcome of interest (typically one per model)?

# How to design a Marketing Mix Model – Step 1

The objectives can refer to the entire marketing funnel (e.g., Sales, market share, website traffic, awareness, purchase intent)



## ***Example***

Sector: *automotive*

Brand: *premium*

Product considered: *"Car line A"*

Objective:

*To identify the contribution of communication activities on the number of contracts*

# How to design a Marketing Mix Model



1

## Setting of the objectives

Measuring vs. planning vs. forecasting? What is the outcome of interest (typically one per model)?

# How to design a Marketing Mix Model



1

## **Setting of the objectives**

Measuring vs. planning vs. forecasting? What is the outcome of interest (typically one per model)?

2

## **Identification of necessary data and data owners**

Data related to the activities of the marketing mix (product, place, promotion, price), the competitors actions (communication campaigns, type of offers, promos) and other contextual elements (seasonality, holidays, trends...)

# How to design a Marketing Mix Model – Step 2

Variables describing the activities of the marketing (media) mix

1. Variables describing product features which can be changed (e.g., introduction of innovations, format changes, etc.)
2. Variables describing characteristics of the distribution which can be changed (e.g. introduction of new formats/distribution channels, etc.)
3. Variables describing price-related characteristics (e.g., discounts, financial and other promotions, etc.)
4. Variables describing communication activities carried out on the different media (e.g., TV, radio, print, OOH, sponsorships, DEM, etc.).

# How to design a Marketing Mix Model – Step 2

## *Example*

PAID	OWNED	EARNED	QUALITATIVE
<ul style="list-style-type: none"><li>• OFFLINE CAMPAIGNS</li><li>• ONLINE CAMPAIGNS</li><li>• RANGE</li><li>• OVERALL NATIONAL SALES COMPANY (NSC)</li></ul>	<ul style="list-style-type: none"><li>• WEBSITE CARLINE</li><li>• WEBSITE CORPORATE</li><li>• SOCIAL POST/VIDEO</li><li>• DEM SENT</li><li>• EVENTS NSC</li></ul>	<ul style="list-style-type: none"><li>• SOCIAL</li><li>• SEO (Organic Search)</li><li>• DEM (Opens and Click)</li></ul>	<ul style="list-style-type: none"><li>• COMMERCIAL PROMO ACTIVITIES</li><li>• CALL TO ACTION</li><li>• TYPE OF PROMO &amp; EFFORTS</li><li>• PRODUCT PROMO ACTIVITIES &amp; EFFORTS</li><li>• OWE</li><li>• PRODUCT LIFE CYCLE</li></ul>

# How to design a Marketing Mix Model – Step 2

Variables describing the context:

1. Environmental, macroeconomic, and contextual variables that influence the response (e.g., seasonality, temperature, inflation, exchange rates, economic-political outlook, etc.).
2. Variables describing competitors activity in terms of marketing actions (e.g. promotions, new product launches, media activities, events, etc.).



# How to design a Marketing Mix Model – Step 2

## *Example*

PAID	OWNED	EARNED	QUALITATIVE
<ul style="list-style-type: none"><li>• OFFLINE CAMPAIGNS</li><li>• ONLINE CAMPAIGNS</li><li>• RANGE</li><li>• OVERALL NATIONAL SALES COMPANY (NSC)</li><li>• DEALER</li><li>• COMPETITION</li></ul>	<ul style="list-style-type: none"><li>• WEBSITE CARLINE</li><li>• WEBSITE CORPORATE</li><li>• SOCIAL POST/VIDEO</li><li>• DEM SENT</li><li>• EVENTS NSC</li></ul>	<ul style="list-style-type: none"><li>• SOCIAL</li><li>• SEO (Organic Search)</li><li>• DEM (Opens and Click)</li></ul>	<ul style="list-style-type: none"><li>• COMMERCIAL PROMO ACTIVITIES</li><li>• CALL TO ACTION</li><li>• TYPE OF PROMO &amp; EFFORTS</li><li>• PRODUCT PROMO ACTIVITIES &amp; EFFORTS</li><li>• OWE</li><li>• PRODUCT LIFE CYCLE</li><li>• CATEGORY TREND</li><li>• PRODUCT LIFE CYCLE</li></ul>

# How to design a Marketing Mix Model – Step 2

## Example

PAID	
• OFFLINE CAMPAIGNS	Net Adv Investment on Carline A and Grp on focus target for TV (FTA, DTT Free, Sky, DTT Pay), Radio (National/ Local), OOH (Standard/Special), Newspapers (National, Sports, Local), Cinema
• ONLINE CAMPAIGNS	Net Adv Investment on Carline A, Impression, Click, View Through rate for video: Digital Display (Reservation/Programmatic), Digital Video (Reservation/Programmatic), FB (Display/Video), YT (Preroll/Masthead, Other), Search
• RANGE	Net Adv Investment Range - Carline A
• NSC	Net Adv Investment NSC excluding Carline A and range (Halo effect)
• DEALER	Adv Investment on Carline A done by dealers spent on TV, Radio, Print, DIGITAL and OOH
• COMPETITION	Nielsen Adv Expenditure net (All media) referred to competitors of the Carline A

# How to design a Marketing Mix Model – Step 2

## Example

OWNED	
• WEBSITE CARLINE	Metrics on the Carline A Landing Page –from Desktop and Mobile: Unique users, Sessions, Bounce Rate, Average Time Spent (Sec.)*, Referral with Direct Access, Search, Social platforms, Others (calculated as the difference between total visits and visits of other types of referrer)
• WEBSITE CORPORATE	Metrics on corporate website from Desktop and from Mobile: Unique users, Sessions, Bounces, Average Time Spent (Sec.)*, Referral with Direct Access, Search, Social platforms, Others (calculated as the difference between total visits and visits of other types of referrer).
• SOCIAL POST/VIDEO	Number of posts about the car-line (only product posts) on Facebook, Instagram, Twitter Number of video about the car-line (only product posts) on YouTube
• DEM SENT	DEM sent by CRM related to carline A and by Marketing Automation
• EVENTS NSC	NSC events were considered with 21 Metrics. See specific reference sheet.

# How to design a Marketing Mix Model – Step 2

## *Example*

EARNED
• SOCIAL
• SEO (Organic Search)
• DEM (Opens and Click)

Facebook(New fans, reactions/Comments/Shares to/of Carline A posts); Twitter (New follower, likes/retweet/reply to Carline A posts), Instagram (New follower, like to Carline A posts); YouTube (likes/shares/comments/views to Carline A video)

Share of Google on a weekly base of models in Carline A:

Number of Dem Opened and number of click to landing page considering both Dem sent by CRM and by Marketing Automation

# How to design a Marketing Mix Model – Step 2

## *Example*

QUALITATIVE	
• COMMERCIAL PROMO ACTIVITIES	Presence of commercial offer on TV, radio, digital (website)
• CALL TO ACTION	Presence of call to action from TV to digital, from radio to digital
• TYPE OF PROMO & EFFORTS	Type of commercial promo(financial or monetary)and effort(low, medium, high)
• PRODUCT PROMO ACTIVITIES & EFFORTS	Presence of product promo on TV, radio, digital (website) and effort(low, medium, high)
• OWE	Open weekend present or not
• CATEGORY TREND	Segment trend positive, flat or negative
• PRODUCT LIFE CYCLE	Product life cycle: launch, running, facelift, run out

# How to design a Marketing Mix Model



1

## Setting of the objectives

Measuring vs. planning vs. forecasting? What is the outcome of interest (typically one per model)?

2

## Identification of necessary data and data owners

Data related to the activities of the marketing mix (product, place, promotion, price), the competitors actions (communication campaigns, type of offers, promos) and other contextual elements (seasonality, holidays, trends...)

3

## Preliminary data analysis

**Data aggregation level:** in case of different levels of granularity, data are typically aggregated to the level of the dependent variable

**Descriptive analytics to understand market dynamics:** What is the dimension of the market? Is the market growing? What is the media strategy of the company? Who are the main competitors and how are they performing?

*+ is there the need to add any other contextual variables?*

# How to design a Marketing Mix Model

4

## Variables selection and transformation

**Variable selection:** based on the preliminary descriptive and exploratory analysis (e.g., correlations) and managerial knowledge of the market examined.

