MANNHEIM BUSINESS SCHOOL

THE ECONOMICS OF (BIG) DATA

PROF. DR. FLORIAN STAHL

The Economics of (Big) Data

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I What about Data?

II What about Economics?

III What about Economics of Data?

IV What about Privacy?

V What about Data Governance?

VI The Importance of Economics of (Big) Data

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What is Data?

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Data truly is ...

01

… a **set of values** of **subjects** with respect to **qualitative** or **quantitative variables.**

02

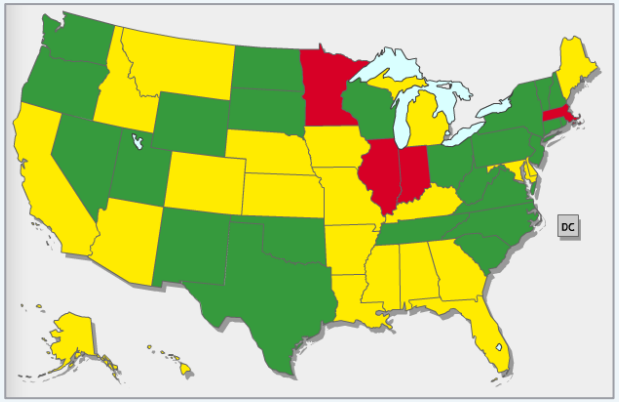
… how we **express observation** in **reusable form.**

Example: Sales by State (in thousands) – YTD

State	Estimated Sales Volume (thousands)	Estimated Margin Dollars (thousands)	As a Percentage of Sales Volume	Reported State Revenue (thousands)	As a Percentage of Sales Volume
Alabama	9,407,662	556,288	5.91%	619,628	6.59%
Florida	27,989,966	1,409,475	5.04%	2,233,129	7.98%
Georgia	17,592,770	846,439	4.81%	934,175	5.31%*
Kentucky	8,373,641	446,225	5.33%	563,168	6.73%
Mississippi	6,062,489	363,781	6.00%	431,432	7.12%
North Carolina	14,963,345	717,689	4.80%	1,654,346	11.06%
South Carolina	8,491,004	450,971	5.31%	531,916	6.26%
Tennessee	11,081,297	592,445	5.35%	849,662	7.67%
Virginia	13,897,635	906,978	6.53%	926,932	6.67%

Source: Calculated from U.S. Department of Transportation and Oil Price Information Service data.

*Including Georgia's 1 percent general fund sales tax increases revenue as a percentage of sales to 6.3 percent.



Why is Data Important?

Why are data not the new oil?

Plenum Discussion

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10100110
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Characteristics of Data

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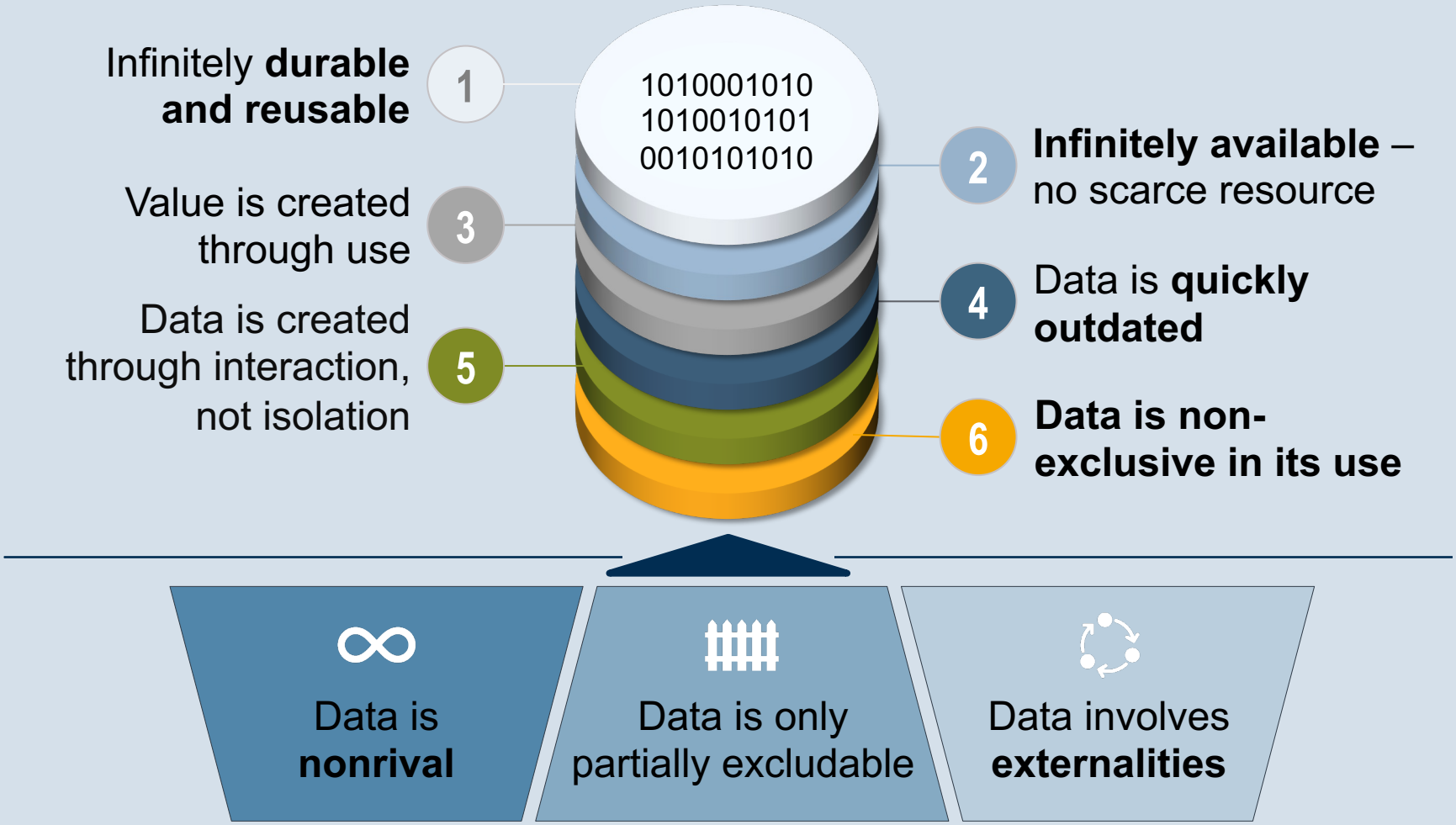

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What are the Economics of Data and Analytics?

Economics and Economic Efficiency

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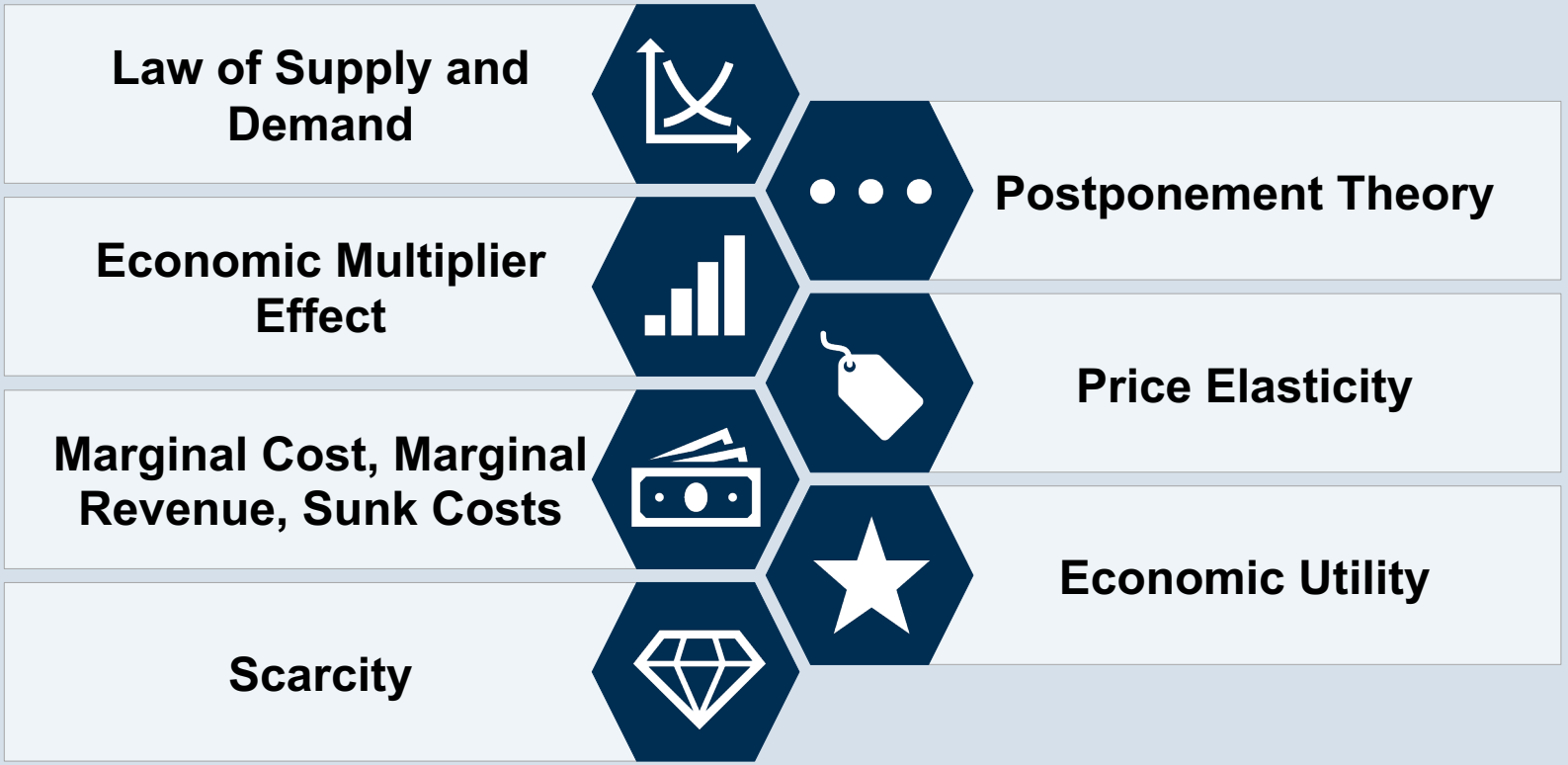
Economics is the branch of knowledge concerned with the **production**, **consumption**, and **transfer of wealth and value**. It is the scientific **study of human action and behaviors**, particularly as it relates to **human choice** and the **utilization of scarce assets** to achieve certain outcomes.

