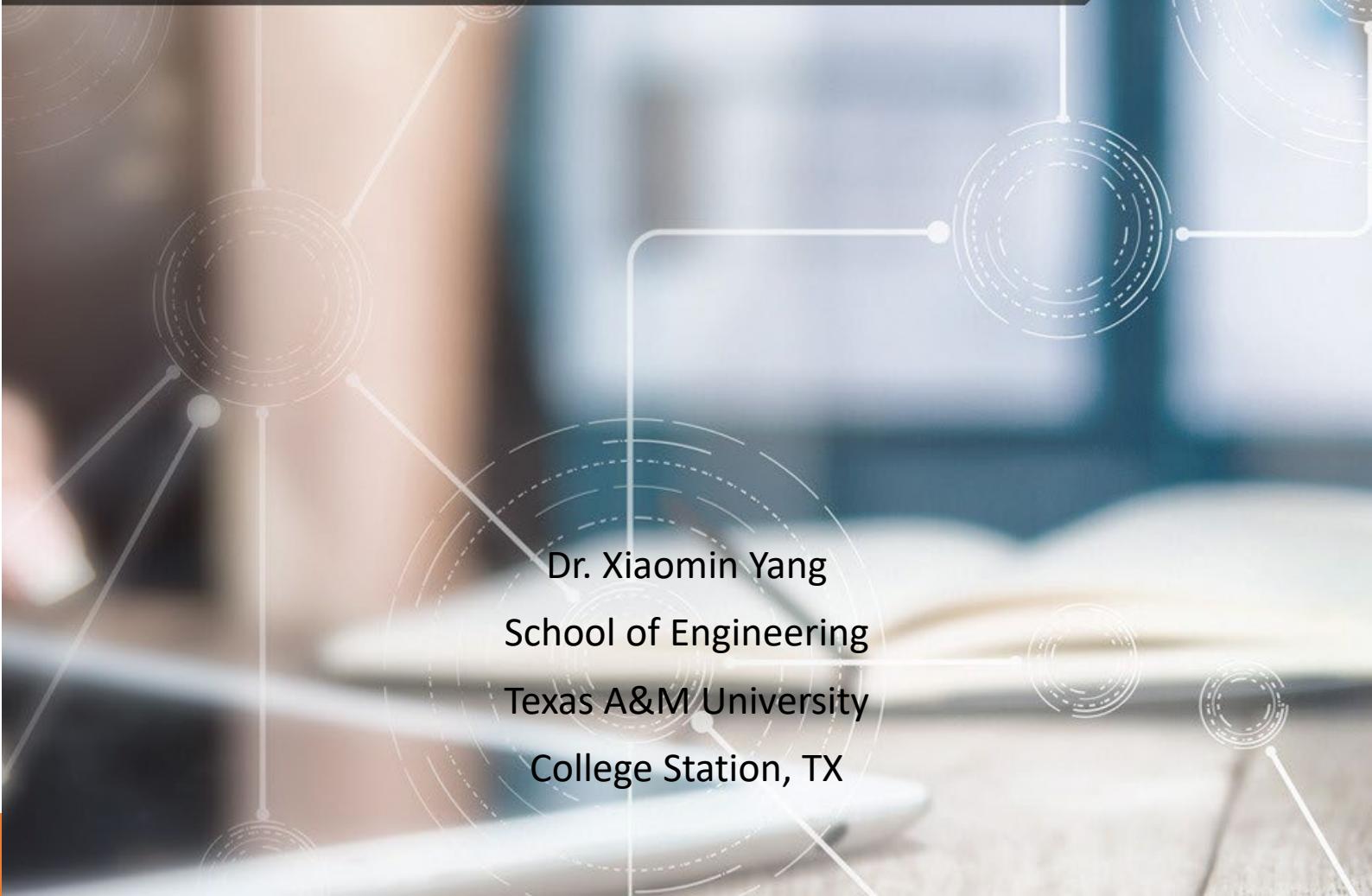


# MASTER OF ENGINEERING TECHNICAL MANAGEMENT

Technology management  
decision-making



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Texas A&M University  
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# Systematic decision-making approach



1. Align business strategy and data integration

Business strategy, value chain and data-driven culture

2. Identify and evaluate options and risks

Decision tree, Simulation, Forecasting methods, and Optimization

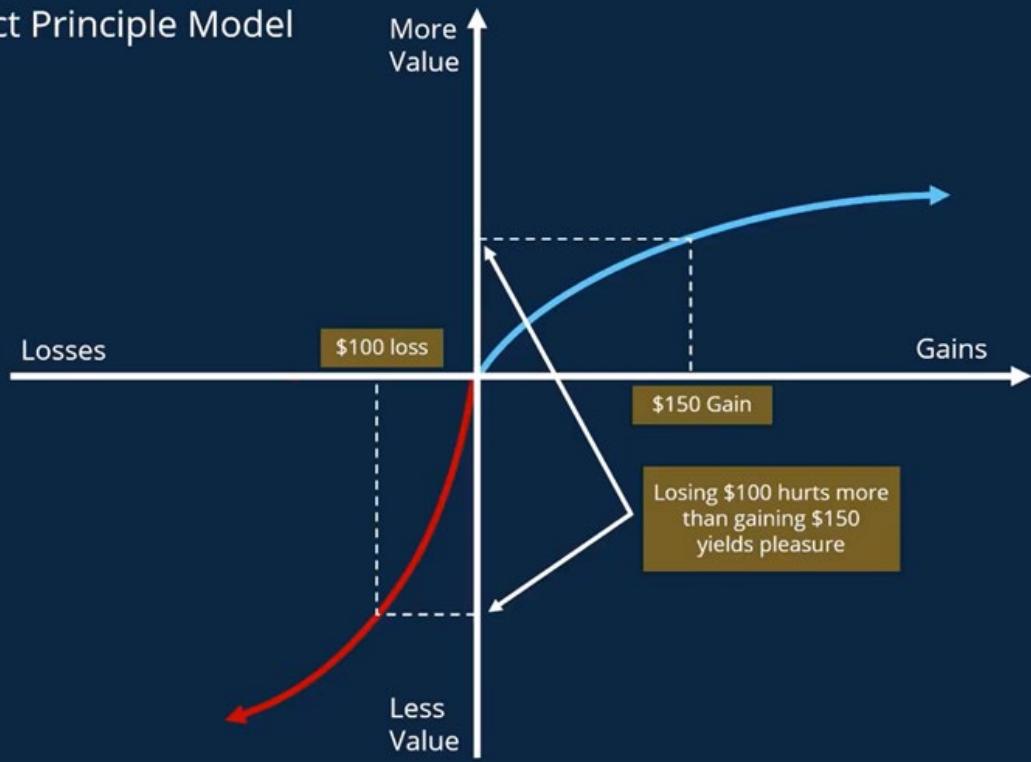
3. Make intuitive judgment

Risking taking and intuitive judgment

Module #	Module Title
1	Roles of data analytics and human in decision-making
2	Intuitive Judgment in decision making
3	Intuitive Judgment in competitive environments
4	Data-driven decision-making: decision tree method
5	Align decision with business strategy
	Mid-term project
6	Predictive analytics - forecasting
7	Analytical decisions - business optimization
8	Uncertain analytics - simulation
9	Integrate data analytics into business
	Final exam

# TCMT 612: Course outline

## Prospect Principle Model

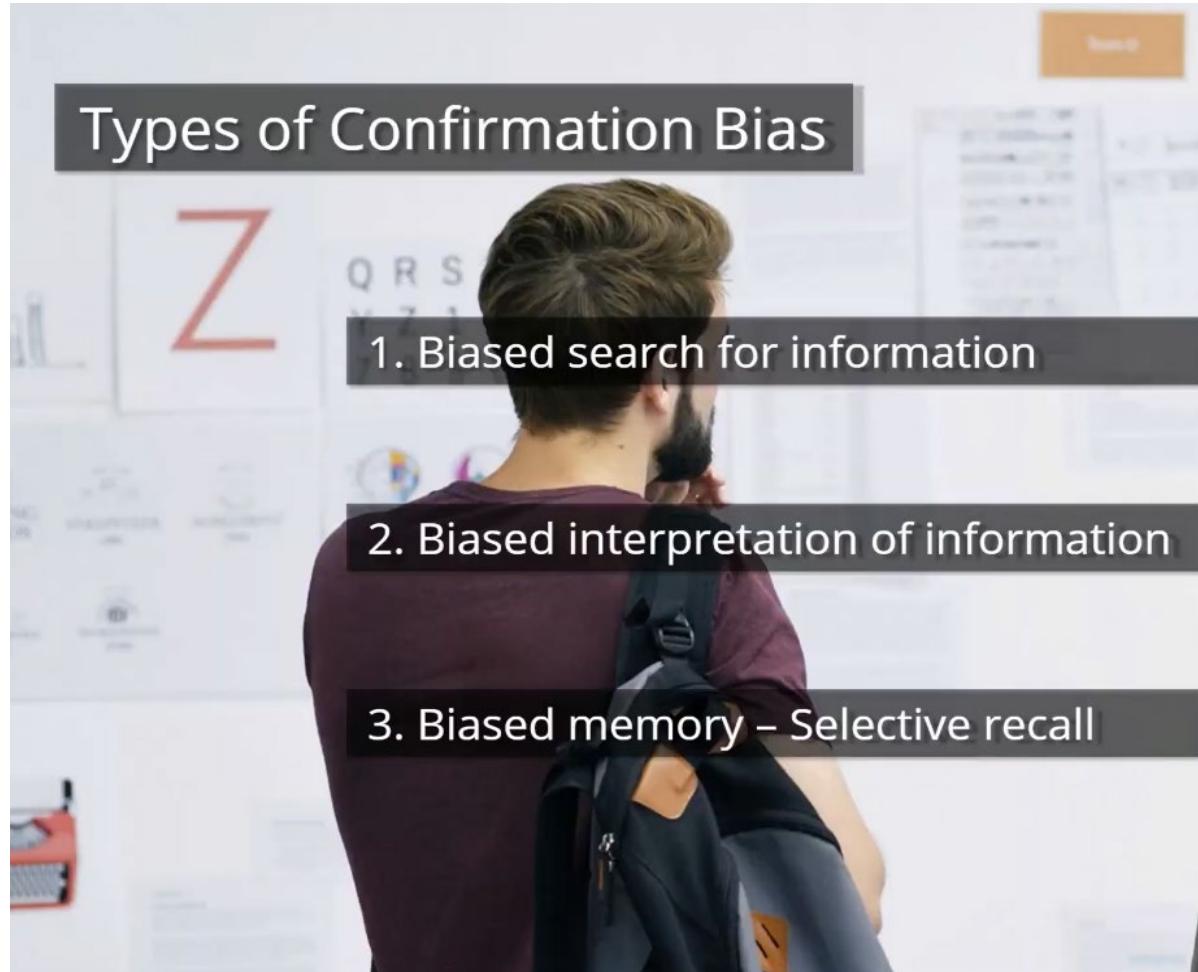


- The x-axis represents the outcomes of economic decisions with financial gains on the right and losses on the left.
- The y-axis represents the subjective perceived value of these outcomes to individuals making decisions.
- The Prospect Principle underscores the economic behavior that individuals encounter risks associated with uncertainty. They often overlook positive outcomes and disproportionately emphasize potential losses.