Suggestion: consider the metrics which reflect the main sales driver

e.g., weekly GRP for TV (=index that measures the campaign expected impact)

**GRP:** reach \* frequency      gross rating point -- tv and some explanation

e.g., weekly impressions for Display Adv

# How to design a Marketing Mix Model

4

## Variables selection and transformation

**Variable transformation** (→ to better describe the relationship between marketing actions and market response):

### 3) *Lag / Adstock Transformations*

*Lag effects* and *carry-over effects*

#### Lag Effect



We must take into account that there can be a **delay between the stimulus and the response**.

A consumer exposed to an advertising message today may wait several weeks before "responding" to that message through, for example, a purchase.



# How to design a Marketing Mix Model

## 4

### Variables selection and transformation

**Variable transformation** (→ to better describe the relationship between marketing actions and market response):

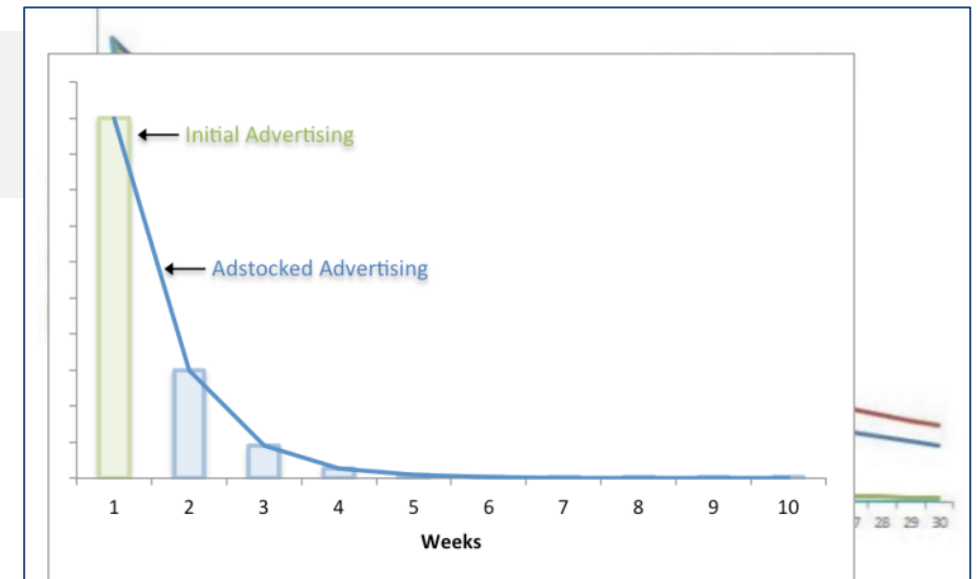
#### 3) *Lag / Adstock Transformations*

*Lag effects and carry-over effects*

#### Carry-over Effect

Communication activities continue to perform even when the communication campaign is over.

**Adstock** is used to capture carryover effects of advertising (→ «inventory» of past and current advertising efforts).



# Adstock

The **most common** form assumes a geometrical decline of effectiveness:

## Geometric Adstock model

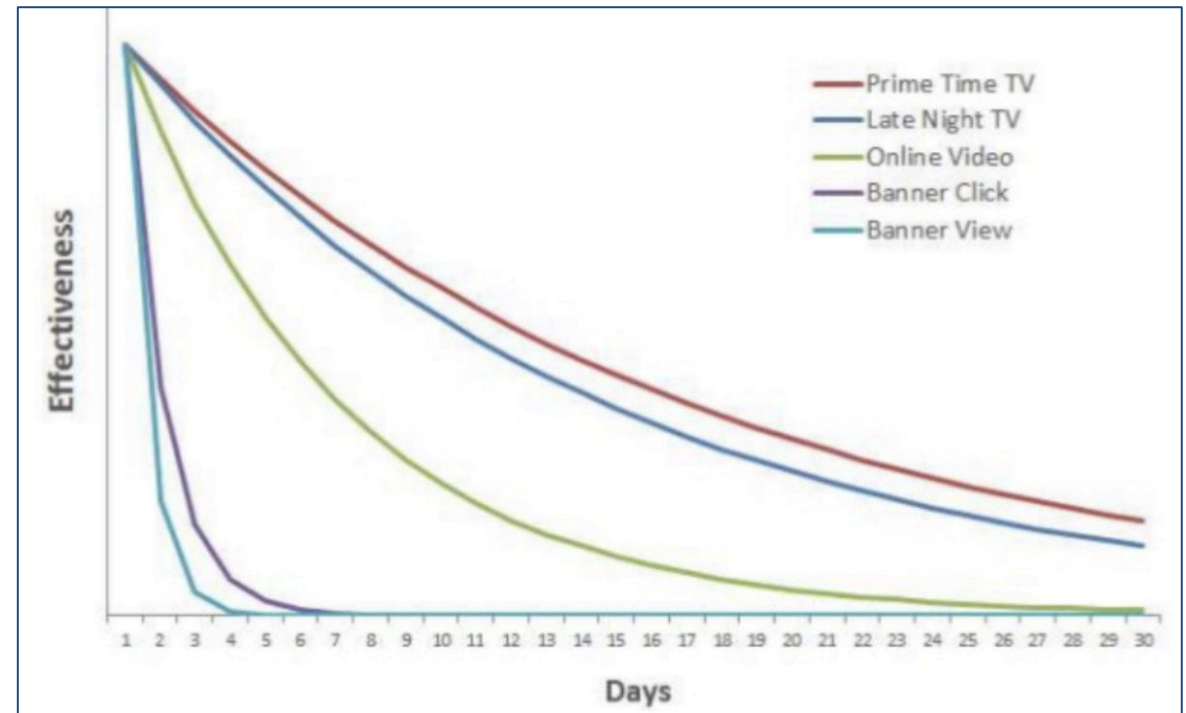
$$A_t = X_t + \lambda A_{t-1} \quad (0 < \lambda < 1)$$

where

$A_t$ : advertising adstock at time  $t$

$X_t$ : advertising spend at time  $t$

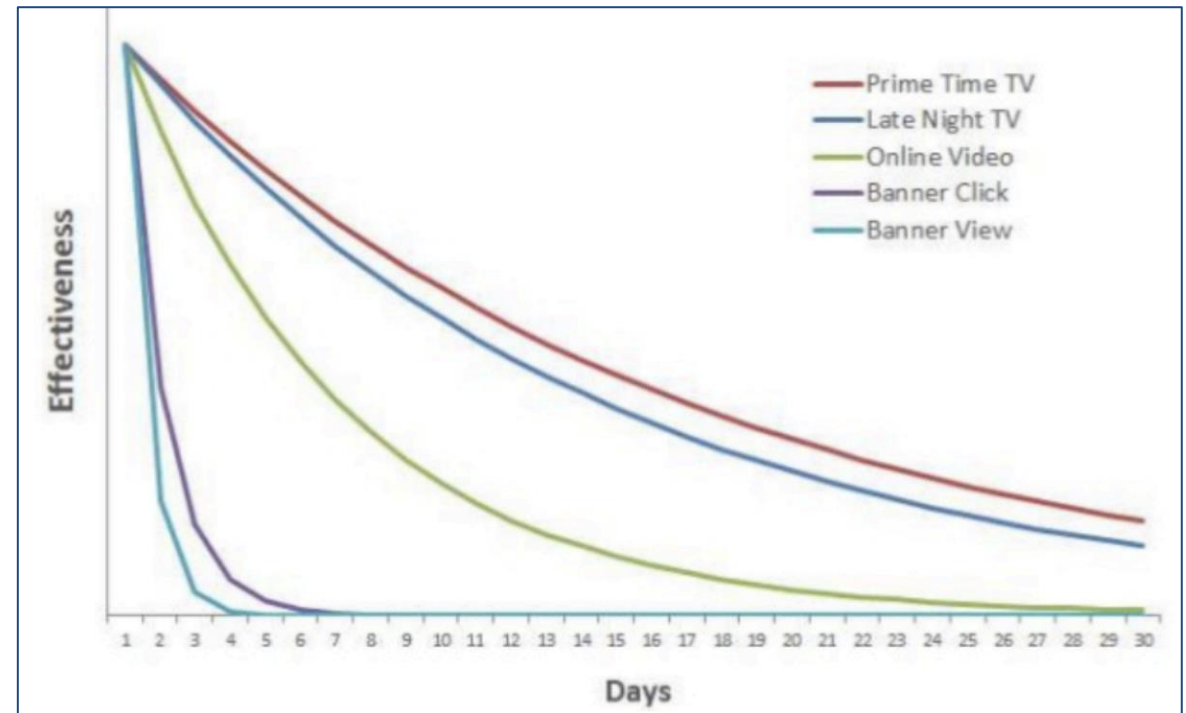
$\lambda$  : carryover coefficient



# Adstock

Realistic ranges for carry-over effect across media

	Carryover coefficient
TV	0,8 – 1
Radio	0,5 – 0,7
Press	0,3 – 0,5
OOH	0,1 – 0,3
Online – Display/Video	0,7 – 1
Online – Search	0,1 – 0,3
Social media influencers	0,8 – 1