Economic efficiency is when **all goods** and **factors** of production are **distributed** or **allocated to their most valuable uses** and waste is eliminated or minimized.

Core Economic Concepts



The Economic Value Curve

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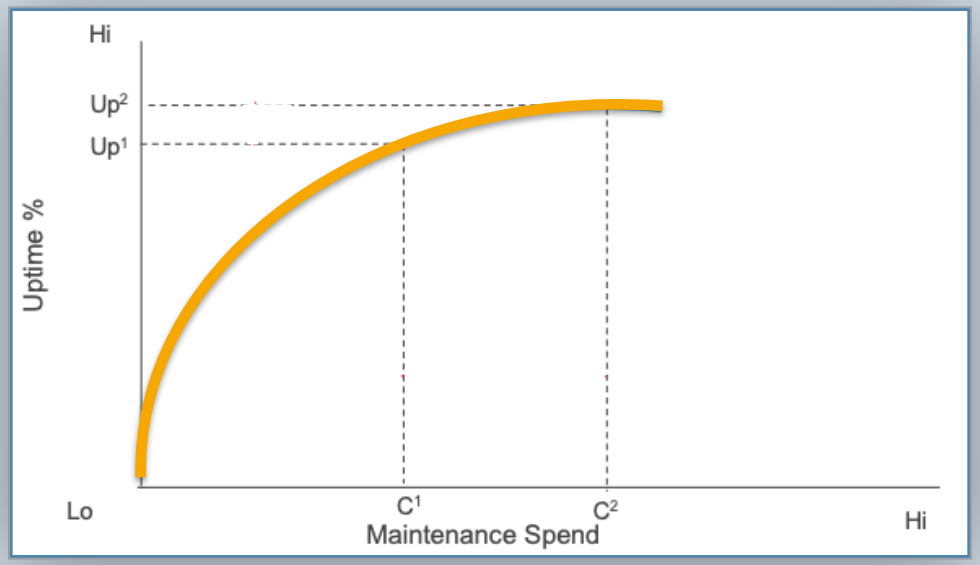
The **Economic Value Curve** measures the relationship between a dependent variable and independent variables to achieve a particular business or operational outcome.



Economic Value Curve Challenge

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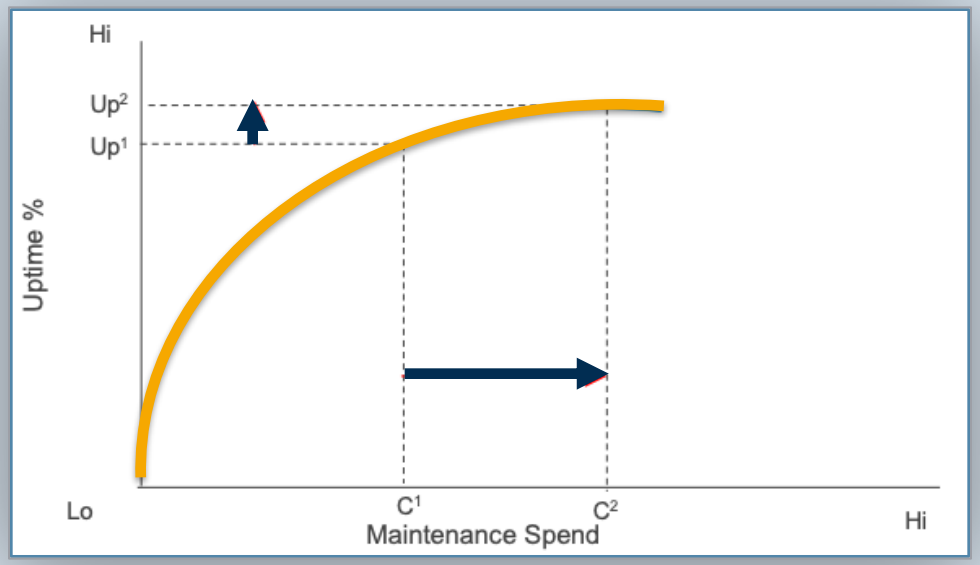
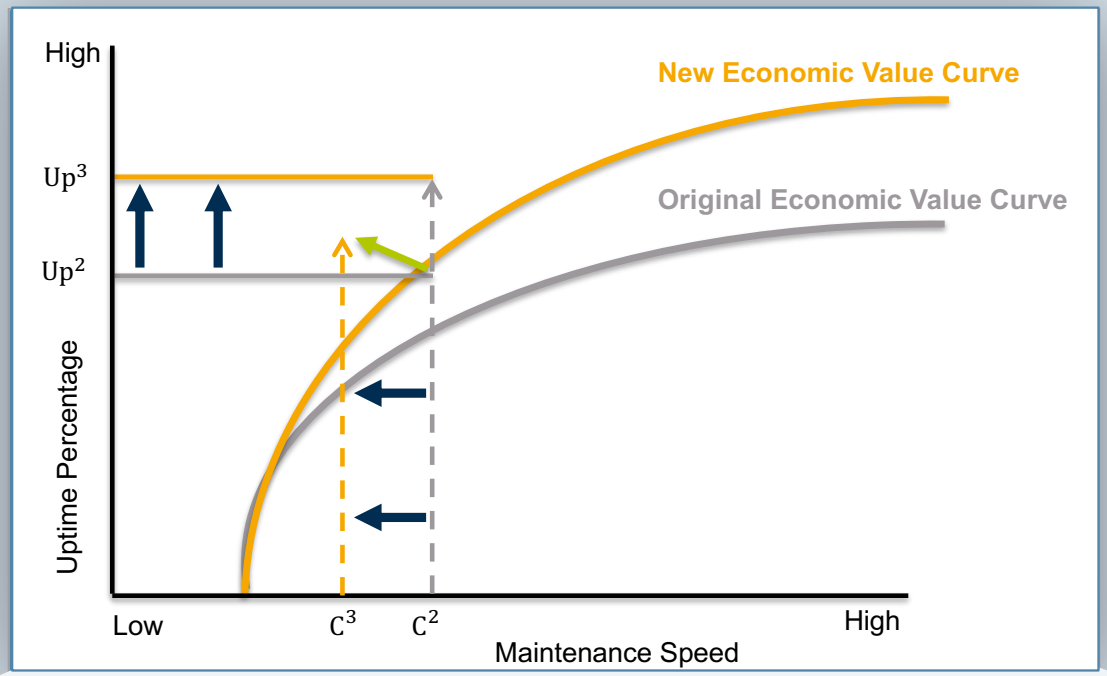
The **Law of Diminishing Returns** is a measure of the decrease in marginal or incremental output of production as the amount of a single factor of input is incrementally increased, while the amounts of all other factors of production stay constant.



Transforming the Economic Value Curve



The way to beat the **Law of Diminishing Returns** is to leverage analytics to create a new **Economic Value Curve.**
That is, increase Uptime with less maintenance spend.