# Judgment Biases: How human Beings Decide and Influence

- Confirmation
- Anchoring
- Framing
- Representative heuristic

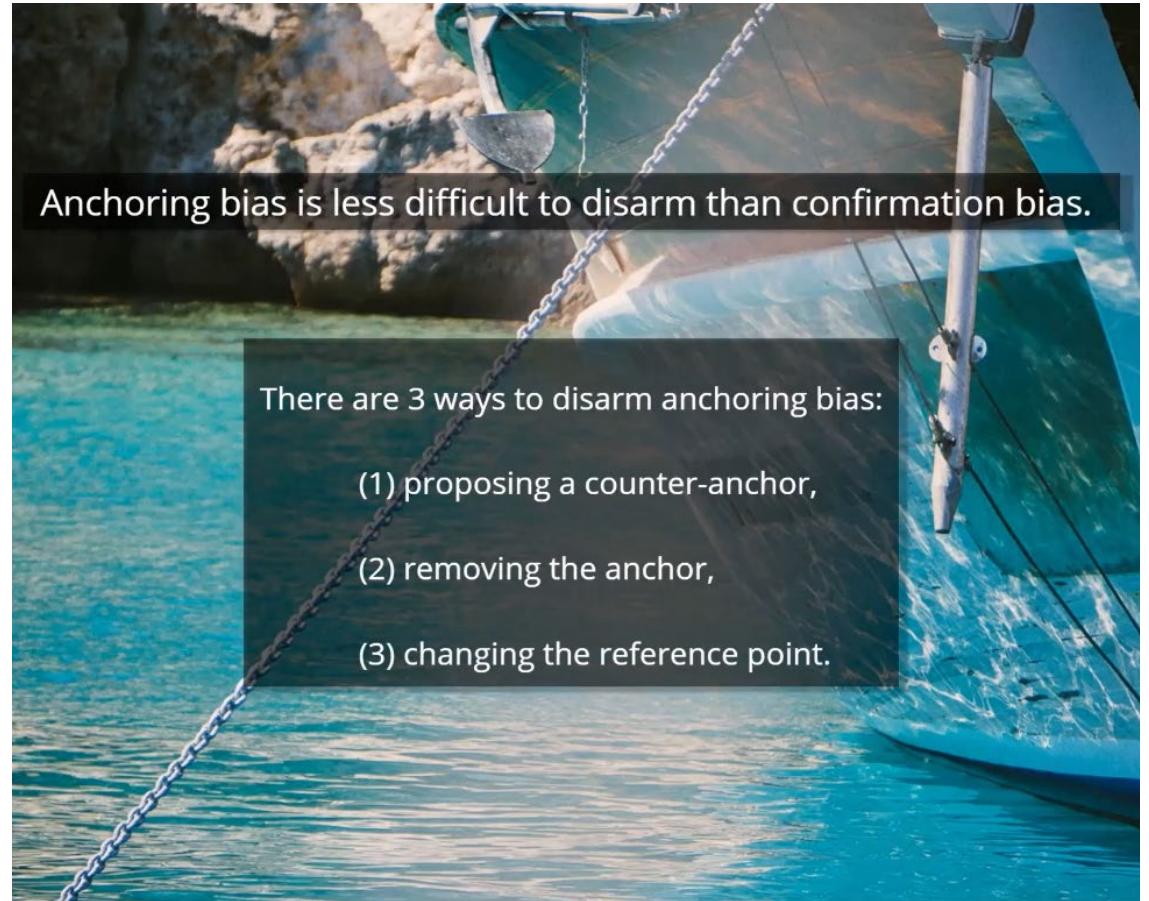
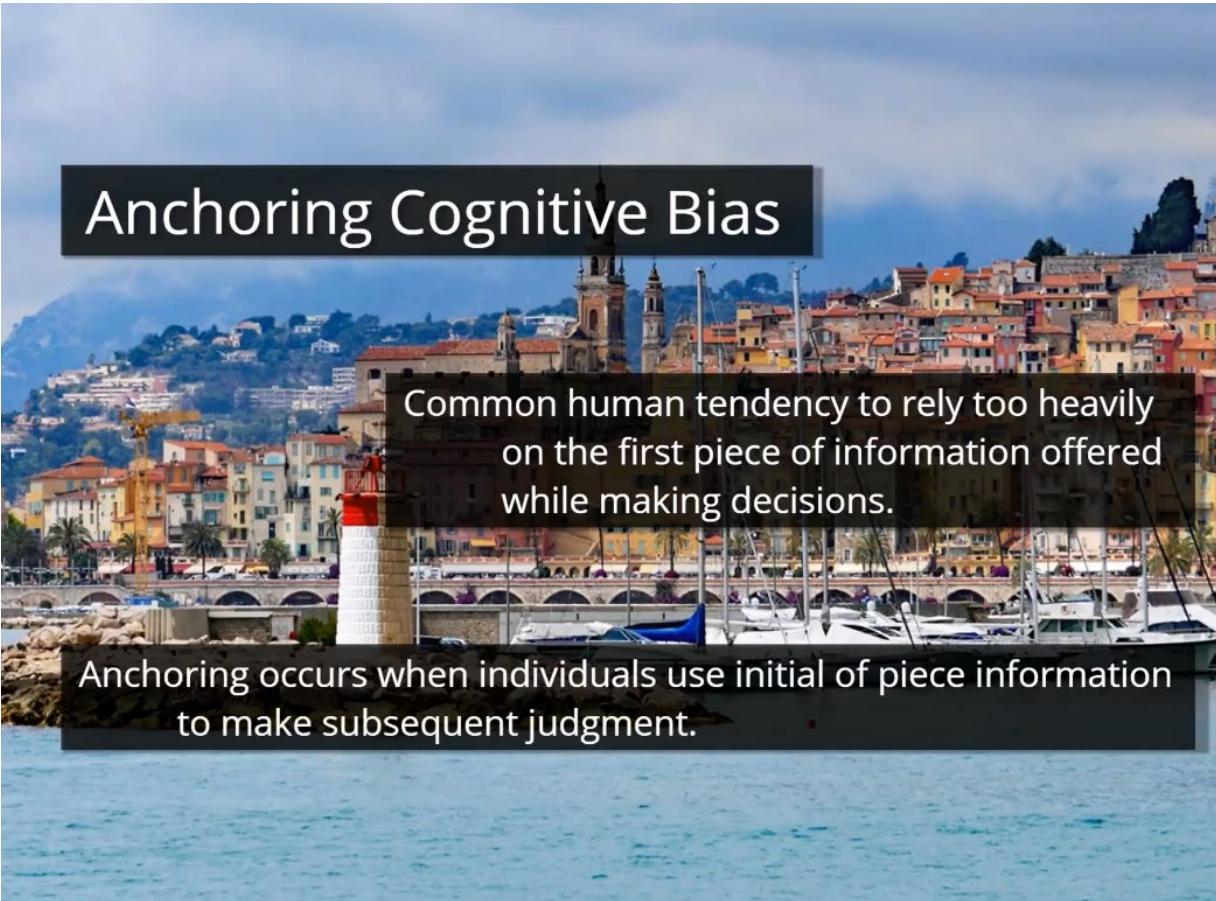




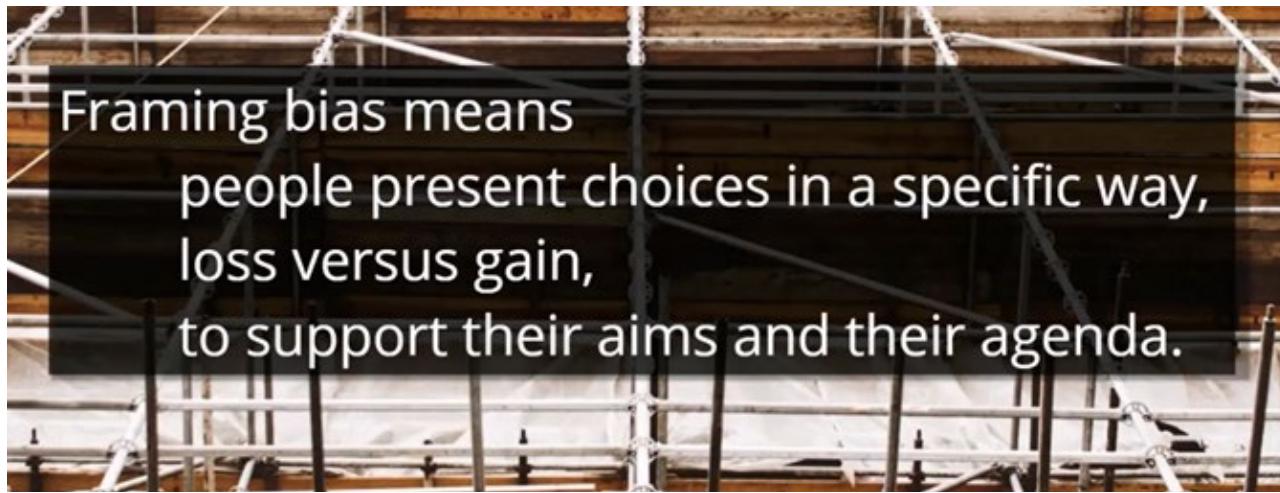
The complexity of confirmation bias arises partly from the fact that it is impossible to overcome it without an awareness of the concept.

Confirmation bias is more influenced by the ability to rationally think than by intelligence levels.

**One way to disarm confirmation bias is to introduce rational thinking.**

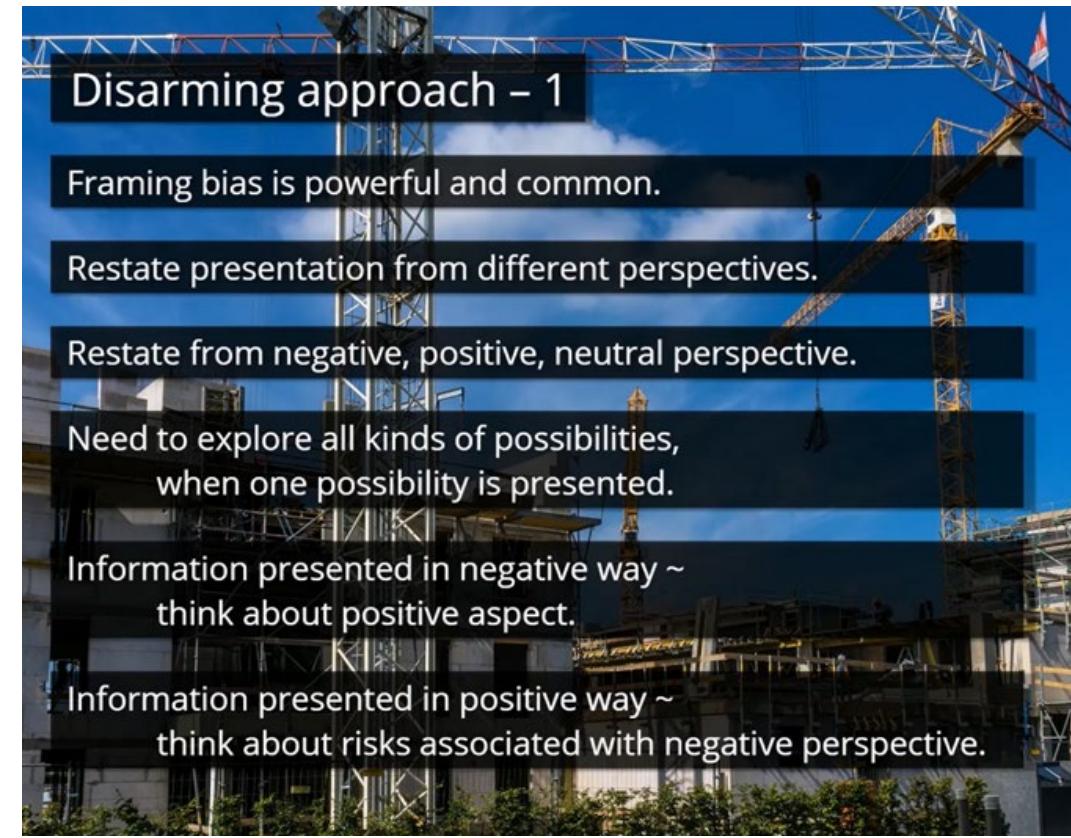


Whatever technique you use to de-anchor, you need to move fast: do not give the anchor a chance to settle before de-anchoring it



Framing bias means people present choices in a specific way, loss versus gain, to support their aims and their agenda.