# How to design a Marketing Mix Model

5

## Model Selection

The general idea is to **find a function** that describes the business performance as dependent on a set of firm-controlled marketing variables and external variables:

$$Q_t = f(X_t, E_t)$$

$X_t$ : Firm's marketing actions at time  $t$

$E_t$ : External factors at time  $t$

$Q_t$ : Firm's business performance at time  $t$

# How to design a Marketing Mix Model

## 5

### Model Selection

To find the functional form that **best describes** the link between  $Q_t$  and the explanatory variables both parametrics and non-parametric approaches can be used.

#### Parametric approaches

Define the functional form of  $f$  as dependent on a limited set of parameters that has to be estimated.

#### Non-parametric approaches

No assumptions on the shape of the function  $f$ , whose value is estimated locally considering a subset of the original observations.

# How to design a Marketing Mix Model

## 5

### Model Selection

To find the functional form that **best describes** the link between  $Q_t$  and the explanatory variables both parametrics and non-parametric approaches can be used.

#### Parametric approaches

- Regression Models
- SEM

#### Non-parametric approaches

- Regression Trees
- Bagging
- Random Forests
- Neural Networks

# How to design a Marketing Mix Model

## 5

### Model Selection

To find the functional form that **best describes** the link between  $Q_t$  and the explanatory variables both parametrics and non-parametric approaches can be used.

#### Parametric approaches

- Limited computational power required
- Relatively small set of observations is enough
- Good trade-off between accuracy and interpretability

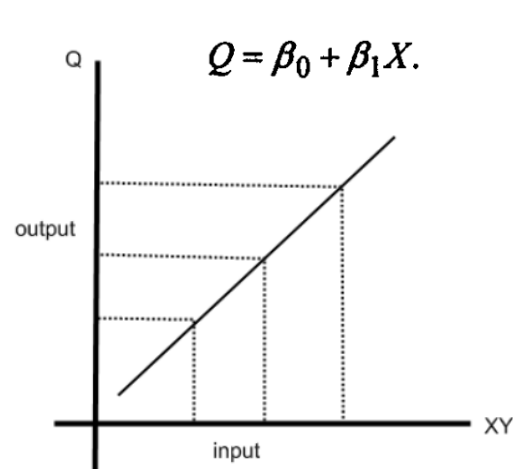
# How to design a Marketing Mix Model

5

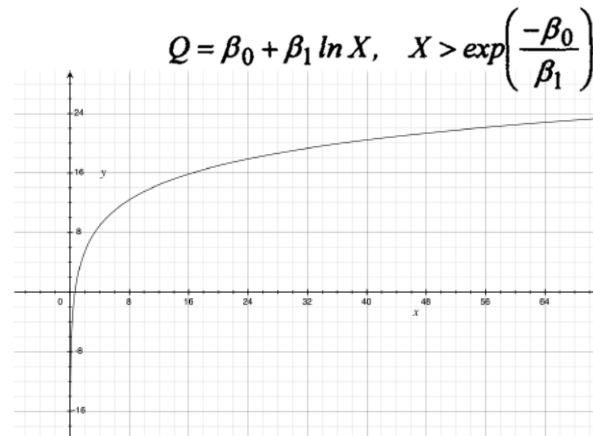
## Model Selection

How to choose the functional forms to use in parametric models?

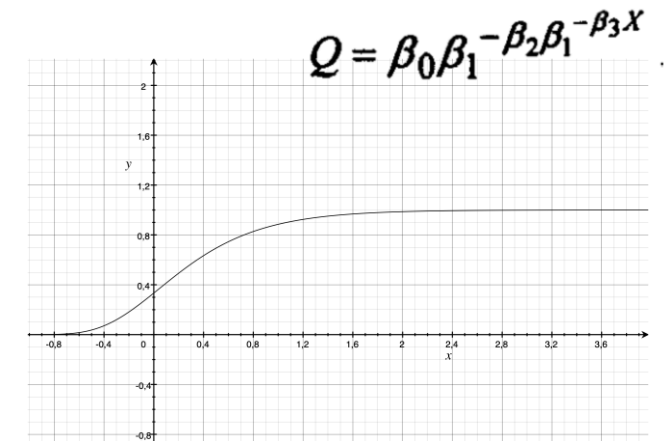
→ Considering the properties observed in real life in the relationship between marketing variables and business performance