Transforming the Economic Value Curve

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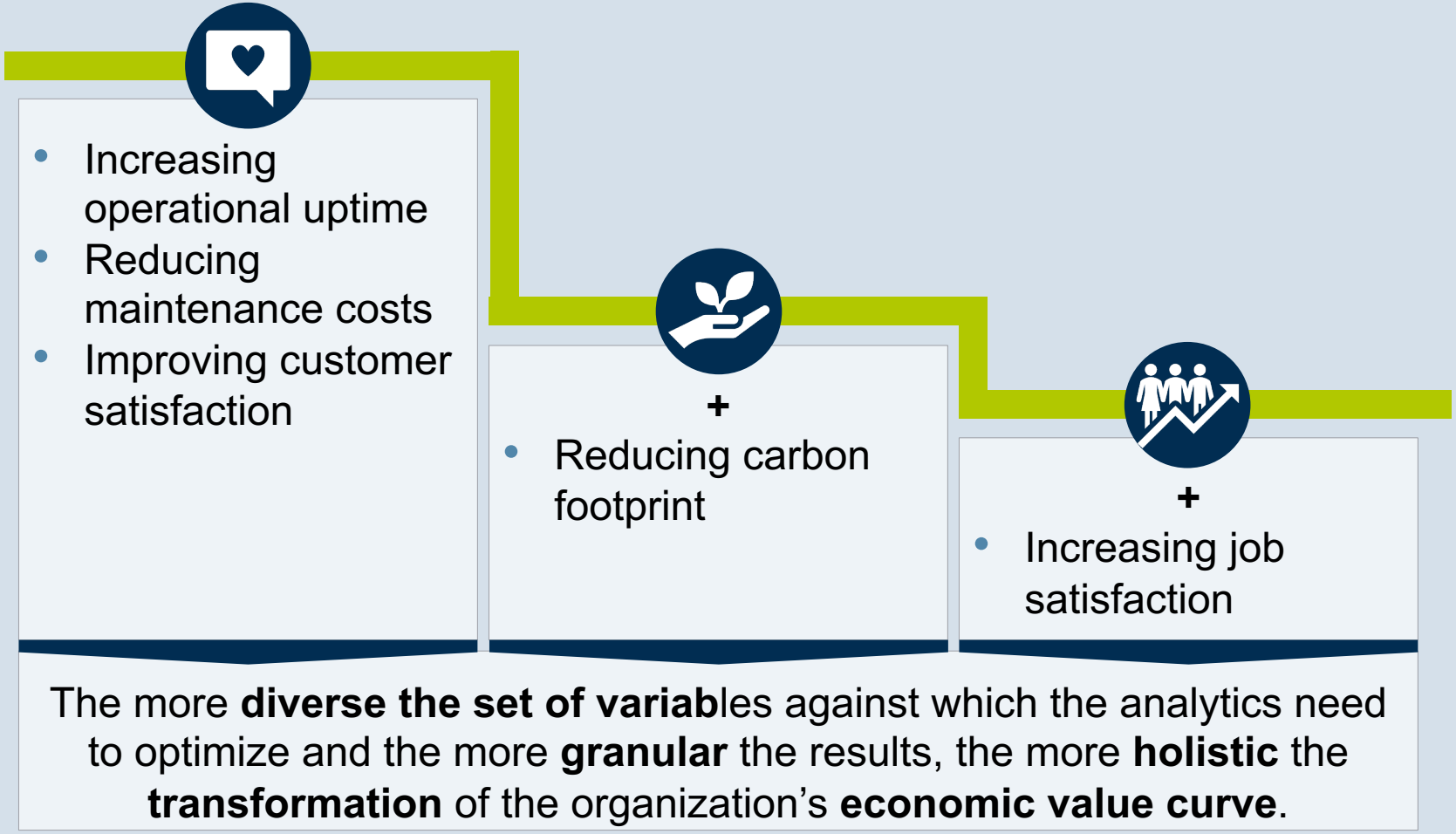
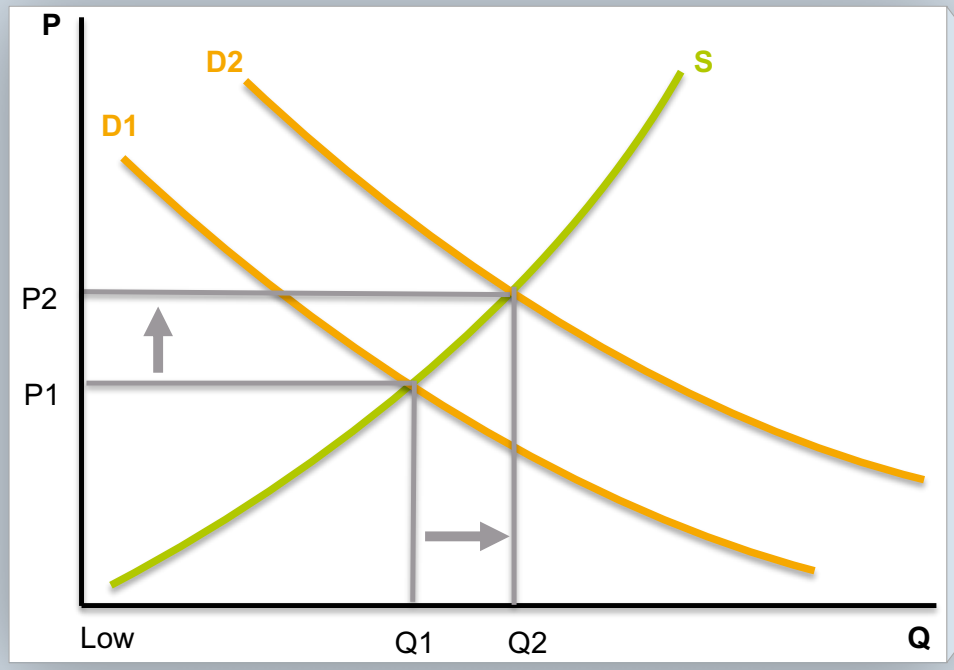


The Law of Supply and Demand

The **Law of Supply and Demand** dictates the relationship between the quantity of a commodity that producers wish to sell at various prices and the quantity that consumers wish to buy.



S = supply

D = demand

P = price

Q = quantity

The Economic Multiplier Effect

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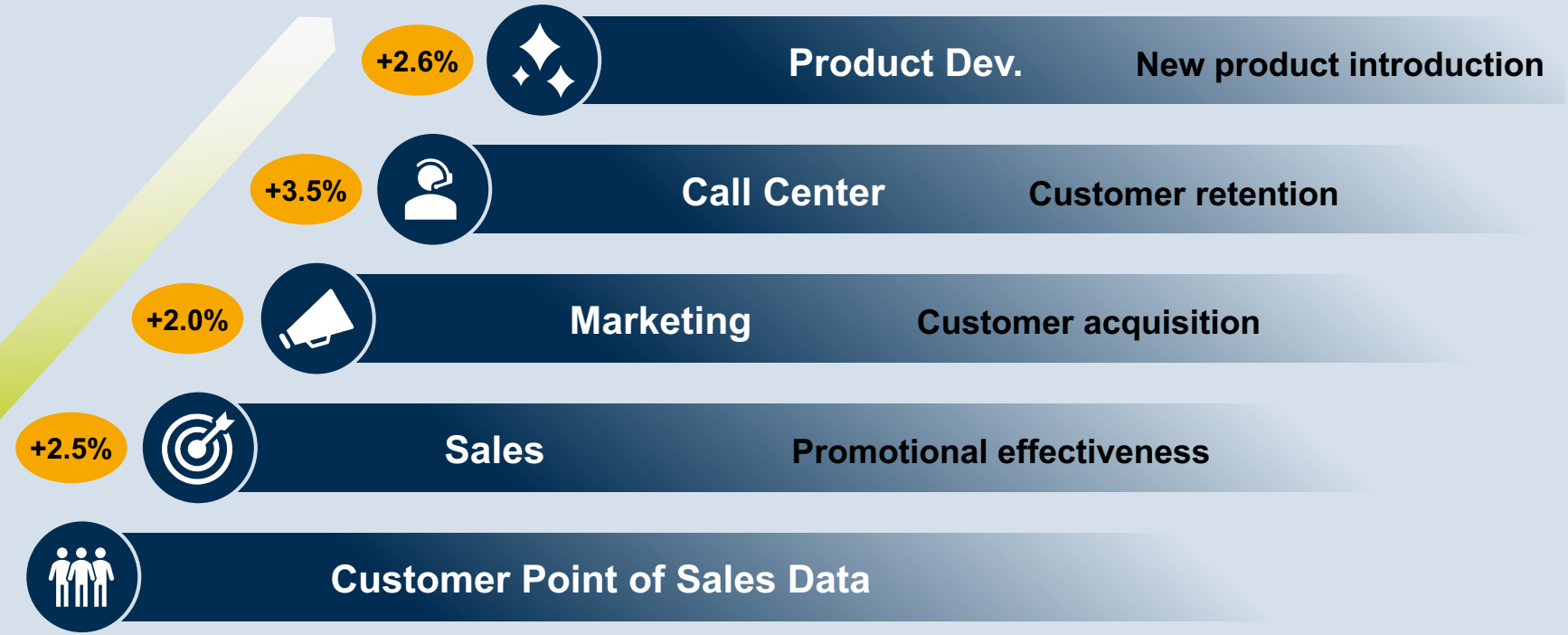
The **Economic Multiplier Effect** is a ratio of the impact of an incremental increase in investment on the resulting incremental increase in value.



Marginal Propensity to Consume

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The **Marginal Propensity to Consume (MPC)** equals change in output as a ratio to the change in investment.

$$MPC = \frac{\text{Change in Output/Production}}{\text{Change in Input/Investment}}$$

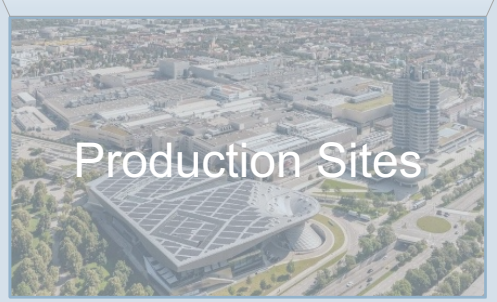
Marginal Propensity to Consume

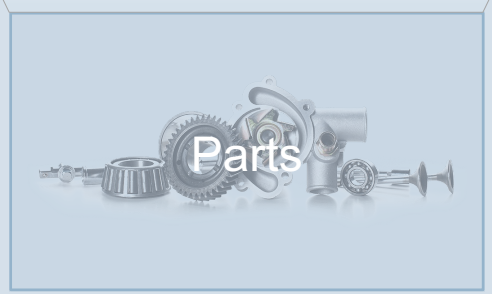
By focusing marketing spend on the top 5 deciles of customers (propensity-to-buy analytic score), we can capture 90% of predicted customer spend with only half the budget.

Marginal Costs

Marginal Cost is the incremental change in the total cost that arises when the quantity produced is incremented by one unit; that is, it is the **cost of producing one more unit of a good**.

Fixed Costs	Variable Costs
do not vary with the level of production	vary with the level of production





Marginal Revenue versus Marginal Cost

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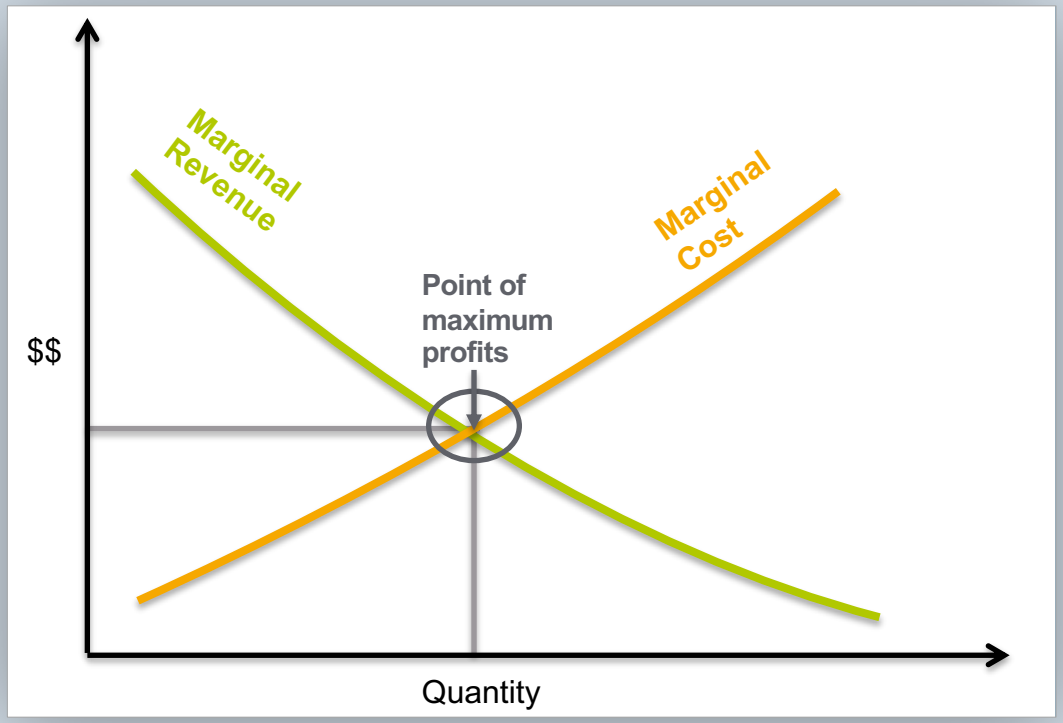
An organization seeking to maximize its profits should produce up to the point where the **Marginal Cost** equals the **Marginal Revenue** for each additional unit of production.