- Positive vs. negative framing
- Framing bias is very **common** in situations with high levels of **uncertainty** and with a limited amount of information to project the outcome of future events.



### Disarming approach - 1

Framing bias is powerful and common.

Restate presentation from different perspectives.

Restate from negative, positive, neutral perspective.

1 Need to explore all kinds of possibilities, when one possibility is presented.

Information presented in negative way ~ think about positive aspect.

Information presented in positive way ~ think about risks associated with negative perspective.

The real challenge of disarming framing bias is to respond **in a constructive way**.

Fourth type of cognitive bias ~ *Representative heuristic*

Also called *Stereotype bias*,  
assessing similarity of events,  
drawing conclusion on individual events,  
based on common features of the category.

Occurs when people take a shortcut  
to bypass detailed analysis of a specific event.

Two types of bias

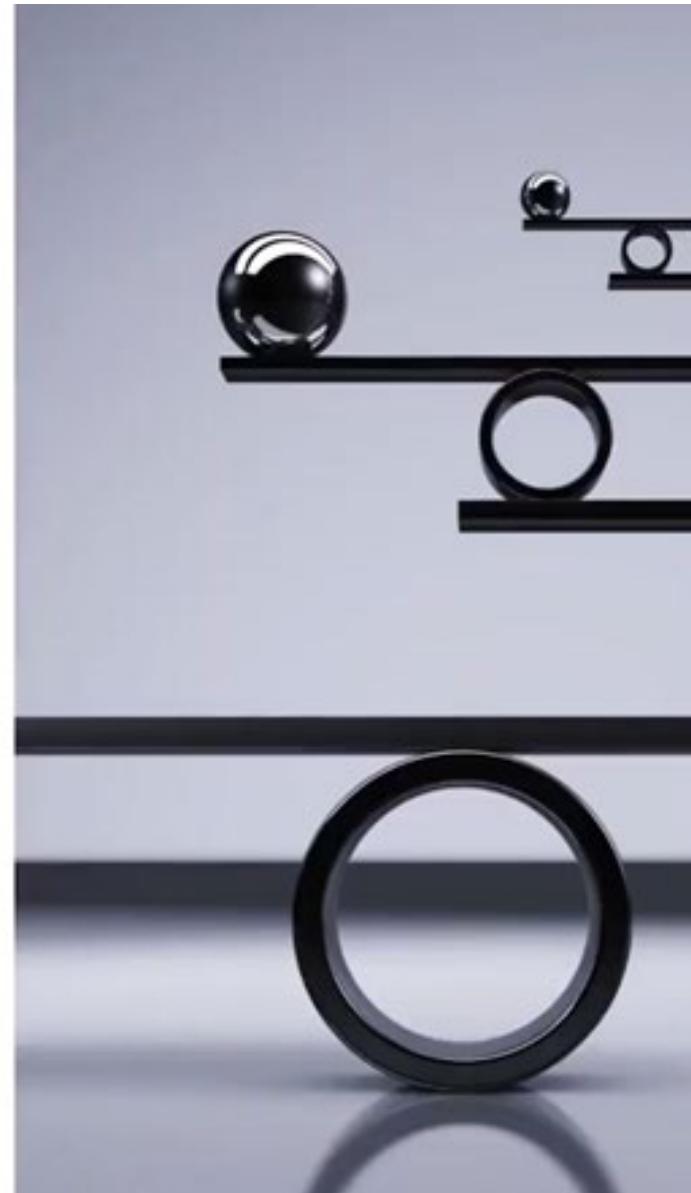
- The first is to label the uncertain situation into a category that favors your desired outcome. (e.g., categorize the product as high risk and high return, to gain support for a new product project.)
- sequence information to stimulate simplification and stereotyping in decision making. (e.g., present value first)

## Disarming Stereotyping Bias

- One tactic is to make events more unique by pointing out the difference between the event and the category.
- Another effective technique to disarm representative bias is to involve people with different viewpoints to clearly define the details of the case.

# Common Judgment Fallacies in Uncertain Business Situations

- Endowment effect
- Status quo bias
- Escalation of commitment fallacy



**Seller's** emotional attachment  
drive them to overprice the object.

One of the most important behavioral principles  
to be aware of and manage  
when making price-related decisions.

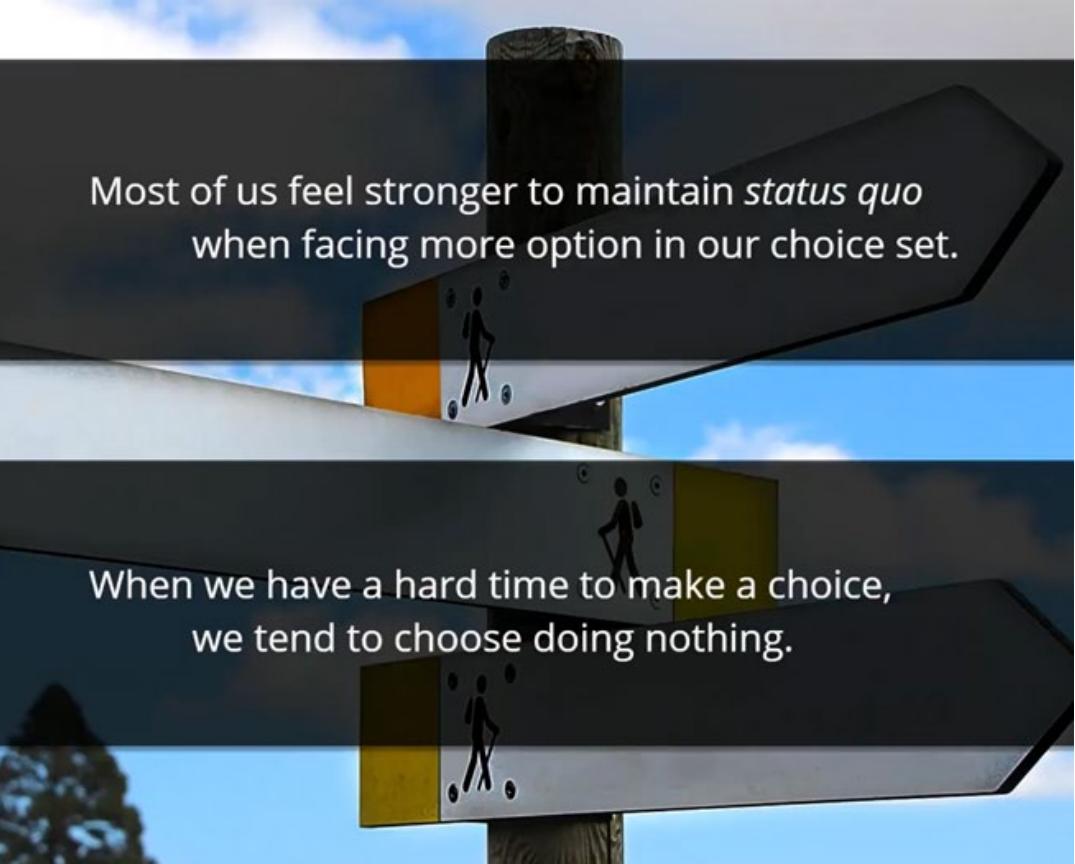
We all tend to overvalue what we own.

Value = intrinsic value + attachment value

**Buyers** are on objective ground.  
**Buyers** tend to focus on money that they are going to spend.  
**Buyers** market research biased toward commodity price.  
Their reference price heavily influences their purchasing price.



**An effective strategy to mitigate the endowment effect create joint ownership**



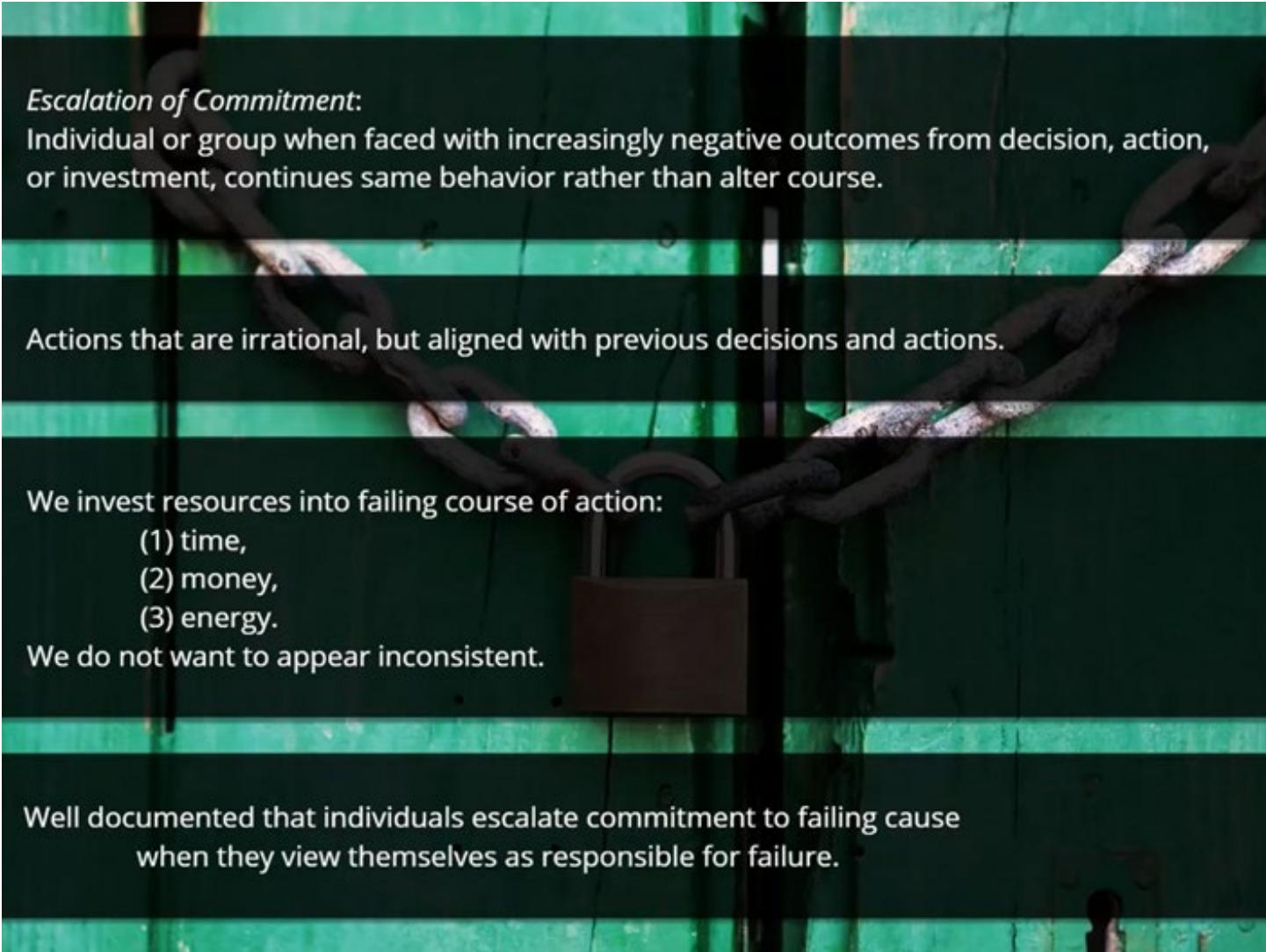
Most of us feel stronger to maintain *status quo* when facing more option in our choice set.

When we have a hard time to make a choice, we tend to choose doing nothing.



Very powerful status quo implication in business world especially in technology and engineering  
“First mover advantage”

Brings significant competitive advantage  
establish status quo type of situation  
followers must overcome  
or follow.



### *Escalation of Commitment:*

Individual or group when faced with increasingly negative outcomes from decision, action, or investment, continues same behavior rather than alter course.

Actions that are irrational, but aligned with previous decisions and actions.

We invest resources into failing course of action:

- (1) time,
- (2) money,
- (3) energy.