Constant scale effects



Decreasing scale effects



S-shaped scale effects

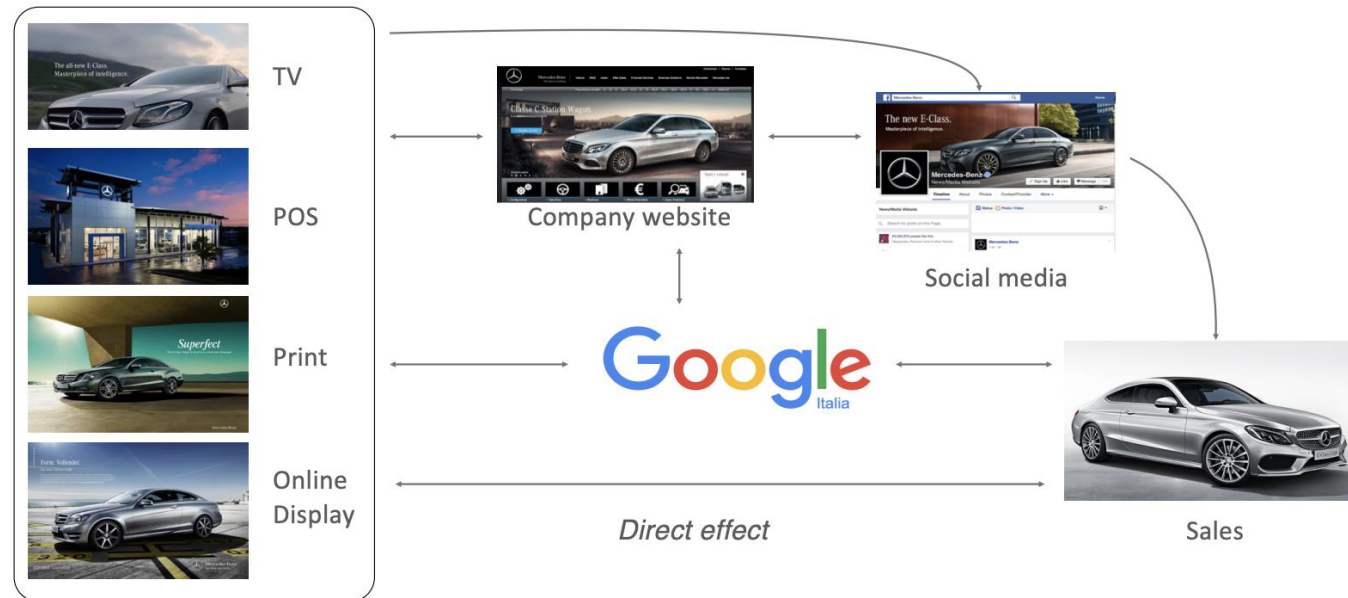


# How to design a Marketing Mix Model

5

## Model Selection

Hypothesize possible interactions among variables

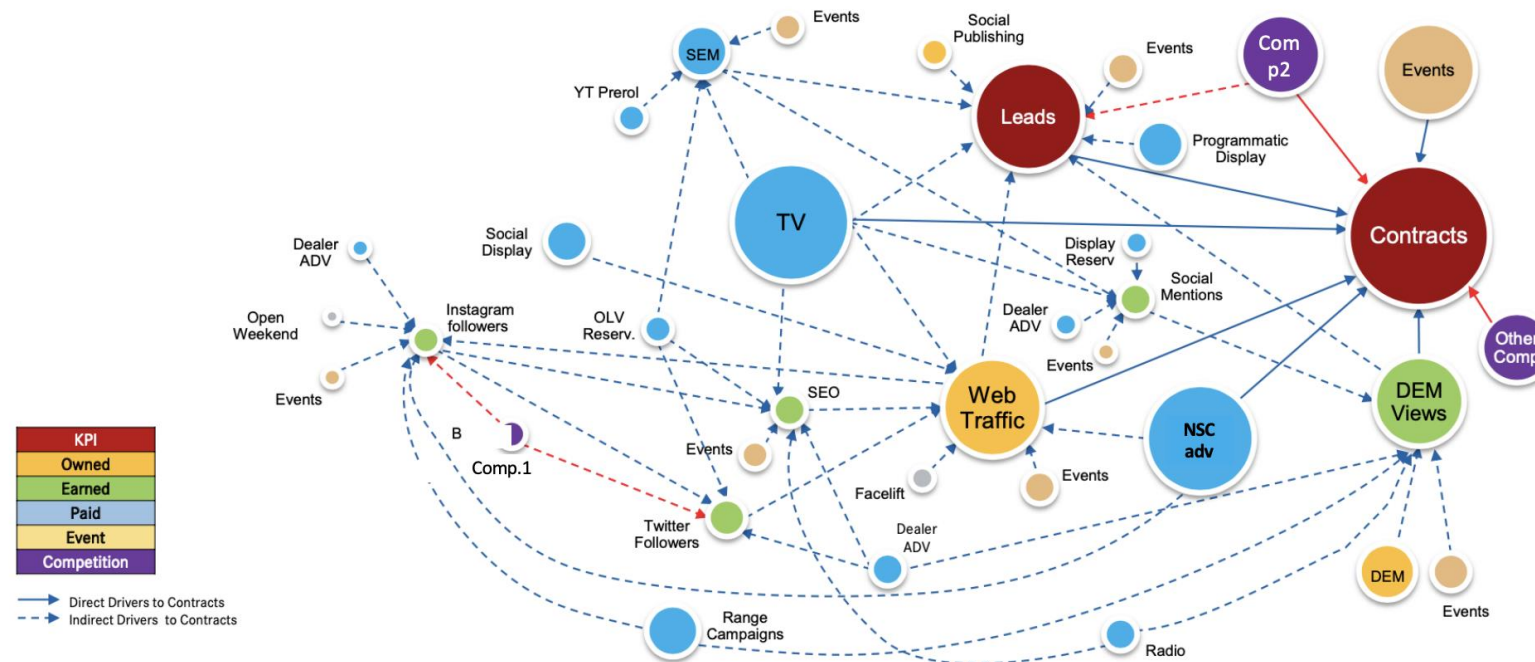


# How to design a Marketing Mix Model

5

## Model Selection

Hypothesize possible interactions among variables



# How to design a Marketing Mix Model

6

## Model fit and hyperparameters optimization

Optimization of hyper-parameters is done by a **gridsearch** (→ tests different combinations of hyper-parameters and selects the combination that maximizes the fit of the model)

7

## Model evaluation

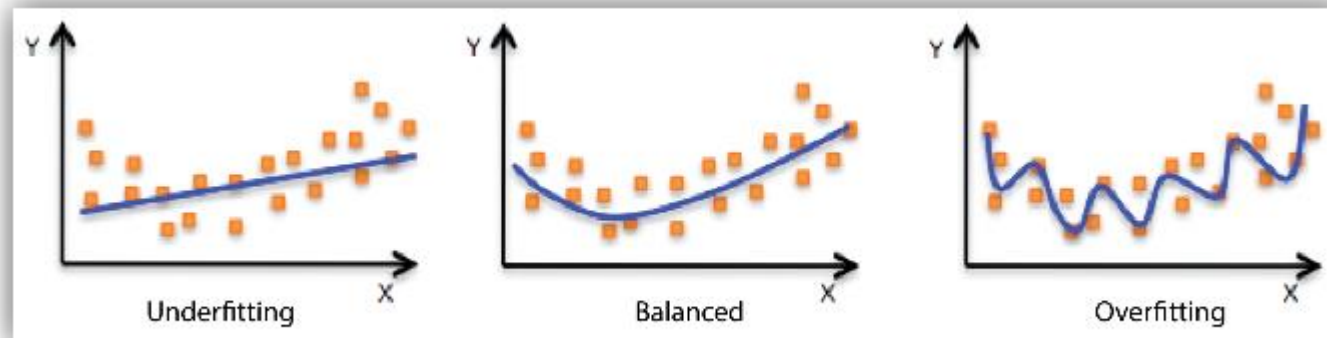
**Statistical Tests**

**Sense Check!**

# How to design a Marketing Mix Model

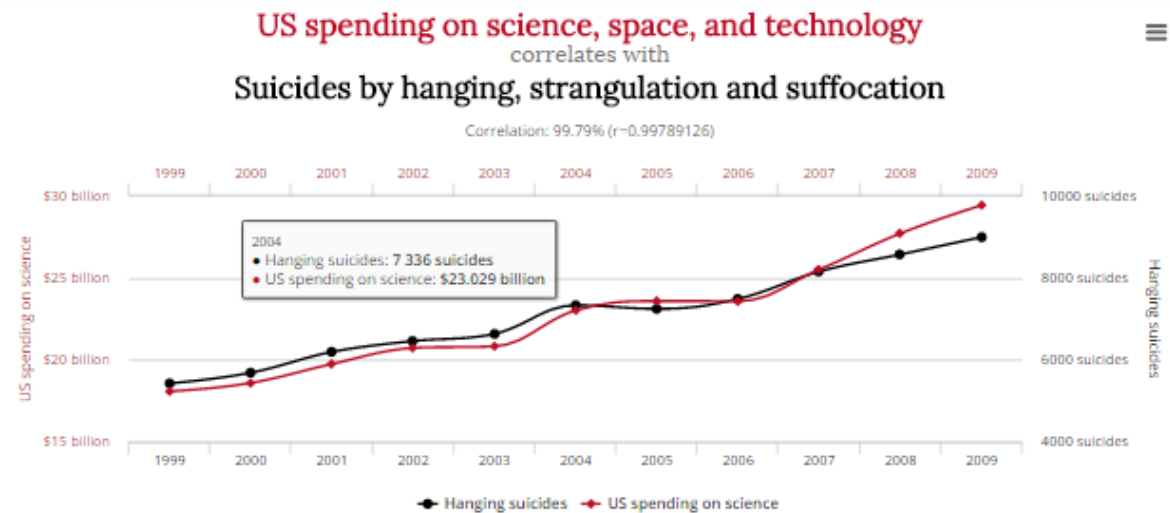
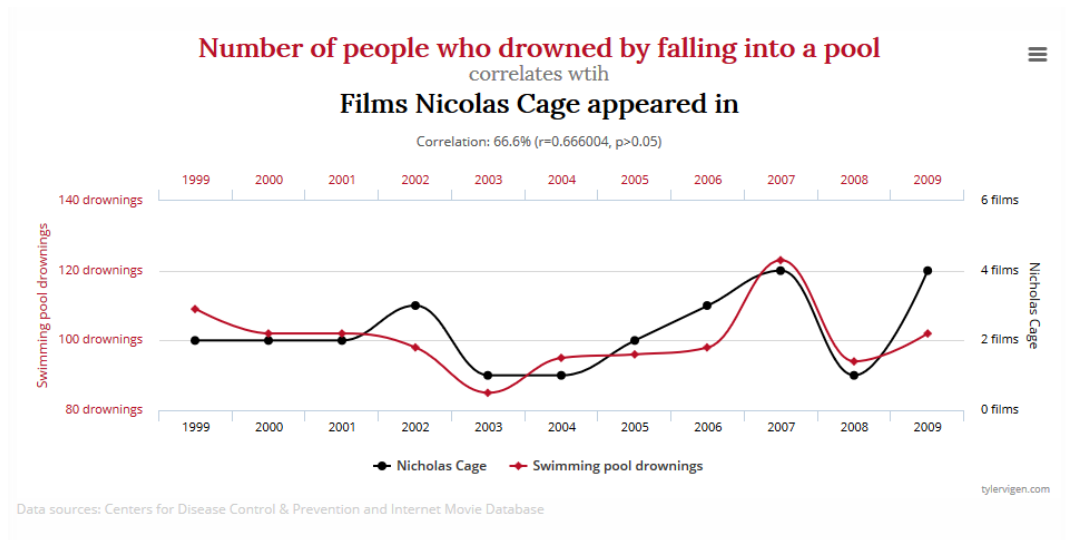
## Statistical Tests