Marginal Costs and Sunk Costs

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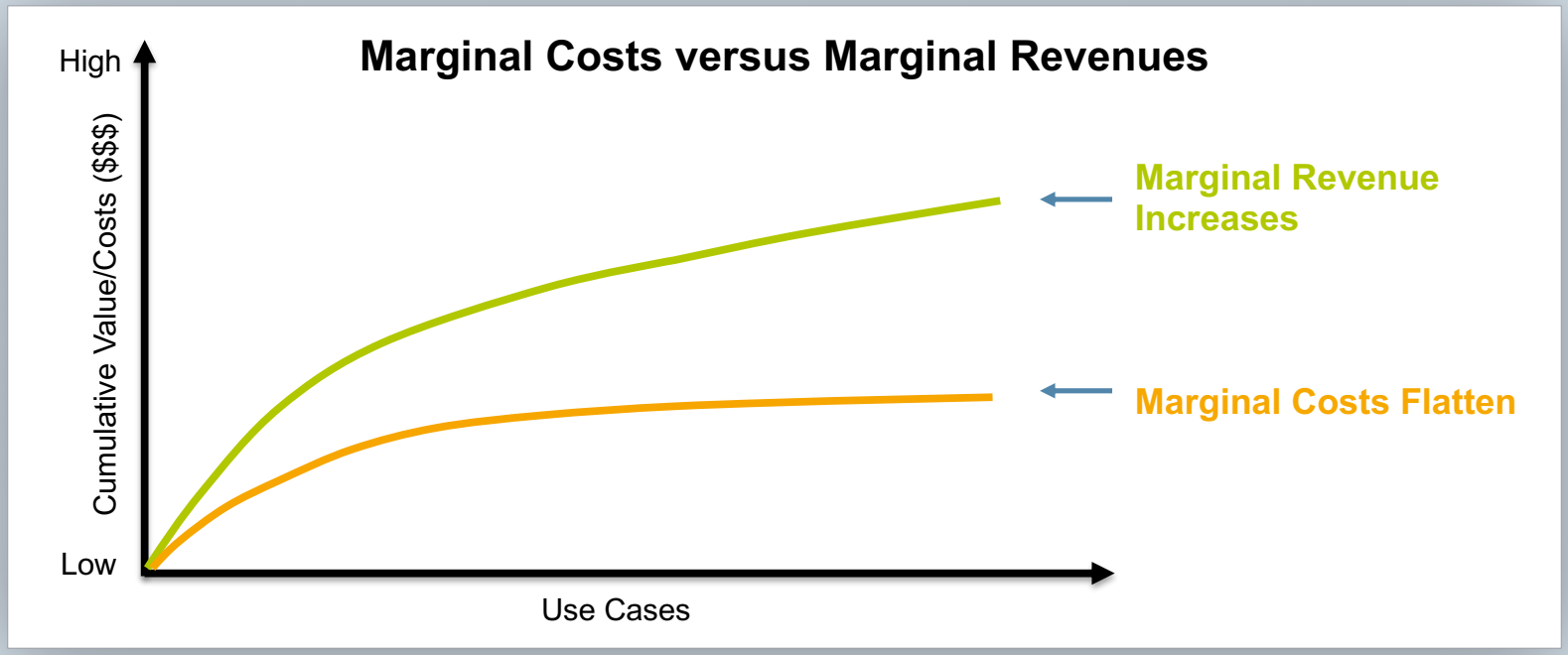
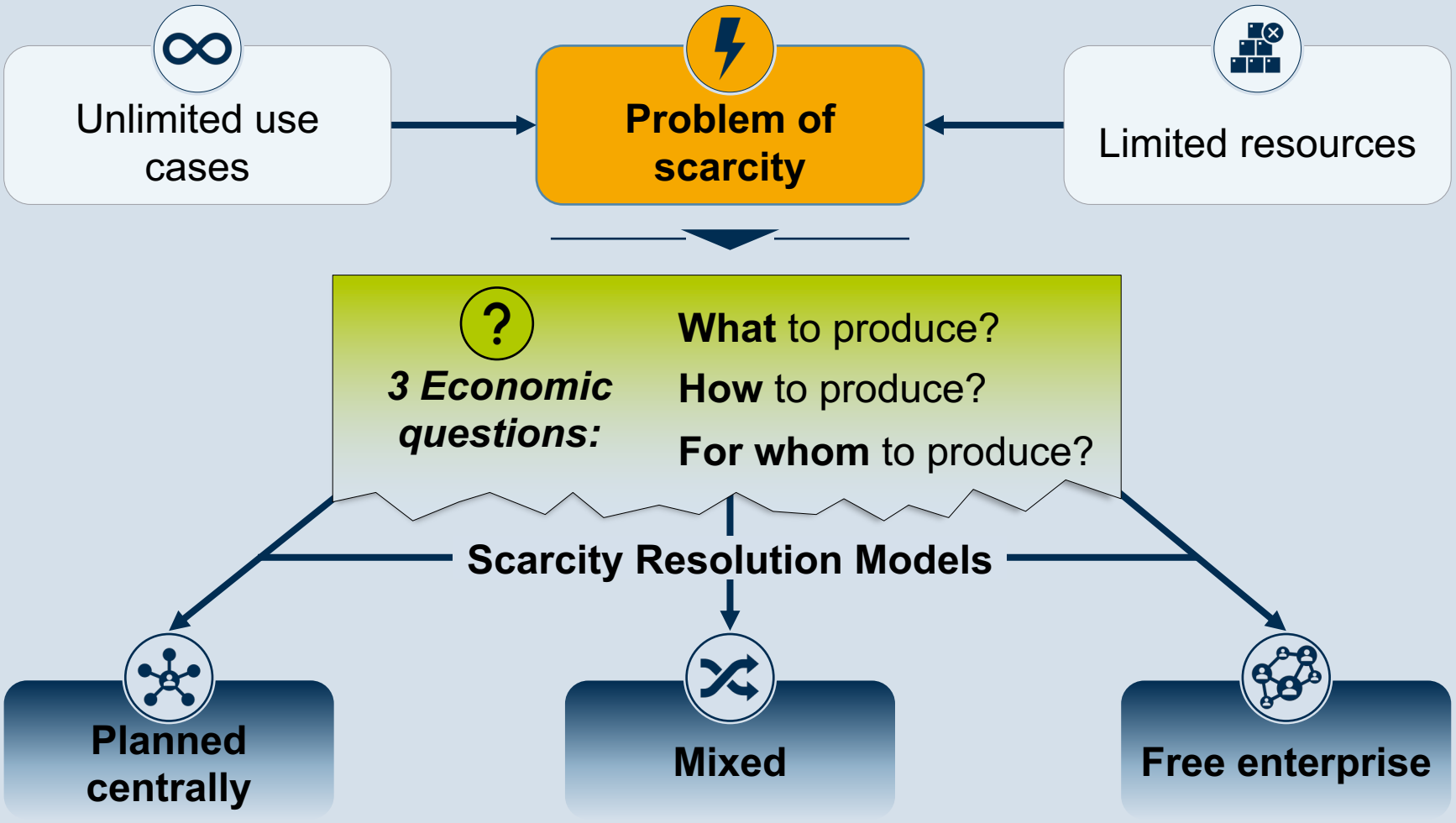
Sunk Costs are costs that have already been incurred and cannot be recovered.

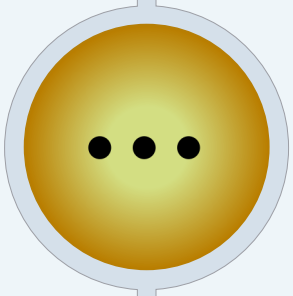


Dilemma of Scarcity



Postponement Theory

Postponement Theory is an economic strategy that maximizes possible benefits and minimizes risks by delaying a decision in order to gain additional data or analytic insights.



Costs of Type I error (false positive)

Costs of Type II error (false negative)

Making Use of Postponement Theory

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What are the **Type I Error** (False Positive) and **Type II Error** (False Negative) risks and costs associated with the decision?

What is the **estimated effectiveness** of the current decision given the Type I and Type II decision risks?

What data *might* be needed to improve the effectiveness of that decision given the Type I and Type II errors?

How much more accurate can the decision be made given these new data sources and additional data science time?

Price Elasticity

Price Elasticity of demand is the quantitative measure of consumer behavior that indicates the quantity of demand for a product/service depending on its increase or decrease in price.

$$\varepsilon = \frac{\Delta q/q}{\Delta p/p} = \frac{\text{\% change in quantity}}{\text{\% change in price}}$$

Price Elasticity of Demand

$\varepsilon > 1$: **elastic** demand → demand is **sensitive** to a price increase

$\varepsilon < 1$: **inelastic** demand → demand is **insensitive** to a price increase

Elastic and Inelastic Goods

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Inelastic Goods

- Demand only reacts weakly or not at all to price changes
- E.g., Energy

Elastic Goods

- Demand reacts strongly to price changes
- E.g., Beverages

Price Elasticity and Data Ramifications

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Take into consideration all the costs associated with data:

Confidence in data is everything!

The Economic Utility Function

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An economic good yields utility to the extent to which it is useful for satisfying a consumer's want or need.

Consumers will strive to **maximize their utility** or value.

Marginal utility is the utility gained by consuming an additional unit of a good/service.

Utility from data and analytics is measured by the perceived value received from the consumption or **usage of an additional unit of data** and analytic assets.