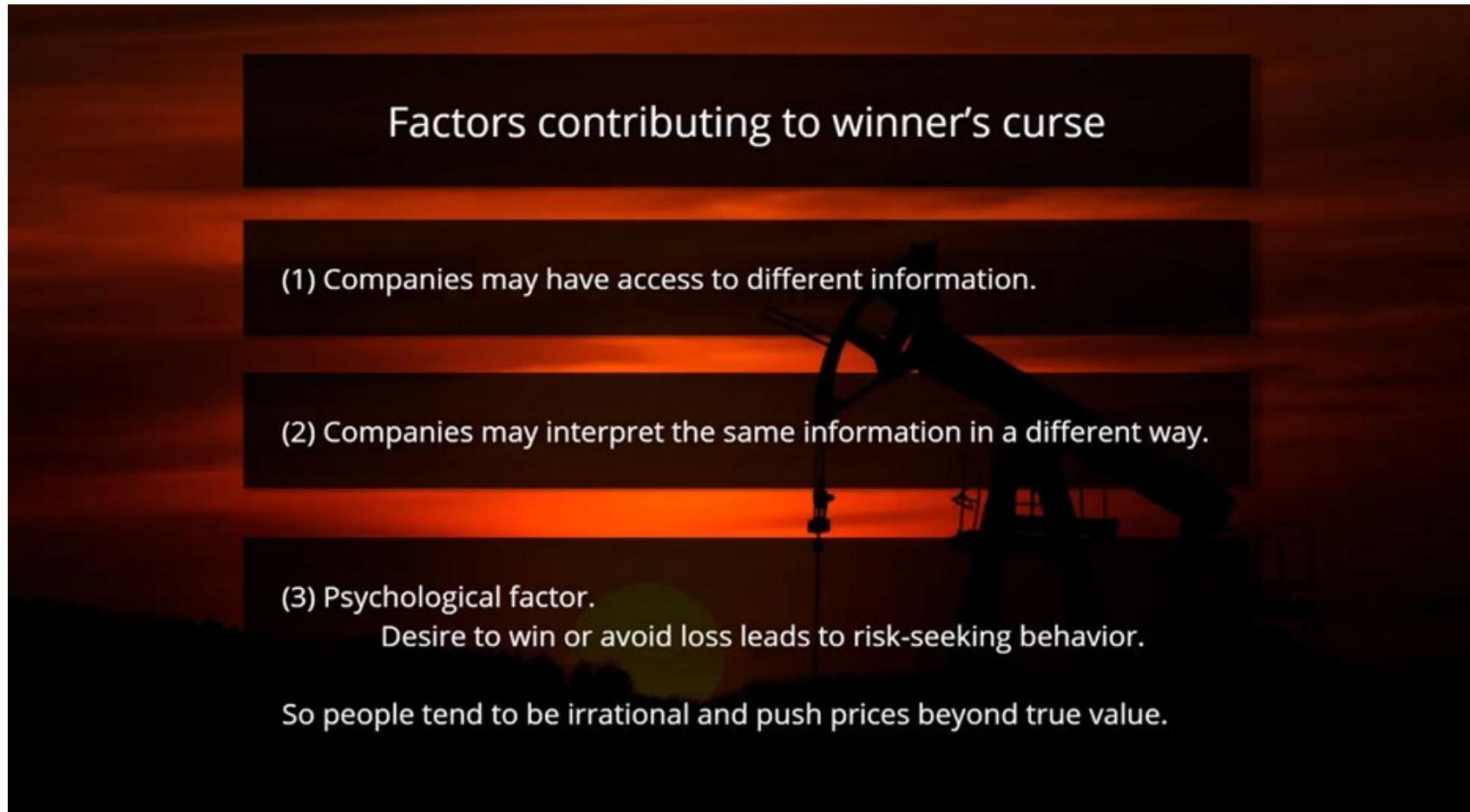
We do not want to appear inconsistent.

Well documented that individuals escalate commitment to failing cause when they view themselves as responsible for failure.

There are many signs in a business where you can tell that escalation of commitment occurs.

- project managers attribute underperforming project to temporary headwinds and refuse to cancel the project or significantly change the course of the project.
- Senior managers refusing to let go of the business they have started.
- Organization could not provide appropriate employee development and trainings to keep their skills and capabilities relevant to their responsibilities.

Winner's curse: a tendency for the winning bid in an auction to exceed the intrinsic value of the item purchased

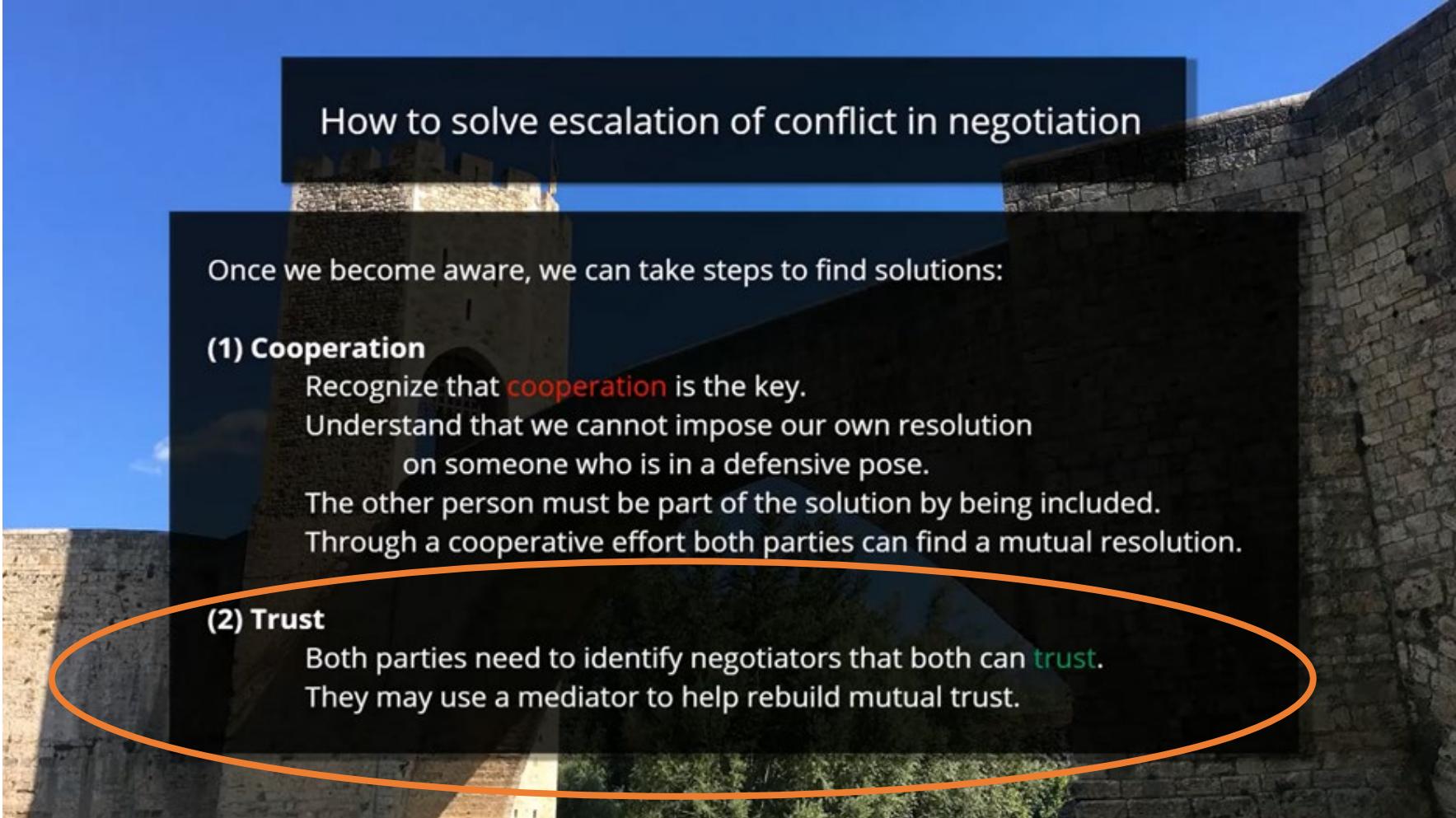


# Integrative approach to negotiation



Some of the guidelines to the integrative approach are:

- First, orient yourself toward a win-win approach (**cooperate to create value**).
- The second is to have a concrete strategy and apply your discussion accordingly.
- When you discuss the terms with your counterpart, **focus on interest, not positions. (share information to gain trust)**.
- To create options for mutual gain (**create a solution together**).
- Take the intangible into account especially when we negotiate with international parties.



## How to solve escalation of conflict in negotiation

Once we become aware, we can take steps to find solutions:

### (1) Cooperation

Recognize that **cooperation** is the key.

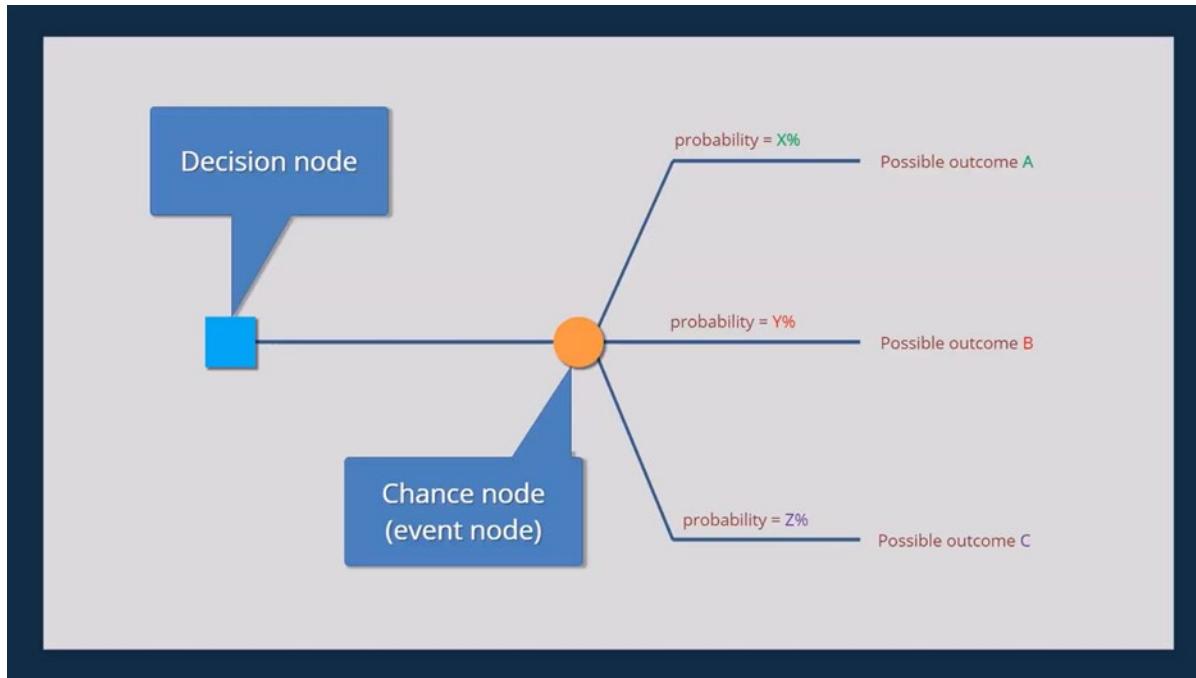
Understand that we cannot impose our own resolution  
on someone who is in a defensive pose.

The other person must be part of the solution by being included.  
Through a cooperative effort both parties can find a mutual resolution.

### (2) Trust

Both parties need to identify negotiators that both can **trust**.  
They may use a mediator to help rebuild mutual trust.