- **R-squared** and Adjusted R-squared
- Mean Absolute Error (MAE) , Mean Squared Error (MSE), Root Mean Squared Error (RMSE)...
- Normality and independence of residuals
- Significance of the coefficients
- Variance Inflation Factor (VIF) to check for multicollinearity



# How to design a Marketing Mix Model

Never forget: Sense Check!



# How to design a Marketing Mix Model

**Never forget: Sense Check!**

Some examples:

- Media should not have a negative effect on sales
- Cannibalization effects may occur
- Media that generate higher brand recall (e.g., TV...) should have a higher adstock value
- There is no lag in promotional effect

# How to design a Marketing Mix Model



6

**Model fit and hyperparameters optimization**

7

**Model evaluation**

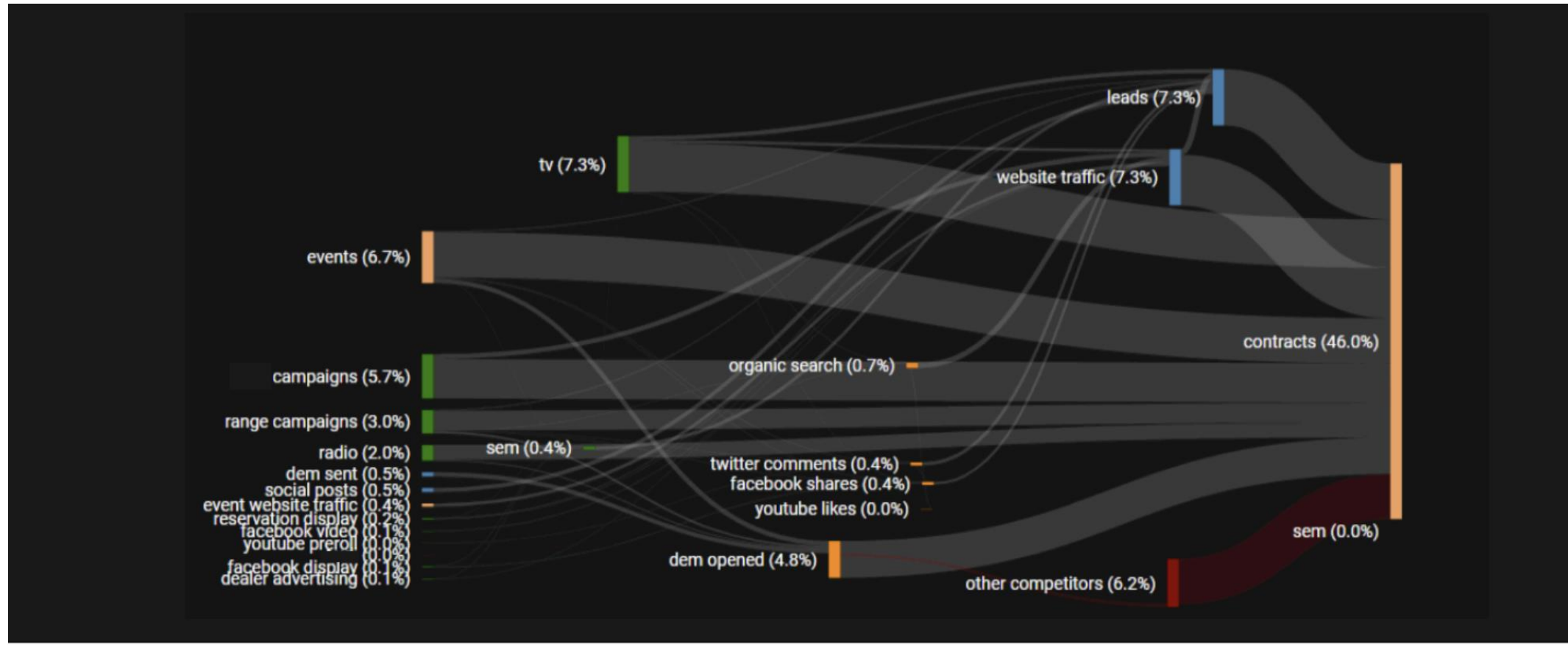
8

**Interpretation of the results and development of managerial guidelines**

**Touchpoint ROI:**  $\text{Incremental sales} / \text{Investments}$

**Touchpoint Effectiveness:**  $\text{Incremental sales} / \text{GRP}$

# How to design a Marketing Mix Model



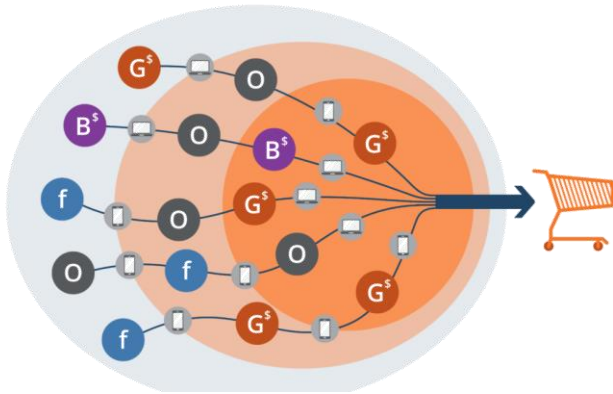


# Attribution Modeling

02

# Attribution Modeling

Especially in digital marketing activities, there are many **touchpoints** that can play a different role in a purchase process:

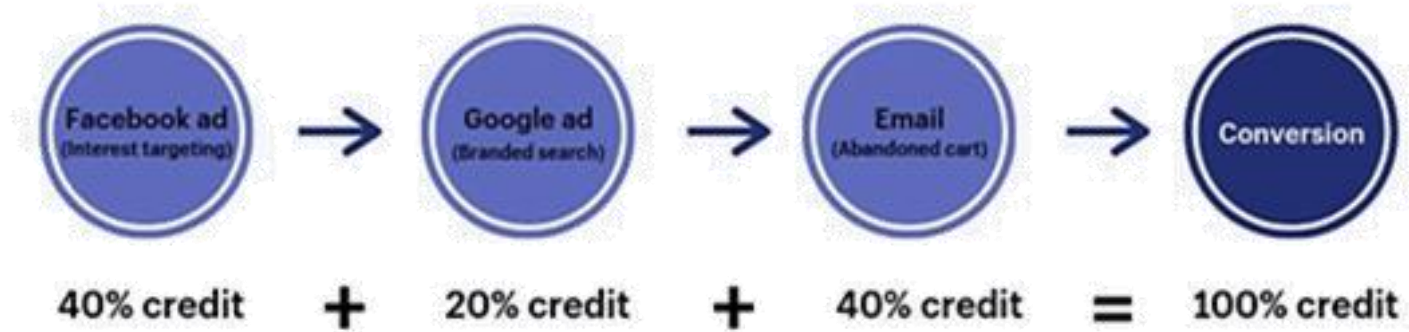


- **Starting point:** beginning of a customer journey
- **Intermediate point:** step in a customer journey moving the customer along the funnel
- **Final point:** final touchpoint, such as the point of conversion