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Influence of Data on Economics

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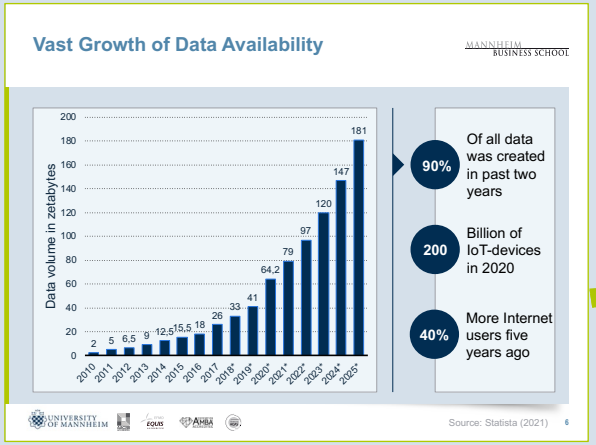

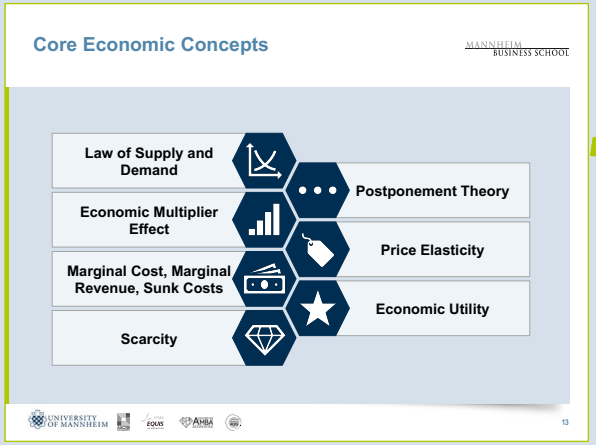

- Big Data results from the datafication of most interactions
- Data conveys the accurate descriptions of reality
- Data analyses increase accuracy of economic variables

Overcoming the Data Scarcity Dilemma

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Are your IT resources focused on capturing or **acquiring** the **most important data** in support of the organization's strategic business initiatives and the key supporting use cases?

Are your data science resources focused on the development of the top priority, **reusable analytic assets**?

Does your technical and cultural environment **support/reward** the capture, refinement, and reuse of the data and analytic assets across multiple business units?

Does your organization have an agreed upon **governance methodology** to manage the scarcity dilemma by prioritizing and focusing your data and analytic resources against those best use case opportunities?

Transforming the Economic Value Curve

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Lift refers to the percent increase or decrease in a particular metric such as orders, purchases, engagements for users who received a special treatment vs. a control group.

amazon

PAYBACK

It is not the volume of data that monetizes, but it is the **granularity at the level of the individual** that monetizes.

Predicting Lift to Change One's Economic Value Curve

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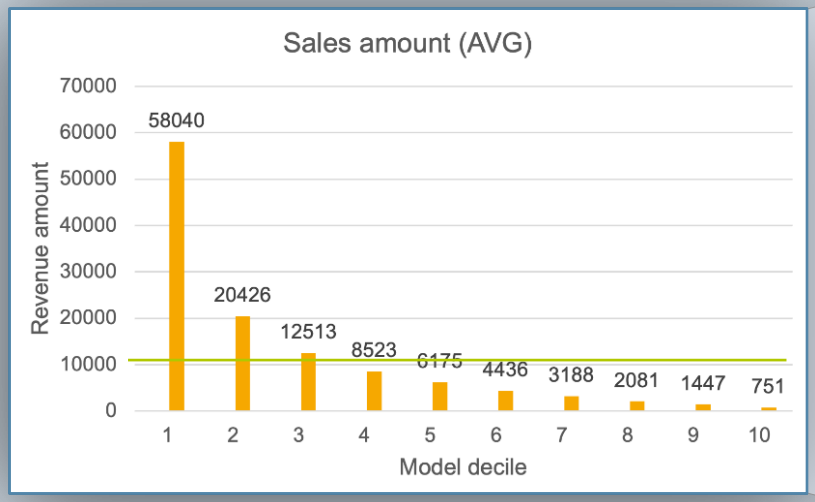

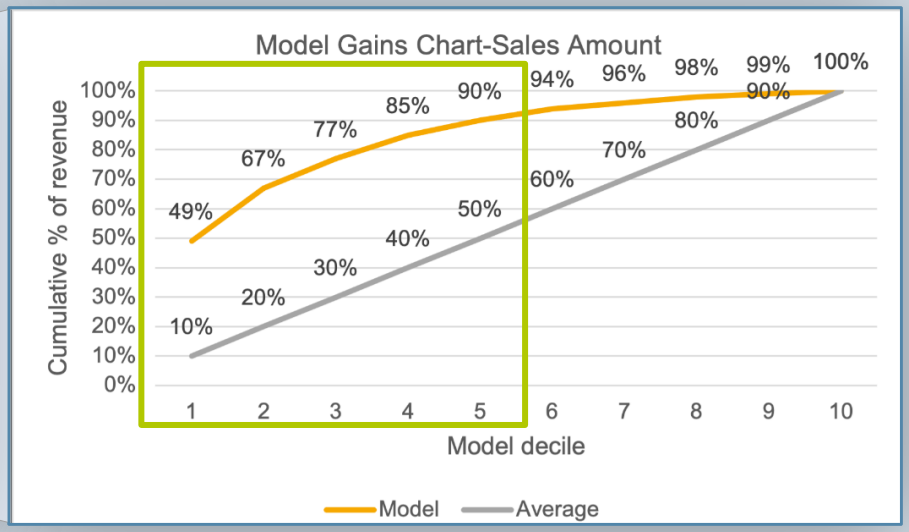

By focusing marketing spend on the top 5 deciles of customers (propensity-to-buy analytic score), we can capture 90% of predicted customer spend with only half the budget.

Analytic Profiles Capture Individual Entities' Analytic Insights

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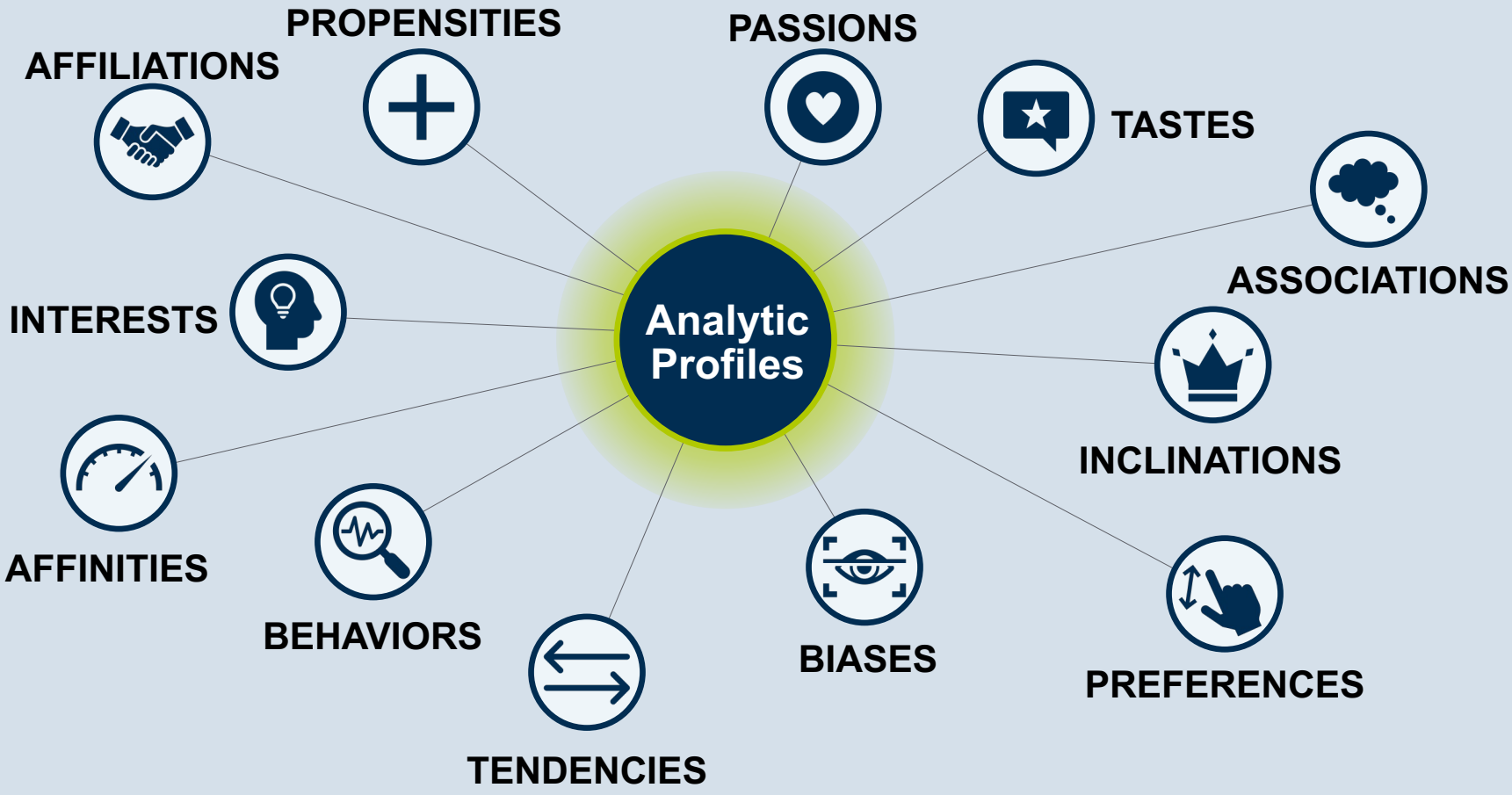

Efficiency

Economic Efficiency is measured by the relationship between the value of the ends and the value of the means.

- Identifying operational deficiencies
- Proposing recommendations (prescriptive analytics)
- Aggregation of usage patterns across customer segments
- New monetization opportunities

Managing Efficiency Challenges

How can we **leverage our existing data** to produce more output for our most important use cases?

What **other data** could be **acquired or gathered** that could help improve operational efficiencies of our most important use cases?

How can we **leverage data and analytics** to **create benchmarks** against which we can flag inefficient processes to help focus the organization's efficiency improvement initiatives?