**Demanding your counterpart to give in their position is NOT effective to build trust**



$$E(x) = x_1 p_1 + x_2 p_2 + \dots + x_k p_k$$

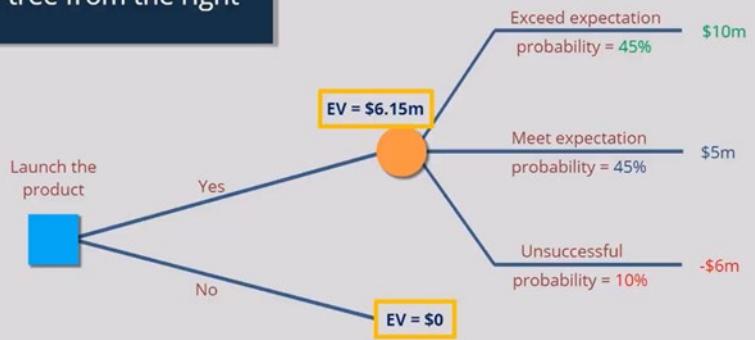
A decision node show decision options.

A chance node shows all possible outcomes of a decision.

Expected value is the sum of probability multiplied by the outcome where P is the probability of an outcome and X is the payoff should the event occur.

Weighted (p) average of all possible outcomes (x) of different scenarios

Solve tree from the right



- (a) chance node ~ calculate EV  
(b) decision node ~ chose best alternative

Solve a tree from right to left

At a chance node, calculate expected value of all possible outcomes

At a decision node, choose the best options (one with the highest expected value)

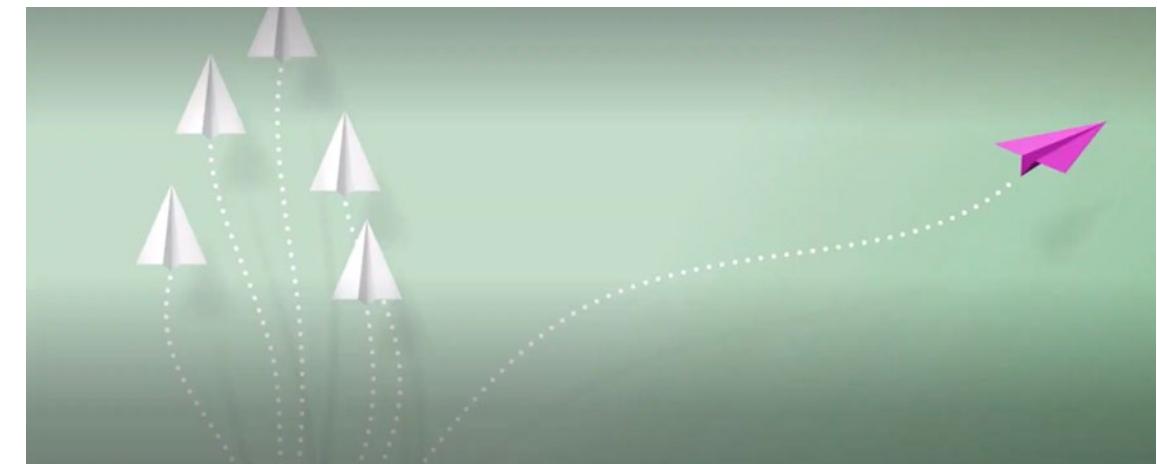
# Applications of decision tree method

## Advantages

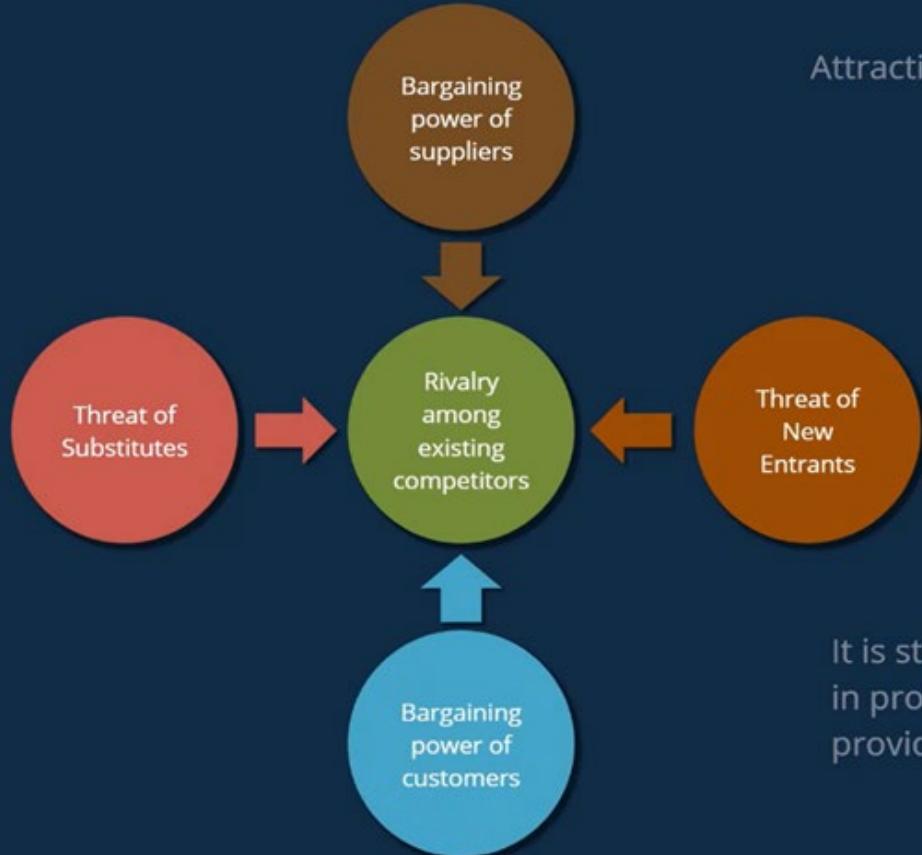
- transparent
- provide a structured evaluation framework
- promote collaboration within organizations
- flexible and can easily integrate with other decision-making techniques

## Disadvantage

- probabilities values used are usually very subjective



Strength of 5 economic forces ~ competitive intensity & attractiveness ~ profitability



Attractive industry = collective effect of 5 forces  
increases overall profitability.

It is strategically important to operate  
in profitable industry,  
provides more opportunities to earn revenue.

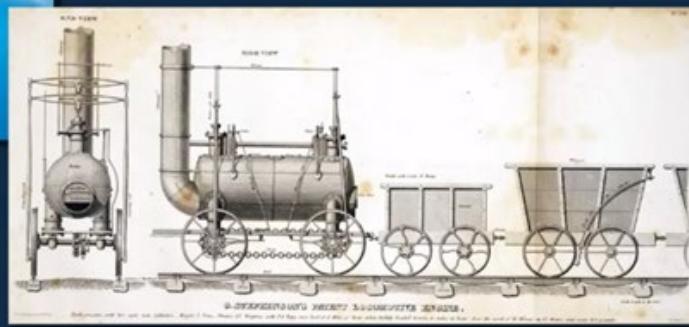
# Example

## Source of Barriers #1 - Experience, Innovation, & Patents

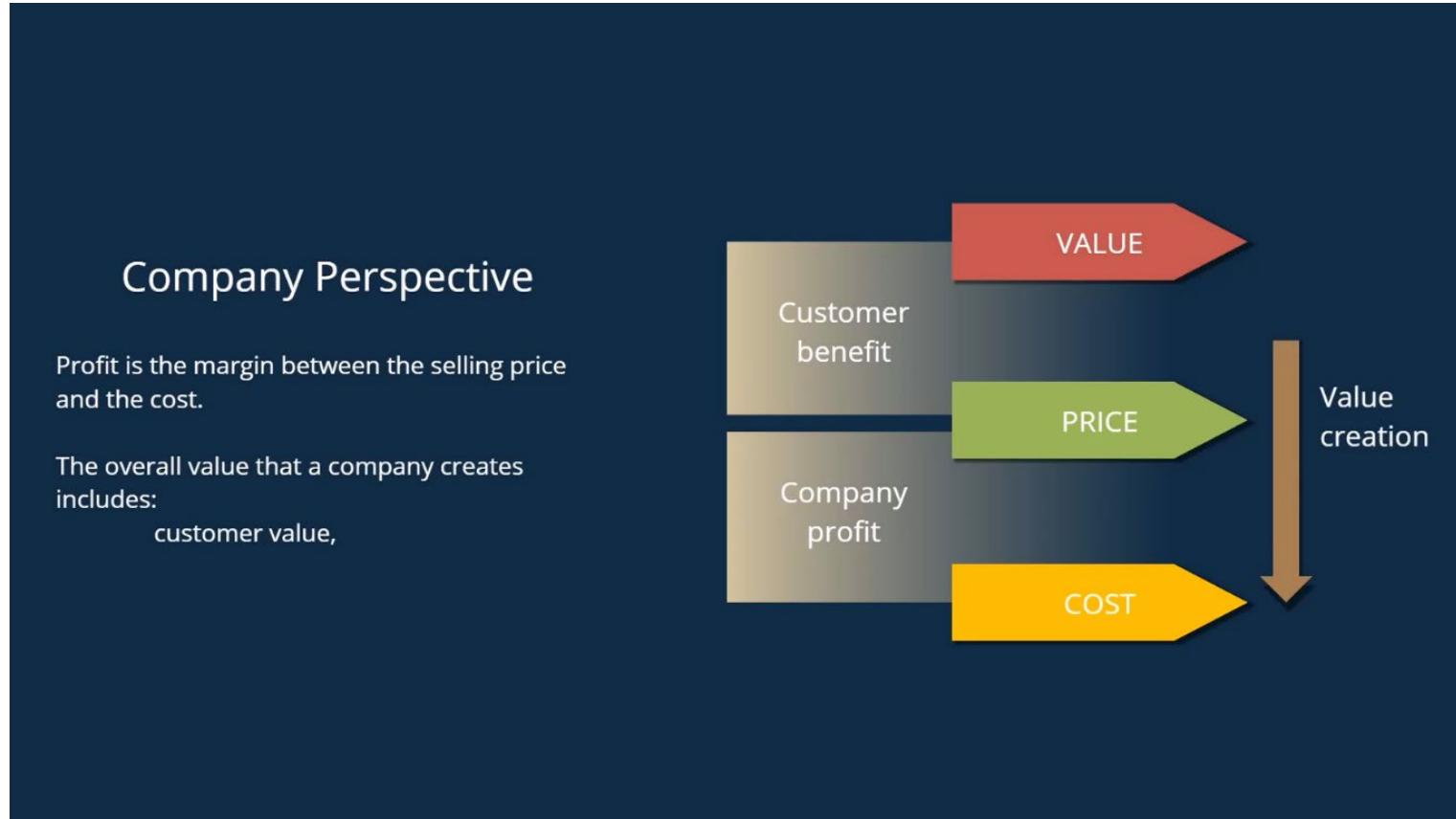


Need to invest in new technologies and patent licenses can act as a barrier for new entrants.

Innovation creates a barrier by forcing entrants to spend heavily to develop new products with differentiating features and functions.