Each of the touchpoints may potentially play a role in creating value. But how do they contribute to the overall success? The answer is all but trivial, and it is addressed through a statistical approach called **attribution modelling**

# Attribution Modeling

Especially in digital marketing activities, there are many **touchpoints** that can play a different role in a purchase process:



Each of the touchpoints may potentially play a role in creating value. But how do they contribute to the overall success? The answer is all but trivial, and it is addressed through a statistical approach called **attribution modelling**

# Attribution Modeling – Possible approaches



**First touch:** 100% of the credit for the sales/conversion is attributed to the first touchpoint in the Customer Journey



**Lead conversion:** 100% of the credit for the sales/conversion is attributed to the first touchpoint in which the prospect becomes a lead (e.g., registration)



**Opportunity creation (or last touch):** 100% of the credit for the sales/conversion is attributed to the touchpoint in which the lead is qualified

# Attribution Modeling – Possible approaches

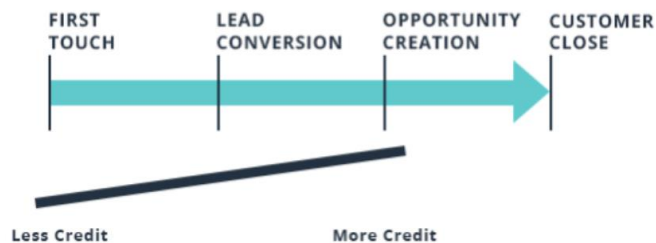


**Customer close:** 100% of the credit for the sales/conversion is attributed to the touchpoint where conversion occurs



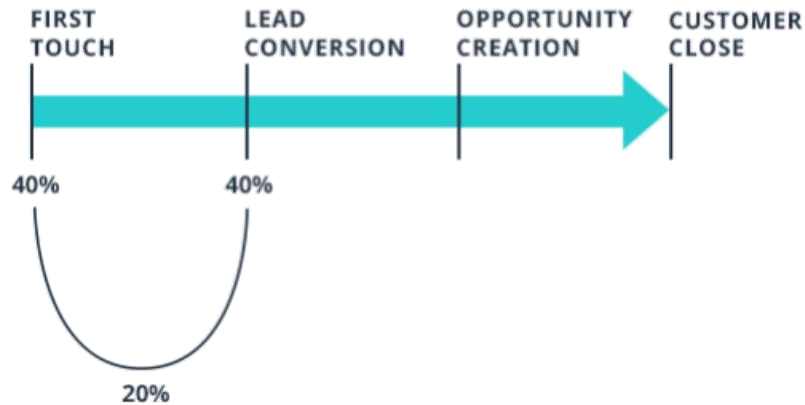
Where X equals the total number of touchpoints

**Linear model:** in a x-touchpoint journey ending up with a sales/conversion, each touchpoint gets  $1/x$  of the credit

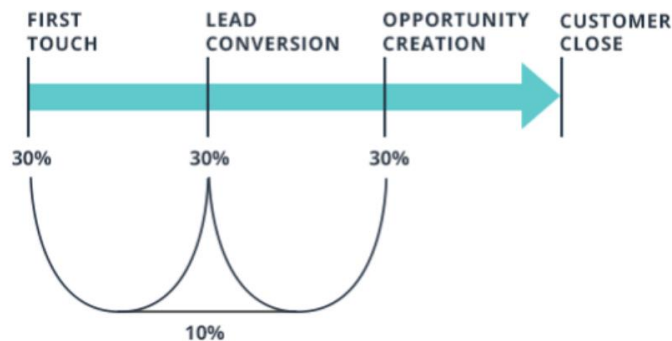


**Time decay model:** The weights in attributing credit increase as we get closer to customer close

# Attribution Modeling – Possible approaches

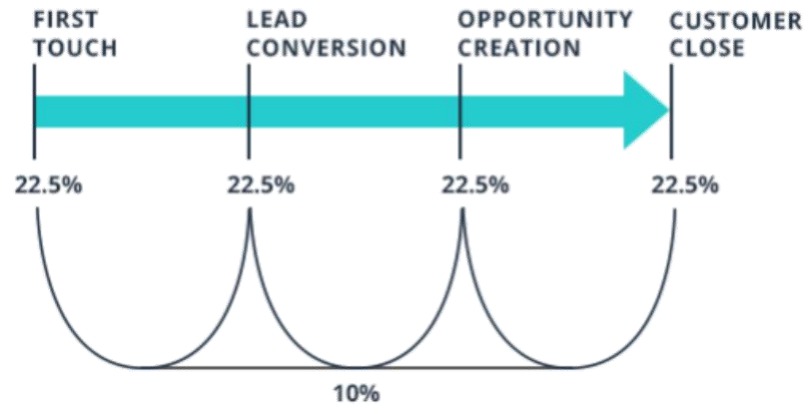


**U-Shaped model:** 40% of the credit is attributed to the first touch and 40% to the lead conversion; the rest is evenly split among the other touchpoints

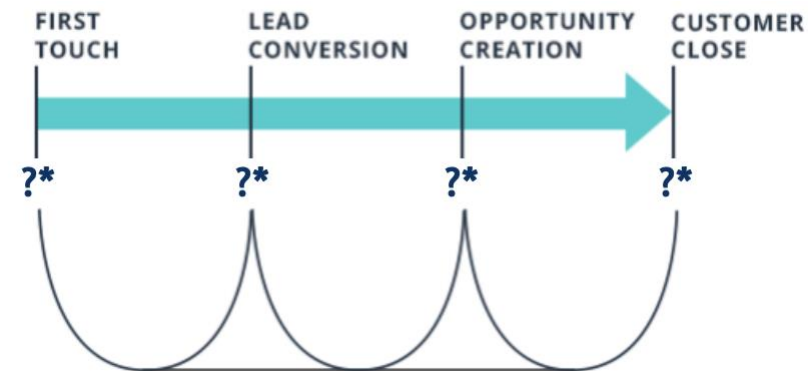


**W-Shaped model:** 30% of the credit is attributed to the first touch, the lead conversion and the opportunity creation and the rest is evenly split among the other touchpoints