Data as Capital

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Capital are already-produced durable goods and assets, or any non-financial asset that is used in the production of goods or services.

Driving the on-going **optimization** of key operational and business use cases

Mitigating security, compliance, regulatory, and governance **risks**; avoiding security breaches, litigation, fines, theft; building **customer trust**

Uncovering new **revenue opportunities**

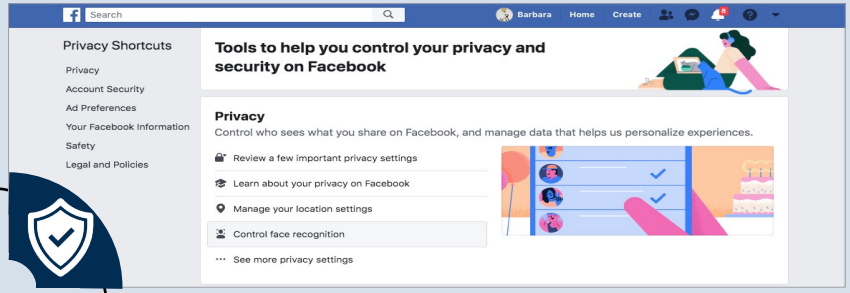
based upon superior customer, product, and operational insights about unmet customer and market needs

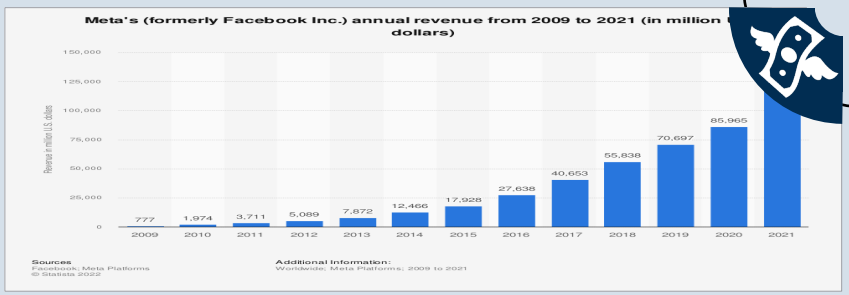
Delivering a more **compelling customer experience**

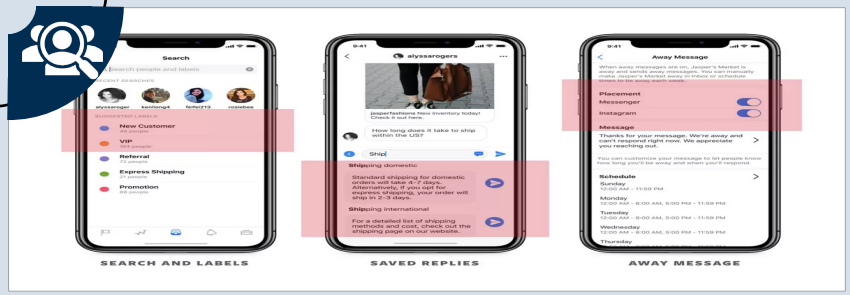
that increases customer satisfaction, advocacy, effectiveness of selling and cross-selling new products and services

Leveraging Data Capital
The Rise of Facebook/Meta

Meta







Supply and Demand of Data

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Not all data is of equal value! The ultimate determinant of the value of a supply of data depends upon the demand for that data driven by its applicability and predictive relevance.

*What is your **data supply inventory** and what is the **condition** of that data from quality, accessibility, completeness, granularity, and latency perspective?*

*Do you have a **process** for identifying, validating, valuing, and prioritizing the use cases or demand against which to apply the data or supply?*

Supply: The Decision to Produce Data

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Active Collection

Data Collector collects and stores the data while incurring costs

Fixed costs

e.g., installation

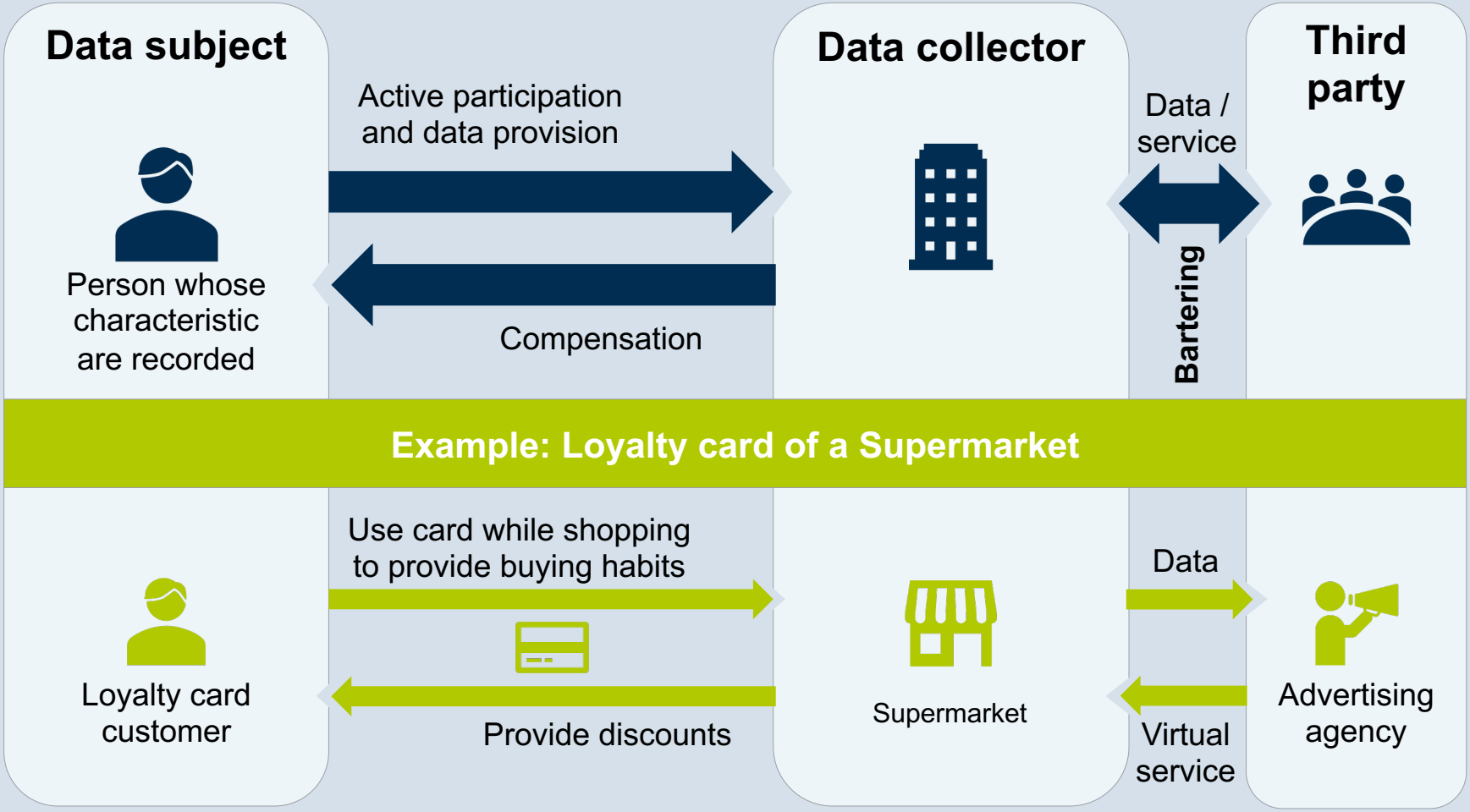
Variable costs

e.g., storage capacity

Data as Byproduct

e.g., transactional data

Supply: Personal Data – Bartering



Demand: Data has Two Primary Functions in Modern Economics

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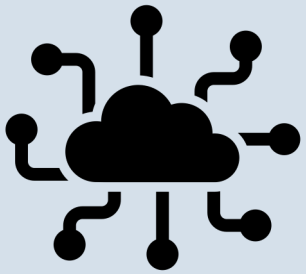
Data as an **input** into the **production of goods and services**

Fosters **innovation** and **efficiency**



Functions of data in modern economics

Data **creates and shifts information** across economic agents

Affects **strategic interactions** and **information frictions**

Demand: Data Serves as a Factor of Production

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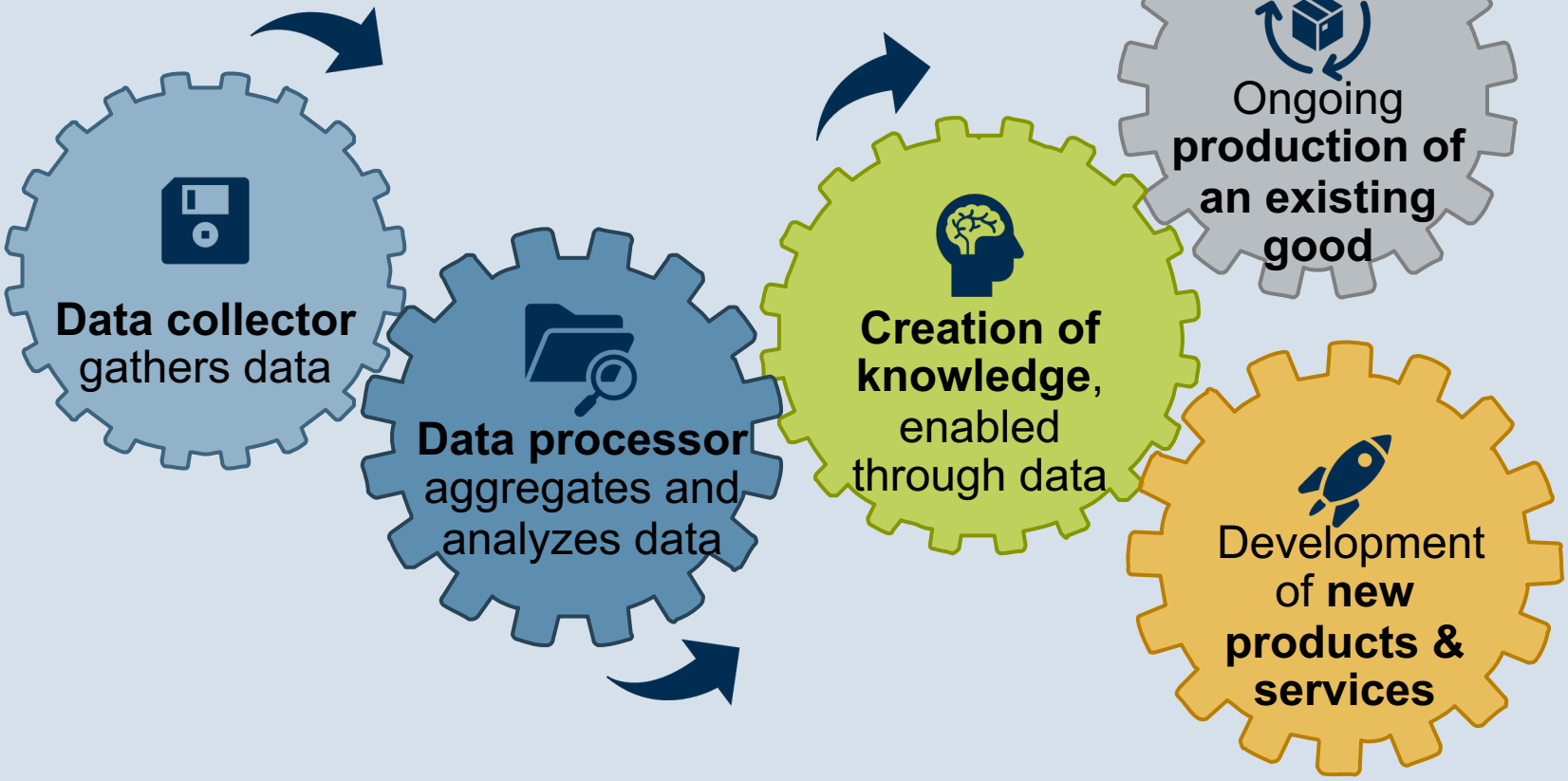