# Value creation



# Generic strategy



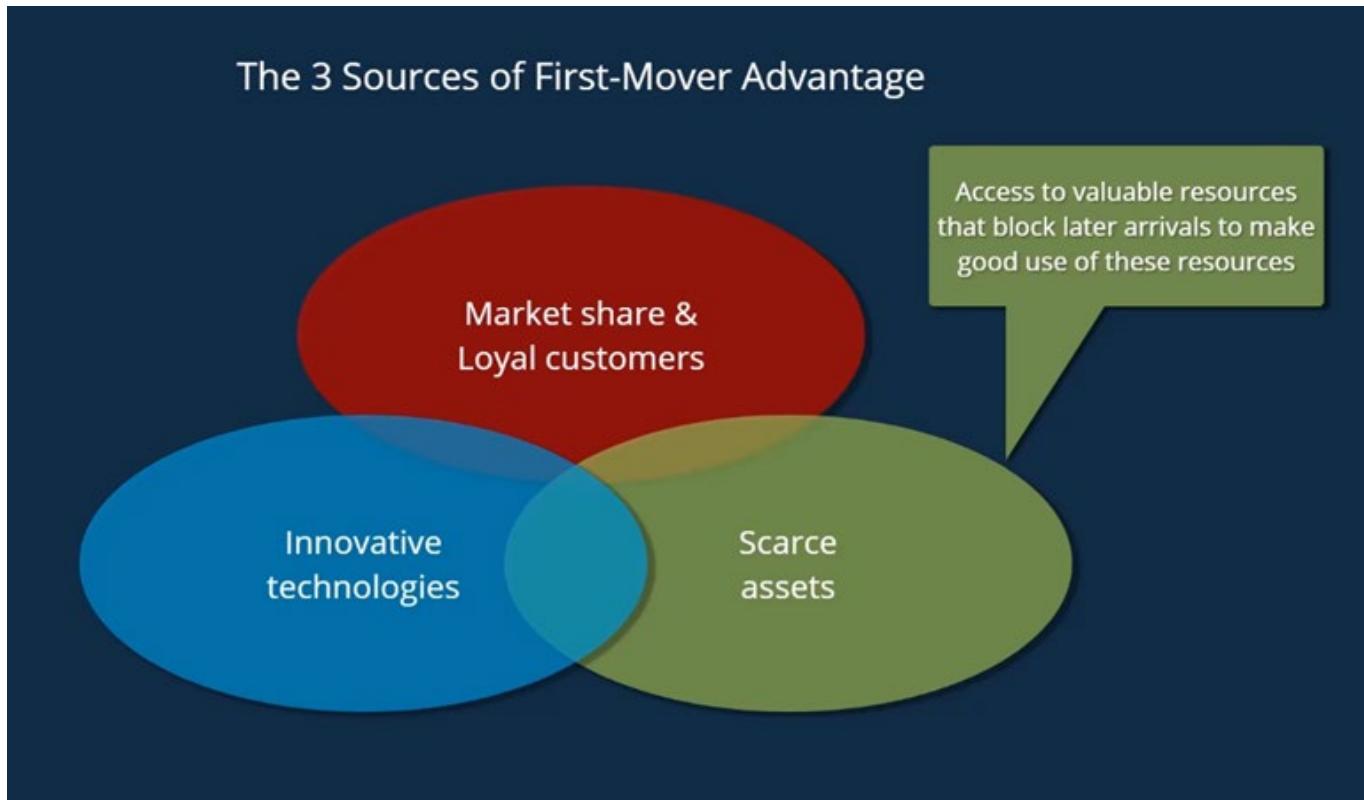
- Cost leadership
- Differentiation



The definition of cost leadership is the lowest cost of operation in the industry.

- Producing highly standardized products
- Improving efficiency, scale, size and scope
- Using advanced technologies, such as automation

# First mover vs. fast follower



## Fast follower

- Make fewer mistakes
- Face less risks for technology deployment
- Transform innovations into a differentiated product

# Portfolio Decision-Making Process





# Best practices for portfolio decision-making

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- Purpose: Link decisions to strategy at high level
- Process: Define clear, measurable evaluation metrics
- People: Appoint a senior manager responsible for portfolio evaluation

# General Types of Forecasting

## Qualitative method

(Limited forecasting scope and short-term)

- High-level market study
- Life Cycle Analogy

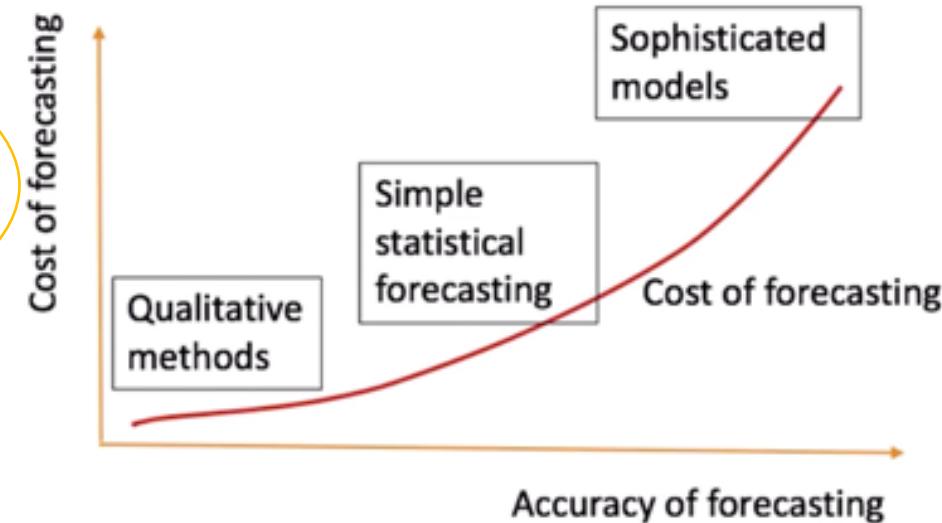
## Simple statistical forecasting

(Use historical data to project future performance)

- Estimate trends and rates
- Time-series moving average analysis
- Seasonality model
- Regression

## Sophisticated (causal) models

- Economic models
- Input-output analysis ( car and tires )

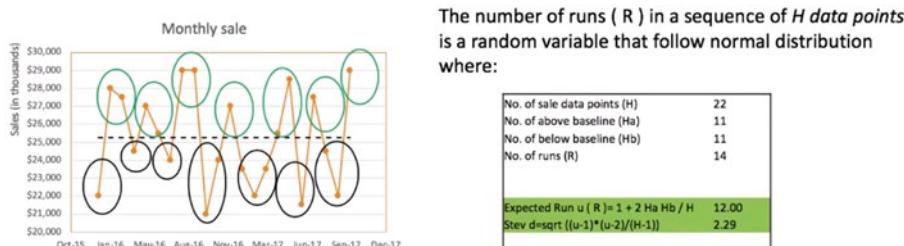


# Noise vs. trend (real-world application of statistics)

## Business Approach to Forecasting



- Smaller run number represents perfect correlation between two variables.
- Greater run number means the two variables do not have any correlation.



## Short-term

### Moving Average Method

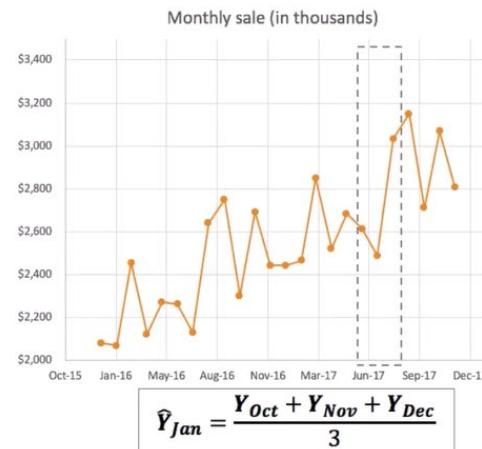
Method: Use the average sale of a period (e.g. 3 months or 6 months) to predict next month's sale

$$\hat{Y}_{t+1} = \frac{Y_t + Y_{t-1} + Y_{t-2} + \dots + Y_{t-k+1}}{K}$$

$\hat{Y}_{t+1}$ : predicted value in month  $t + 1$

$Y_t$ : sale of month  $t$

$k$ : number of months in the average window

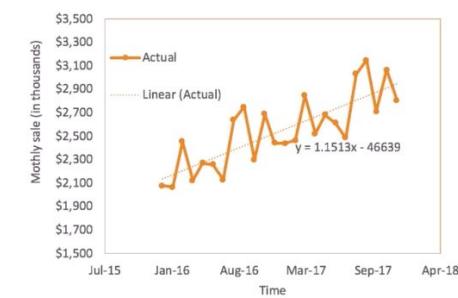


Use an average method to predict next period's value

## Long-term

### Forecasting: Regression Method

Time	Monthly sale (in thousands)
Jan-16	\$ 2,080
Feb-16	\$ 2,068
Mar-16	\$ 2,458
Apr-16	\$ 2,124
May-16	\$ 2,272
Jun-16	\$ 2,261
Jul-16	\$ 2,130
Aug-16	\$ 2,640
Sep-16	\$ 2,750
Oct-16	\$ 2,300
Nov-16	\$ 2,691
Dec-16	\$ 2,442
Jan-17	\$ 2,442
Feb-17	\$ 2,466
Mar-17	\$ 2,850
Apr-17	\$ 2,523
May-17	\$ 2,684
Jun-17	\$ 2,613
Jul-17	\$ 2,487
Aug-17	\$ 3,034
Sep-17	\$ 3,148
Oct-17	\$ 2,712
Nov-17	\$ 3,067
Dec-17	\$ 2,808



A practical method to forecast the trend

MS Excel provides multiple trend regression options

Estimate a liner model that can approximate the trend of the historical data

# Forecasting Seasonal Business Performance

	A	B
1	Time	Monthly sale (in thousands)
2	Jan-16	\$1,980
3	Feb-16	\$1,966
4	Mar-16	\$2,353
5	Apr-16	\$2,020
6	May-16	\$2,167
7	Jun-16	\$2,155
8	Jul-16	\$2,023
9	Aug-16	\$2,531
10	Sep-16	\$2,639
11	Oct-16	\$2,188
12	Nov-16	\$2,578
13	Dec-16	\$2,327
14	Jan-17	\$2,334
15	Feb-17	\$2,292
16	Mar-17	\$2,723
17	Apr-17	\$2,338
18	May-17	\$2,538
19	Jun-17	\$2,482
20	Jul-17	\$2,402
21	Aug-17	\$2,867
22	Sep-17	\$3,052
23	Oct-17	\$2,606
24	Nov-17	\$2,984
25	Dec-17	\$2,675
26	Jan-18	
27	Feb-18	
28	Mar-18	
29		

1. Run regression models to establish a trend line

2. Compute seasonal indices using moving average techniques

3. Adjust trend predictions with seasonal indices

Generate annual performance insights to support business decisions

Understand seasonal factors to support operation decisions

# Risk of Forecasting

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Intrinsic risk:

- Noise vs. trend

Data set risk:

- Collect Insufficient amount of data, particularly seasonal data
- Include older data that is not representative of current conditions

Model risk:

- Forecasting is not a mathematics exercise
- Provides business insights

# Business Optimization

## Value of Business Optimization

- Make most efficient use of limited asset
- Reduce operations and administrative overhead
- Inspire employees to focus on high priority tasks

## Secondary Benefit

- Increase access to accurate business information
- Improve performance monitoring capability

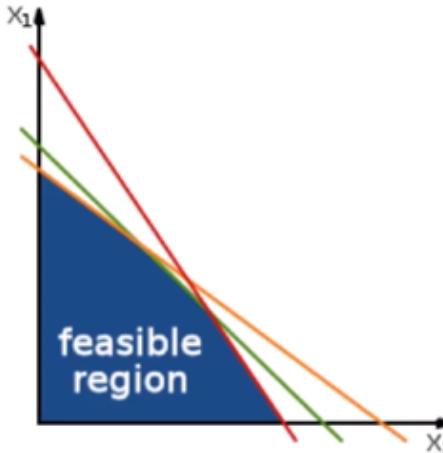
# Linear optimization

**linear optimization** is a method to achieve the best outcome (such as maximum profit or lowest cost) in a mathematical model whose requirements are represented by linear relationships." - Wikipedia

Decision variables:  $X_1, X_2, \dots X_n$

Objective:      Maximize (or Minimize)  $f(X_1, X_2, \dots X_n)$   
                        - Linear function:  $f(X)$

Constraints:     $f_1(X_1, X_2, \dots X_n) \leq b_1$   
                   $f_2(X_1, X_2, \dots X_n) \geq b_2$   
                   $f_m(X_1, X_2, \dots X_n) = b_m$   
                   $X_n \geq 0$