# Attribution Modeling – Possible approaches

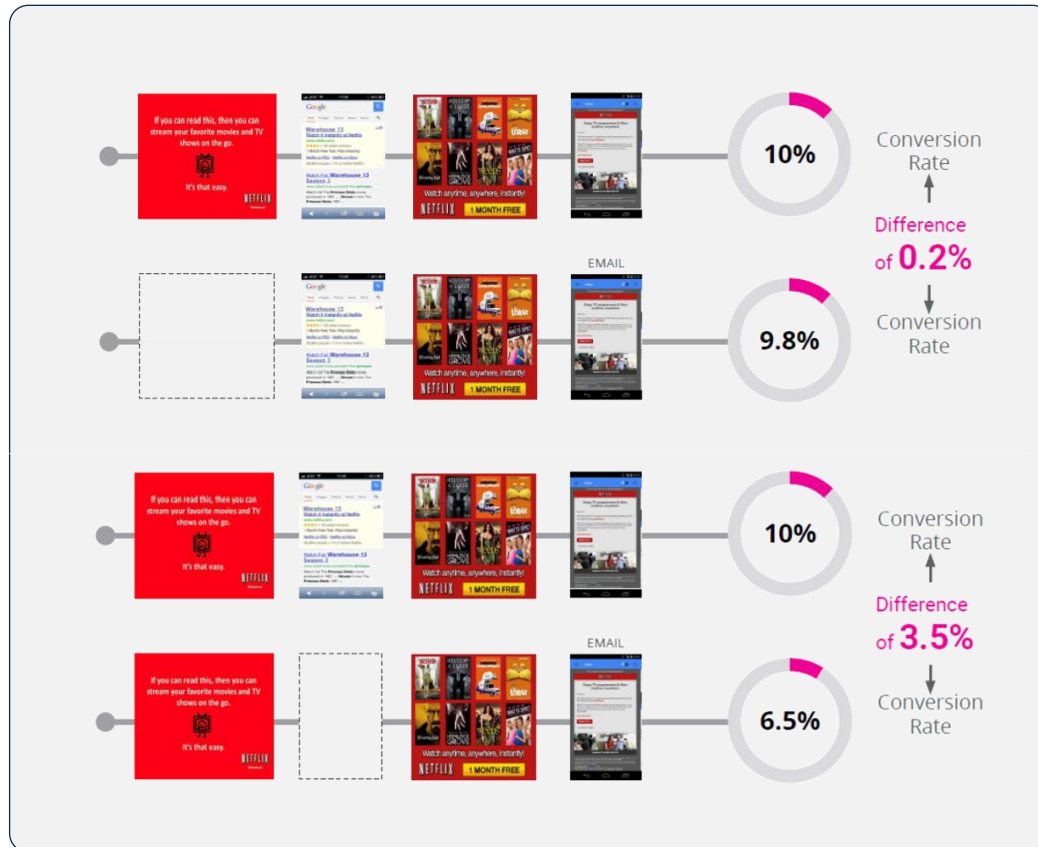


**Z-Shaped model:** 22.5% on the nodal steps and the remaining 10% evenly split among the other touchpoints



**Algorithmic model:** no fixed rules, but development of a suited statistical approach

# Attribution Modeling – Possible approaches



## Markov Model

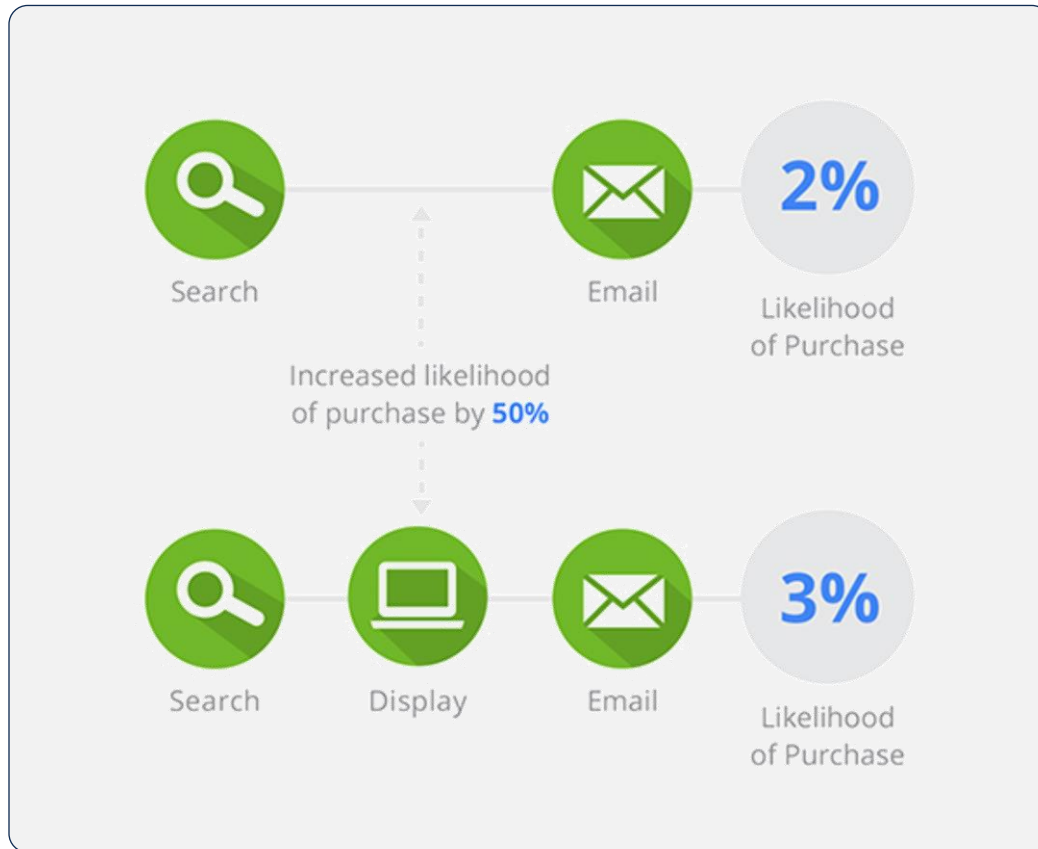
Basic idea:

**Step 1:** map the possible touchpoints and customer journeys

**Step 2:** removal effect, i.e., the contribution of a touchpoint is determined by the number of conversion that would have occurred without that touchpoint



# Attribution Modeling – Possible approaches

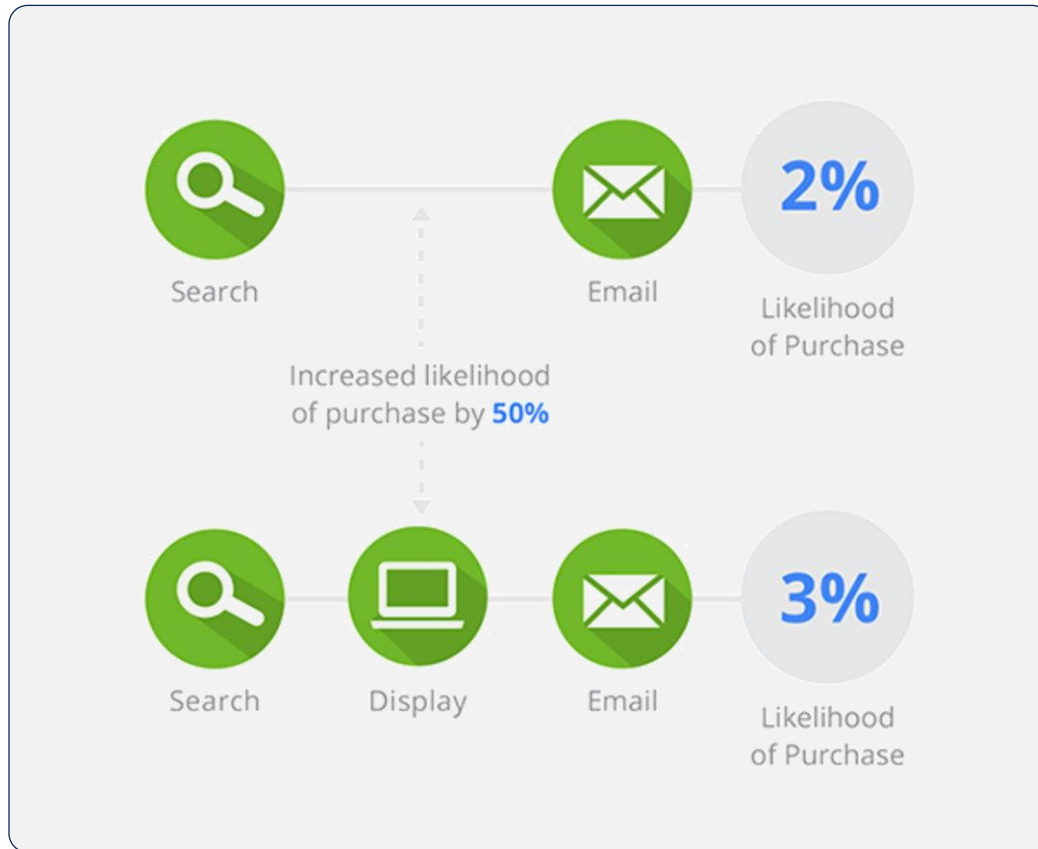


## Shapley Value

Shapley value is an algorithm based on game theory in a cooperative situation. Game theory is defined as the study of **mathematical models of conflict and cooperation** between **rational decision makers**

Shapley value is used in **cooperative games** to **distribute credit** or value to each player/participant.

# Attribution Modeling – Possible approaches



## Shapley Value

For an attribution model, the **players** are replaced by **the touchpoints** that collaborate in the generation of the results (i.e., conversions).

- ❑ This algorithm allows to attribute to each touchpoint its contribution to the generation of conversions.
- ❑ The main problem associated with this approach is the need to compute a Shapley value for each combination of touchpoints.