Data-driven Product Management
A/B-Testing at Amazon

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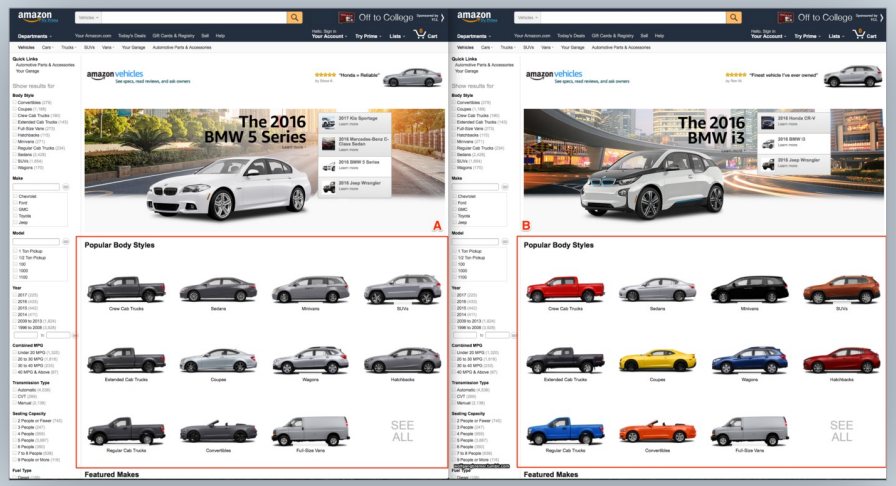
- Two different designs are sketched
- Designs are presented to real customers
- Customer behavior is observed

- Behavioral data gets aggregated and analyzed

- More engaging webpage-design is being identified



- AmazonVehicles adopts the more engaging webpage-design
- New design will be monitored, evaluated and improved using the same process

Demand: Data Creates Information and Shifts it Across Agents (1/2)

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Data on characteristics of potential buyers
(e.g., interests, buying habits)

Deliver more superior personalized goods / services
e.g., advertisements for desired products

Seller

Buyer

Make more informed buying decisions
by assessing more accurately how they fit one's needs

Data on characteristics of potential products
(e.g., product reliability via reviews, popularity via social media)

Demand: Data Creates Information and Shifts it Across Agents (2/2)

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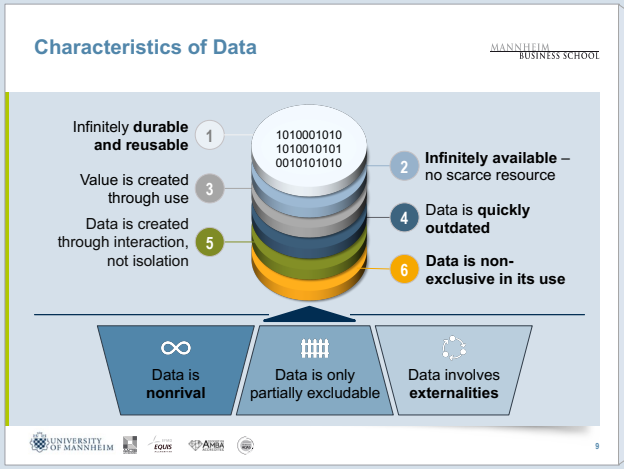
Opportunistic Behavior – Price Discrimination

Data collector with market power		Airline in a poorer country		Contractor / craftsman
		Charging higher prices		
Customer		Citizen from a wealthier country		Owner of a very valuable home

! More information can **increase economic efficiency**. Still, **acquiring exclusive information** that others don't have provides a **strategic advantage**, potentially making some groups worse off.

The Price of Data



Characteristics of data imply heterogeneity

- Data differ in a large number of attributes
- Difficult to determine a single price

WITHIN narrow classes of data varieties:

Definition of **meaningful markets and prices possible**

OUTSIDE narrow classes of data varieties:

Use degree of complementarity

Use degree of substitutability

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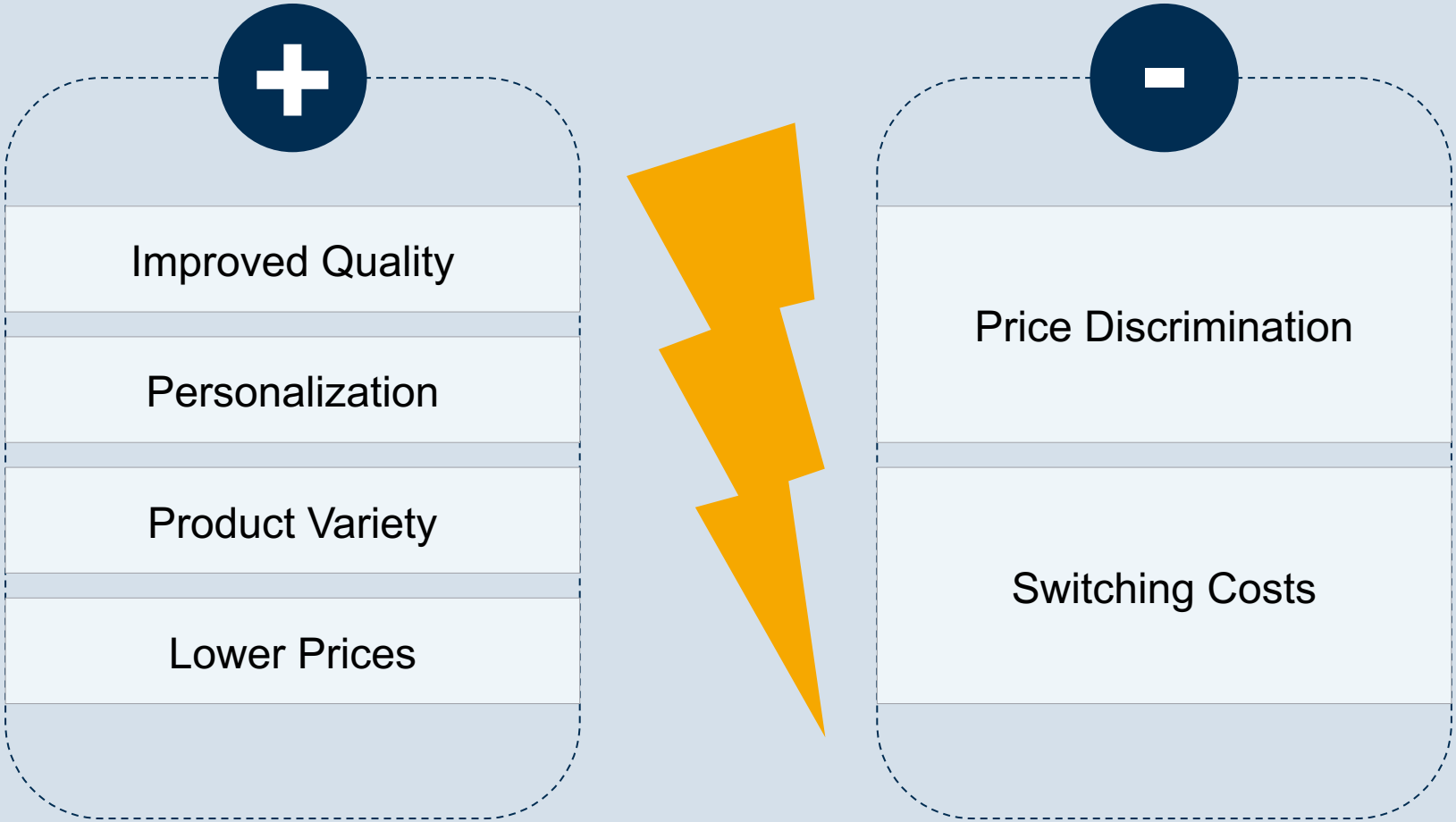
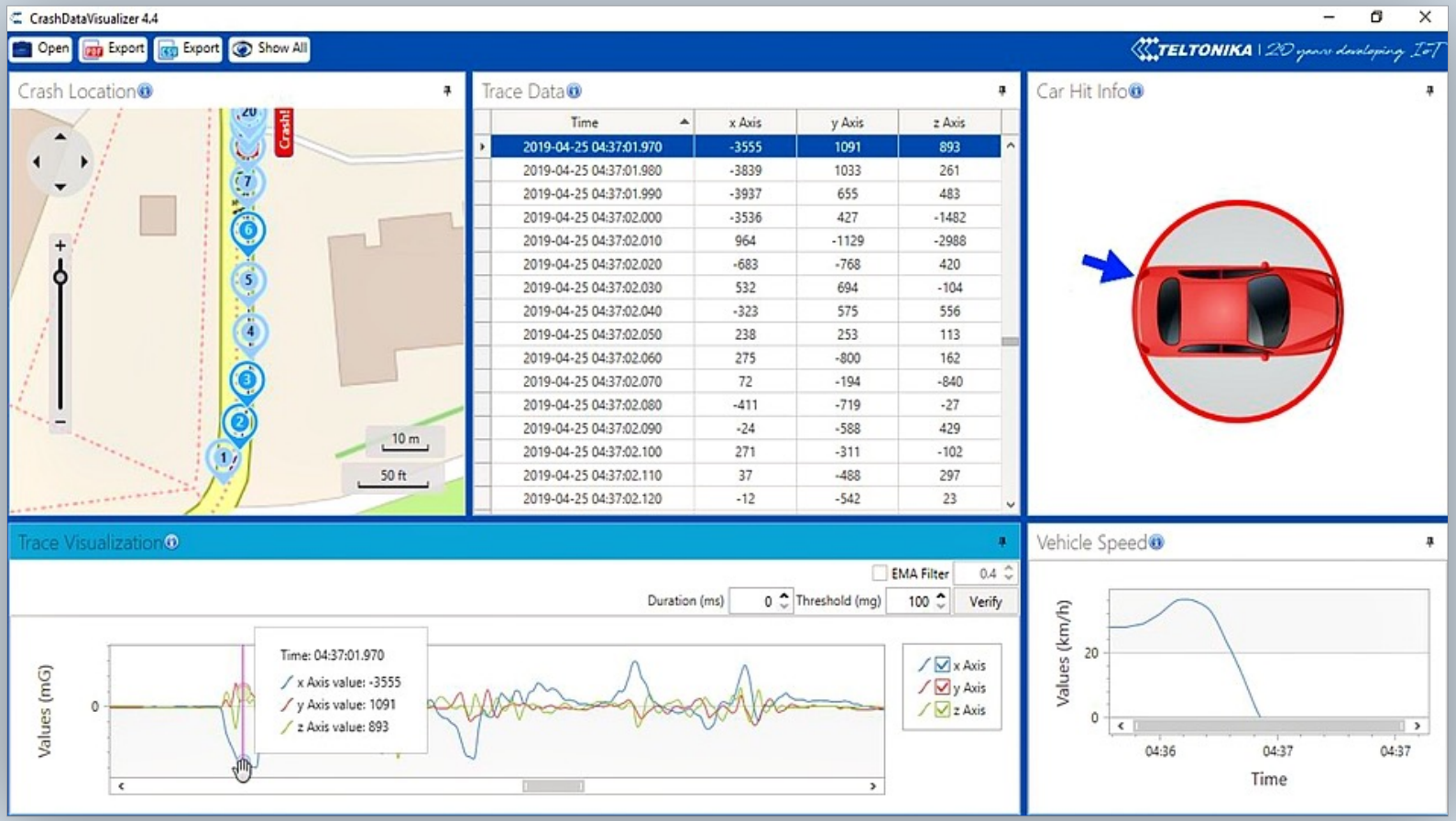
Consumer Benefits and Costs of sharing Data