# Business value of LP for decision-making

## Adoption of analytical decision making

	ASPIRATIONAL	EXPERIENCED
Motive	<ul style="list-style-type: none"><li>Use analytics to justify actions</li><li>Financial management and budgeting</li><li>Operations and production</li><li>Sales and marketing</li></ul>	<ul style="list-style-type: none"><li>Use analytics to guide actions</li><li>All Aspirational functions</li><li>Strategy/business development</li><li>Customer service</li><li>Product research/development</li></ul>
Functional proficiency		
Business challenges	<ul style="list-style-type: none"><li>Competitive differentiation through innovation</li><li>Cost efficiency (primary)</li><li>Revenue growth (secondary)</li></ul>	<ul style="list-style-type: none"><li>Competitive differentiation through innovation</li><li>Revenue growth (primary)</li><li>Cost efficiency (secondary)</li></ul>
Key obstacles	<ul style="list-style-type: none"><li>Lack of understanding how to leverage analytics for business value</li><li>Executive sponsorship</li><li>Culture does not encourage sharing information</li></ul>	<ul style="list-style-type: none"><li>Lack of understanding how to leverage analytics for business value</li><li>Skills within line of business</li><li>Ownership of data is unclear or governance is ineffective</li></ul>
Data management	<ul style="list-style-type: none"><li>Limited ability to capture, aggregate, analyze or share information and insights</li></ul>	<ul style="list-style-type: none"><li>Moderate ability to capture, aggregate and analyze data</li><li>Limited ability to share information and insights</li></ul>
Analytics in action	<ul style="list-style-type: none"><li>Rarely use rigorous approaches to make decisions</li><li>Limited use of insights to guide future strategies or day-to-day operations</li></ul>	<ul style="list-style-type: none"><li>Some use of rigorous approaches to make decisions</li><li>Growing use of insights to guide future strategies, but still limited use of insights to guide day-to-day operations</li></ul>

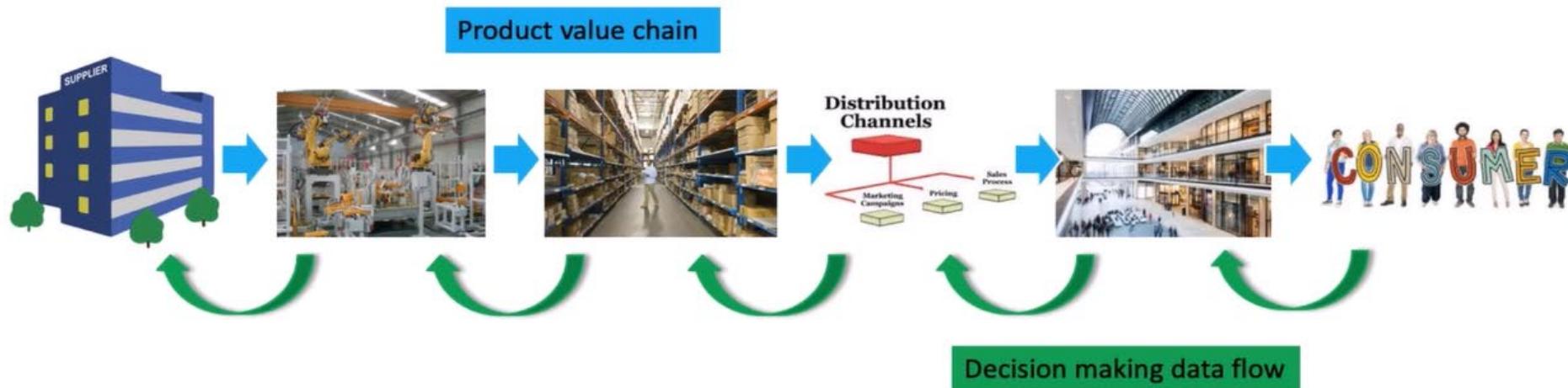
**Value of analytics**

**Cost efficiency (primary)**

**Revenue growth (secondary)**

**Competitive differentiation**

## Industry Best Practice – Demand Driving Production



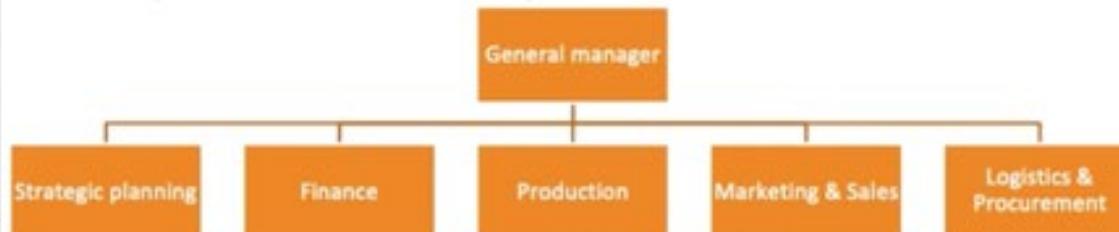
Companies make what they can sell – market pull drives the production

Aggregate planning is a technique for adjusting production to the ups and downs of demand.

# Demand Forecasting

Method	Accuracy	Cost of forecasting	Time required	Data required
Qualitative methods				
Market survey	Good	\$\$	months	limited
Panel consensus	Fair	\$	weeks	minimum
Historical analogy	Fair to good	\$	days	Several year's of historical trend
Quantitative methods				
Moving average	Fair to very good	\$	days	At least 2 years
Regression model	Good to very good	\$	weeks	Several years of data
Time series with seasonal analysis	Very good	\$	weeks	Multiple years of data
Economic model	Excellent for long-term	\$\$	months	Several years of data

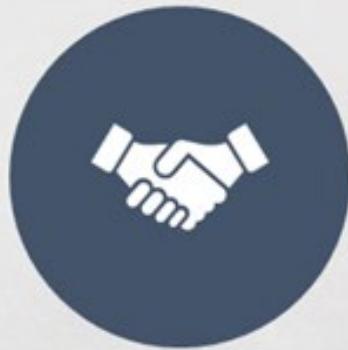
An integrated forecasting model involves the collaboration of multiple functions of the organization



Organizational contributions to forecasting



# Mindset and Opportunity



Managing uncertainty requires a mindset that recognizes uncertainty as not only a risk but also as a potential source of opportunity.

Managing uncertainty is about positioning the business to thrive and seize untapped opportunities in volatile market dynamics.

A systematic process provides valuable insights and foresight, aiding managers in making more informed decisions amidst uncertainty.

Simulation results inform risk management strategies and making data-driven decisions

## Scenario Analysis Definition

What if analysis is a method used by organizations to anticipate the impact of different situations or changes on their operations.

**Process:** create and evaluate hypothetical situations

**Benefits:**

- identifying risks and opportunities,
- evaluating the viability of strategies, and
- enhancing decision making clarity.



## Benefits of Scenario Analysis

Prepares businesses to face multiple future scenarios

Fosters a dynamic, adaptable culture

Structured framework for potential decisions

Blueprint for a robust response plan

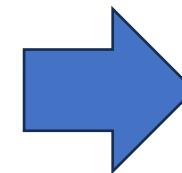
## Building Scenario Analysis Model

Scenario analysis models assist in navigating through uncertainties by examining key uncertain factors to simulate the impact of these adjustments on overall performance.

Pinpoint key influencing factors

**Develop Scenarios**  
Best Case Scenario  
Worst Case Scenario  
Most Likely Scenario

11



## What-if analysis



# Benefits of Scenario Analysis



Integration flexibility



Efficient data use



Informed decisions



Clarity and communication

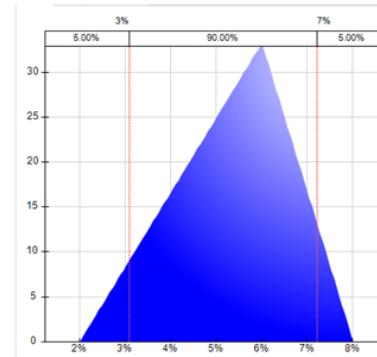
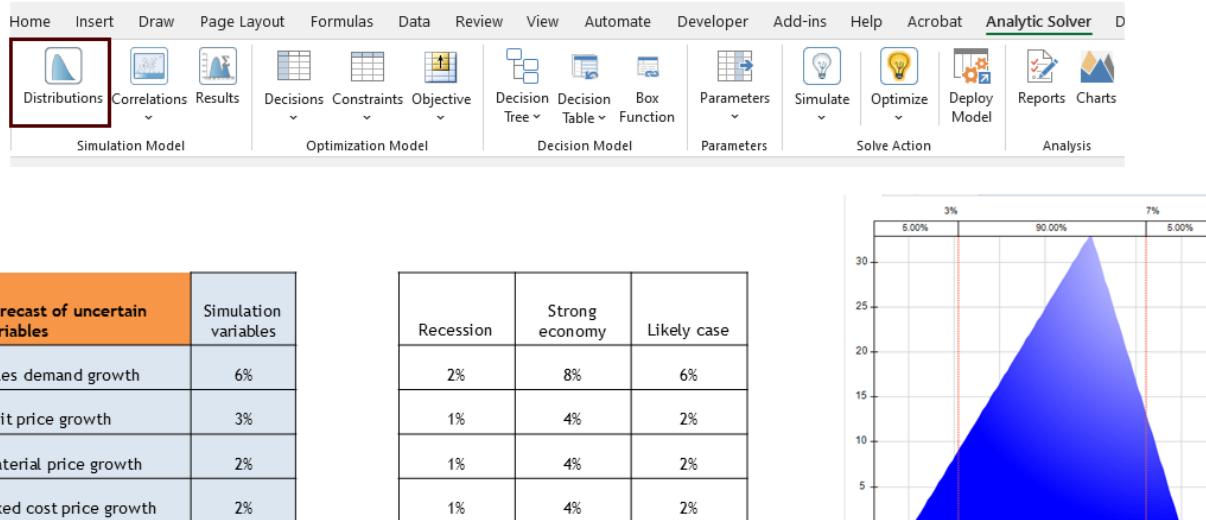
## Limitations of Scenario Analysis

**Low probability:** Best and worst-case scenarios represent extreme situations.

**Critical Question:** To what extent can these extreme scenarios really help managers make more informed decisions than just showing the boundaries of risks and opportunities?

# Simulation: Continuous distribution of uncertain variables

## Define Distribution Functions of Uncertain Variables

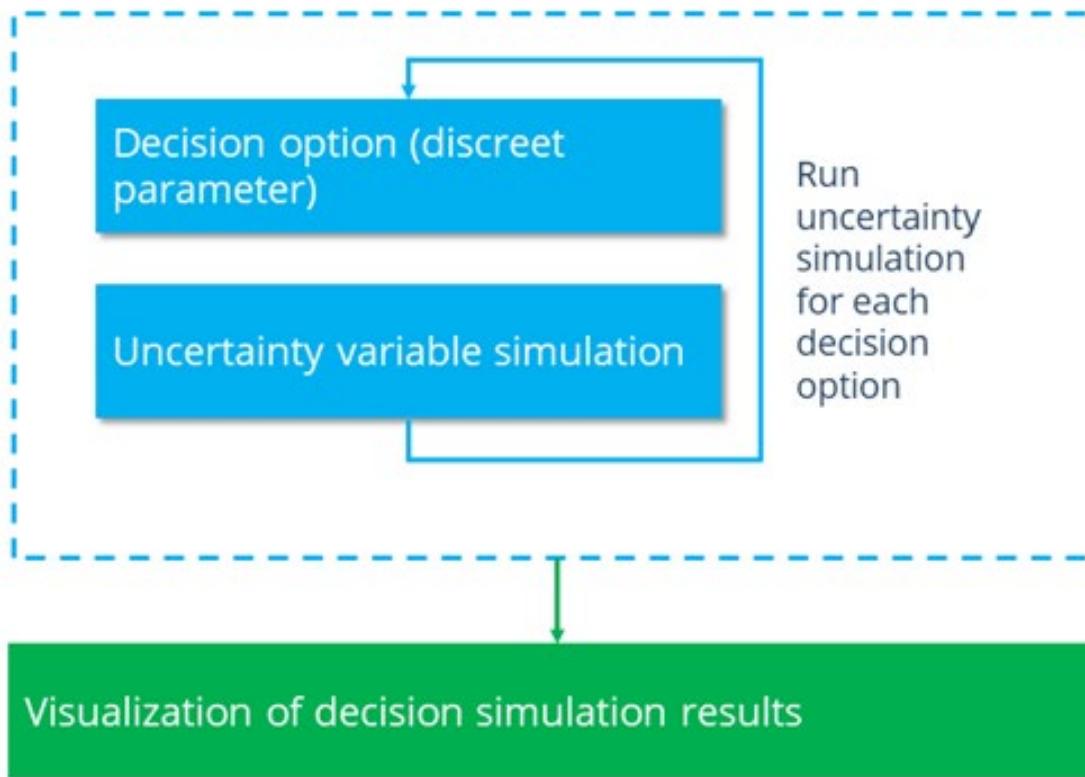


Triangle distribution of sales demand growth (2%, 6% and 8%)