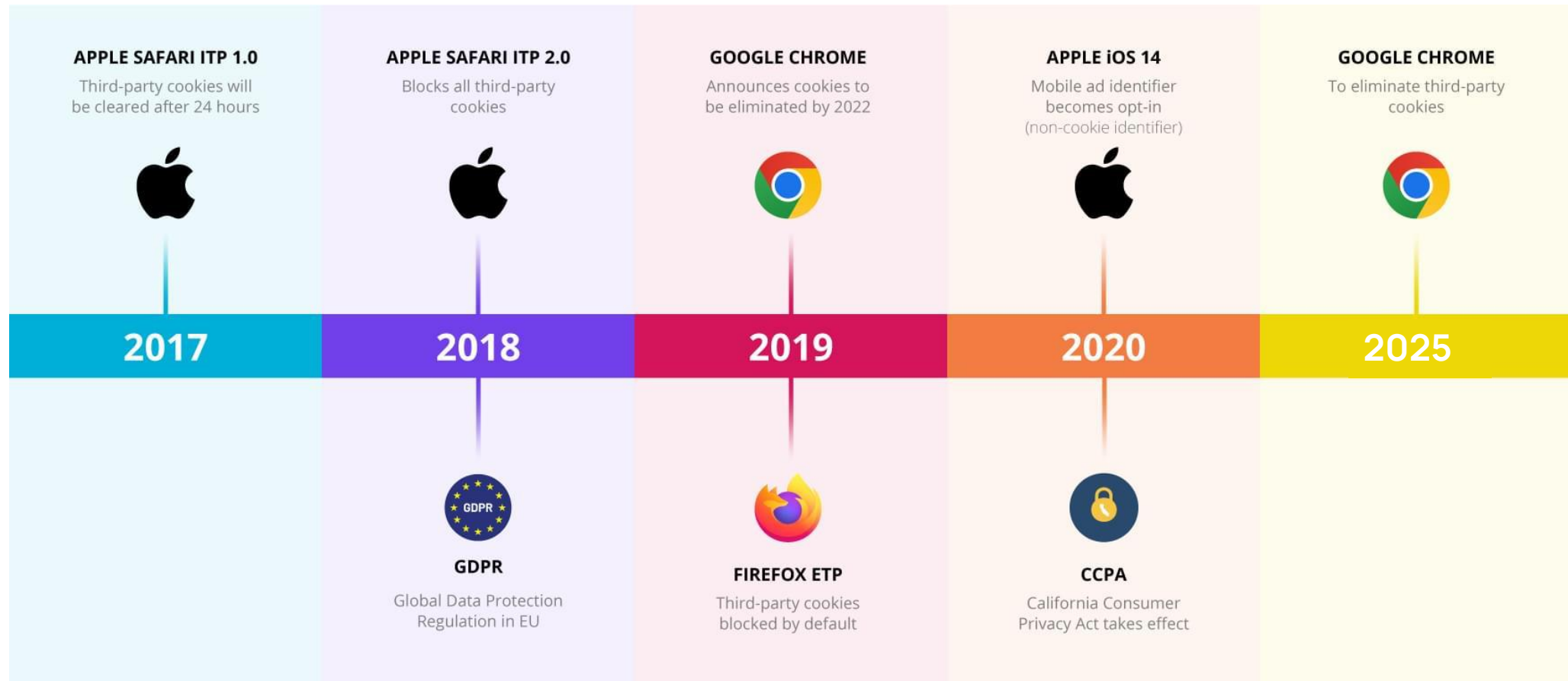
## In conclusion

	Marketing Mix Model	Attribution modelling
Approach	Top-down	Bottom-up
Data model	Aggregate data on marketing investment, conversion/sales and contextual elements (e.g., competitors, general economy, etc.)	Individual consumer's touchpoint data linked to digital conversions
Objectives	Identifying the «base» marketing performance and the «incremental» ones Analyzing short-termed and long-termed impacts Scenario simulation Resource optimization	Potentially, real-time optimization of <b>digital marketing</b> expenditures Identification of »assists« and synergies among touchpoints
Limits	Mid- to long-termed planning (at least quarterly)	Difficulty in linking digital and non-digital touchpoints (addressability) → over-evaluation of the digital touchpoint contribution

## Current Landscape and Challenges

03

# Increasing relevance of Marketing Mix Modeling



# Challenges and frontiers



**Long-term or Short-term?**



**Media Interactions**



**Media or Creativity?**



**Local Effects**

# Challenges and frontiers

**ROI < 1 → Why keep investing?**



## Long-term or Short-term?

What are the long term effects (BE) of marketing activities?  
How to analyze brand related KPIs (Top of Mind, Brand Awareness..)?



## Media Interactions

How activities on different media affect each other and how to quantify synergies or cannibalization effects?

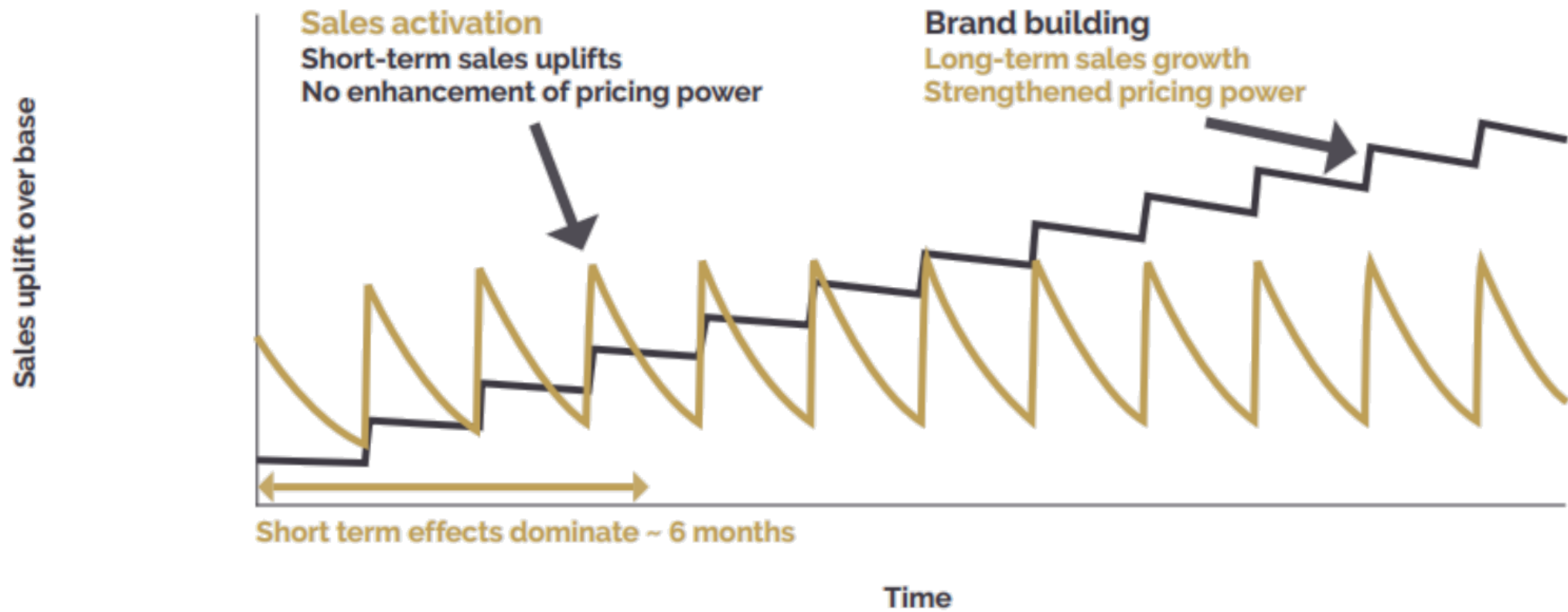


## Media or Creativity?



## Local Effects

# Challenges and frontiers





# Challenges and frontiers



## Long-term or Short-term?

What are the long term effects (BE) of marketing activities?  
How to analyze brand related KPIs (Top of Mind, Brand Awareness..)?



## Media or Creativity?

How changes in the ads format, creatives, sponsor or influencers affect the media efficacy ?



## Media Interactions

How activities on different media affect each other and how to quantify synergies or cannibalization effects?



## Local Effects

How the activities on different channels affect different geographical areas ?



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