### Three applications:

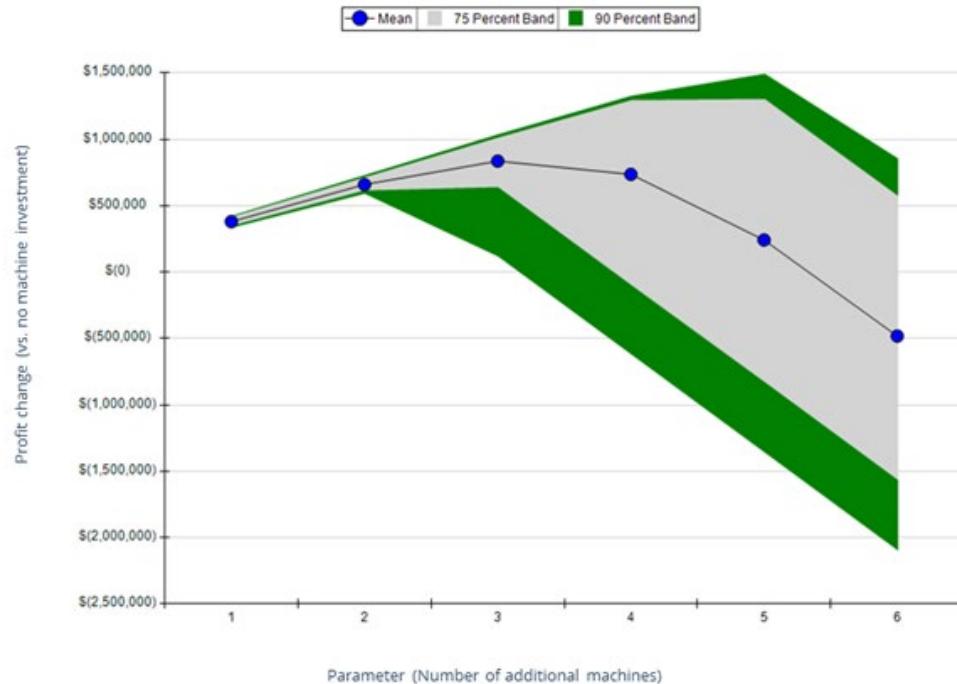
- Simulate uncertain market conditions
- Assess decision options
- Automated decision-making system: integrated optimization and simulation

# Simulation Model for Decision Parameters



Running multiple simulations with varying decision options to assess their impact on profitability.

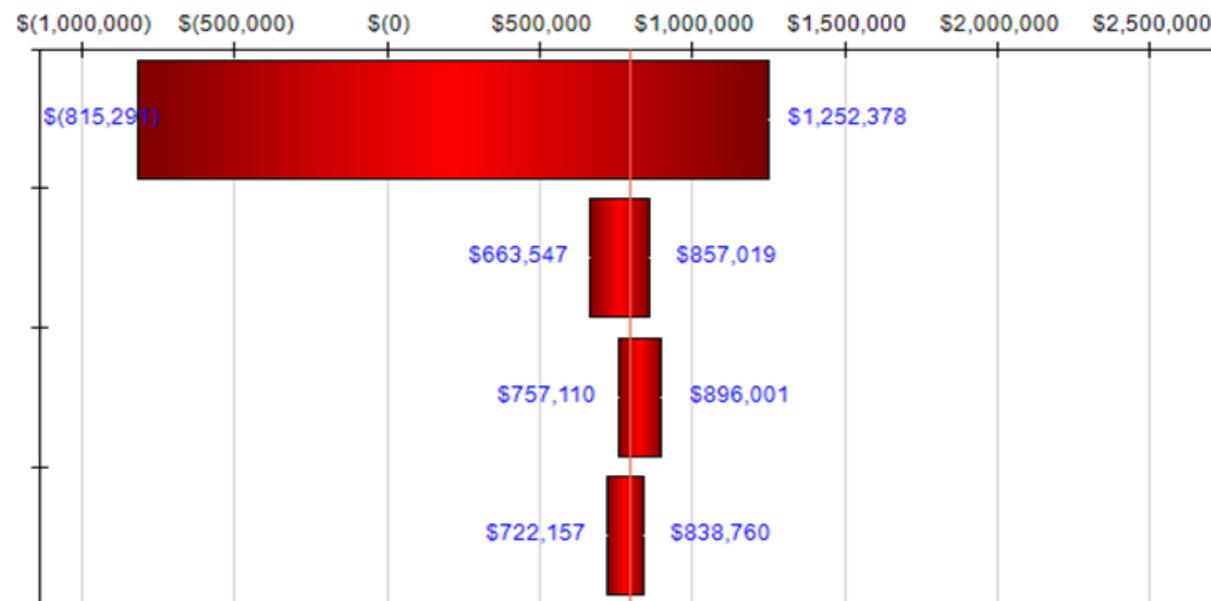
# Confidence interval



- A range of estimated values within which the true value of the parameter is expected to lie with a certain level of confidence (e.g., 75% and 90%)
- The visualization provides a clear view of average expected profit, associated risks, and opportunities for each decision option.

# Understand Simulation Results: Sensitivity

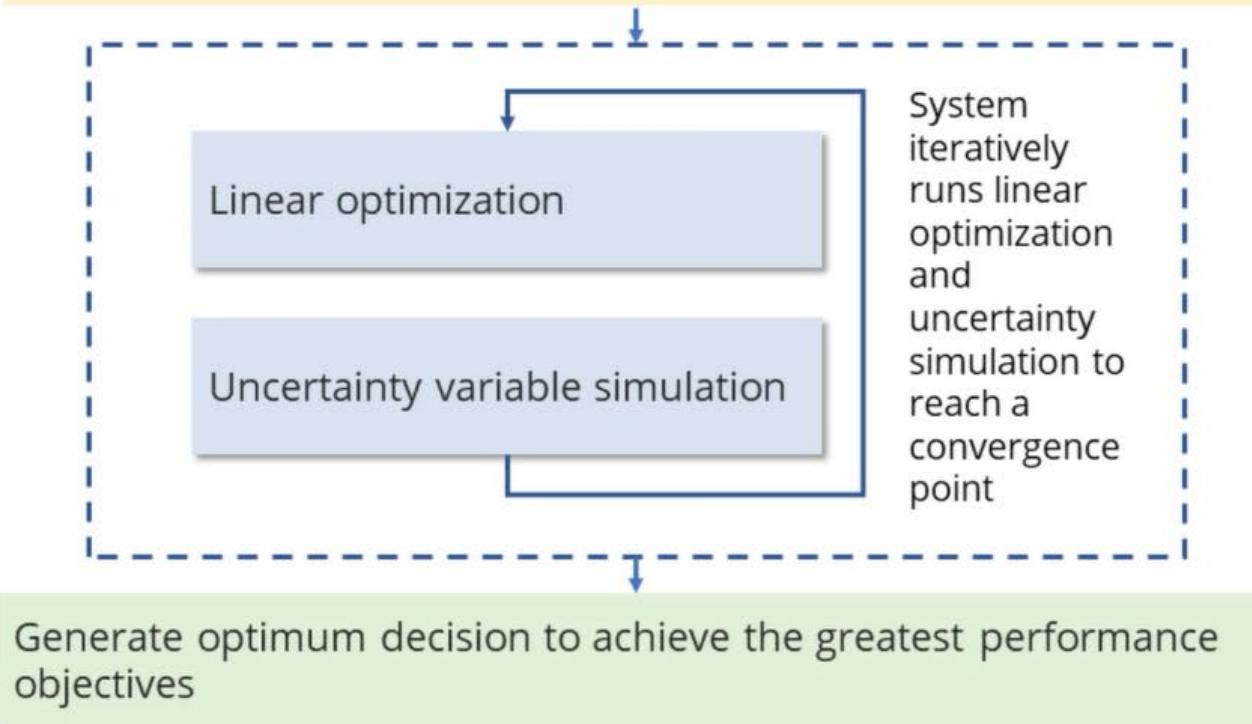
Sensitivity analysis measures how susceptible the output of a model is to alterations in the value of its inputs.



Which input variables have the most significant impact on the outcomes?

# Automated Decision-making Process

Define clear decision-making business objectives (value and risk)



Stream-lined process

- Clear business objectives (e.g., maximize profit)
  - Robust business economic models
  - Statistical forecast of uncertain business variables (e.g., sales)
  - Powerful simulation and optimization tools
- => Actionable decisions from the data analytics process

# Data-drive business case studies

## Amazon

- Supply chain management system (o9)
- Accurate personalized product recommendations (A9) accounts for about 30% of total sales

## Netflix

- International expansion and localization strategy
- Original content production
- Through A/G testing, Netflix explores new algorithms to improve recommendations without disrupting the user experience.



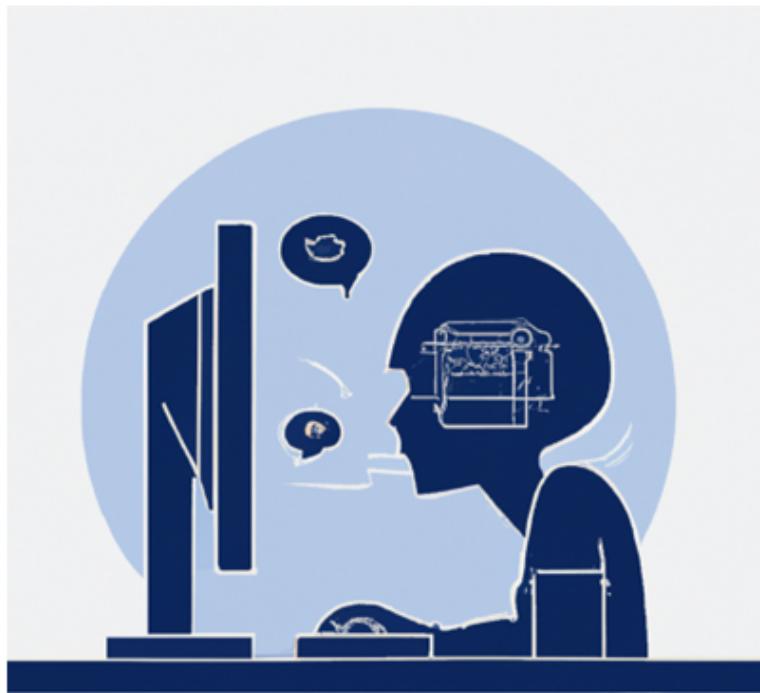
# Learning from iBuying Case

## Root Causes

The failure of the algorithms can be attributed to:

- Highly unpredictable short-term fluctuations of home prices
- Inadequate adaptation to changes in supply chains
- Zilllow's decision to retool the algorithms against analyst recommendations

# Computer-Human Collaboration



- A data-driven solution creates value by meeting the needs of customers and the service provider
- Integrate the automation core with complementary features, particularly machine-human cooperation functions to create a superior product or service package

# Systematic decision-making approach



1. Align business strategy and data integration

Business strategy, value chain and data-driven culture

2. Identify and evaluate options and risks

Decision tree, Simulation, Forecasting methods, and Optimization

3. Make intuitive judgment

Risking taking and intuitive judgment