Usage-based Insurance Driving Trackers



Privacy as Source of Economic Inefficiencies

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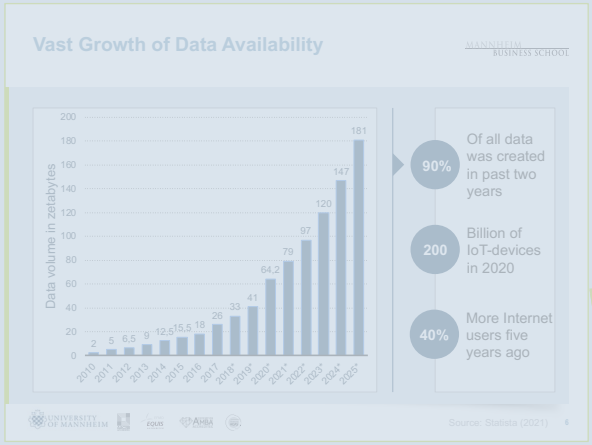

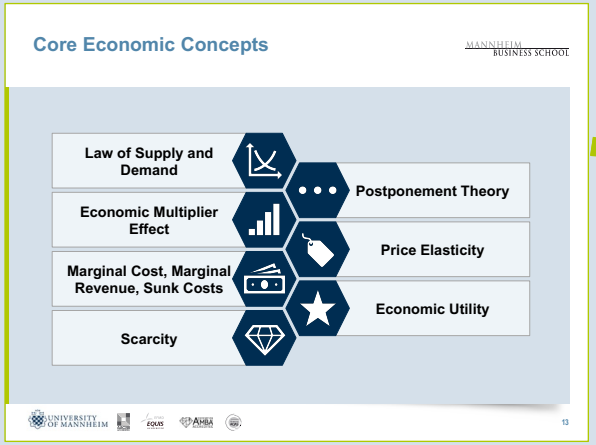

- Data Privacy results in less data shared
- Less shared data means less information
- Less information causes inaccuracy in economic models
- Economic inefficiencies arise

Privacy as Source of Economic Inefficiencies - Limitations

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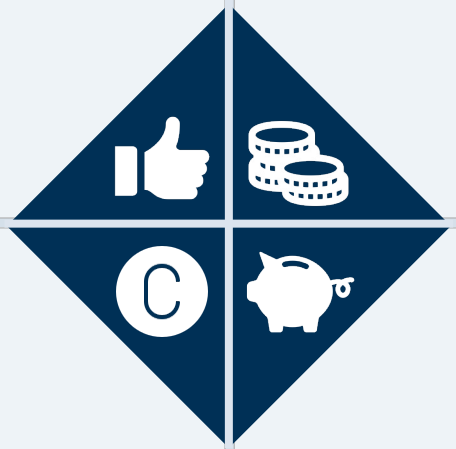
Insurance Concepts

Lagging Markets



Over-investing in data collection

Negative consumer externalities
e.g., unsolicited marketing

Disclosed vs. Protected Data

Disclosed Data

Disclosed data refers to states in which the **data subject** may have knowingly or unknowingly **shared data with other parties**, or states in which **other parties** may have entered in **possession** of the **subject's data**, independently of her knowledge or even consent.

Protected Data

Protected data refers to situations in which such **disclosures have not taken place**, independently of whether this may be due to the data subject's intentional protection of personal information, or the potential data holder being unable, or uninterested in, accessing the latter.

Benefits of Disclosed Data for Data Holders

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- Less advertising costs
- Targeted offers
- Coupon strategies
- Improved CRM
- Maximize ROMI
- Less inventory risk
- Predict trends
- Consumer loyalty
- Recommen-dations
- Price discrimination
- Improve service offering
- Sell consumer data

Benefits of Disclosed Data for Data Subjects

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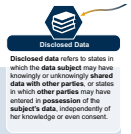

- Immediate Compensation
- Improved services
- Targeted offers
- Price reductions
- Wider product choice
- Less junk mail
- Information
- Free services
- Integrated data profiles

Costs of Disclosed Data

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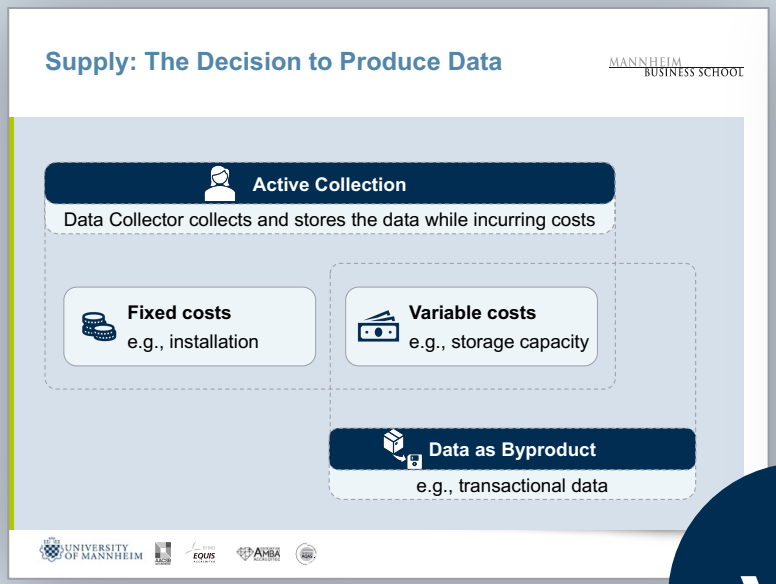
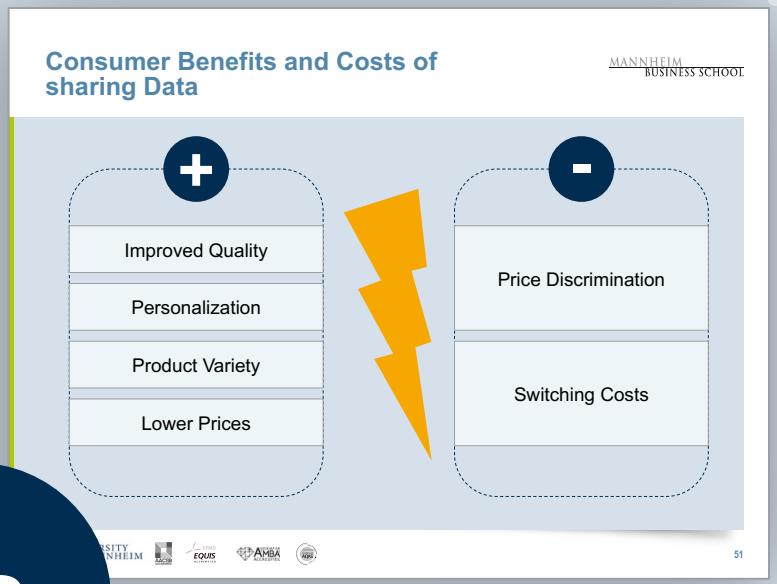
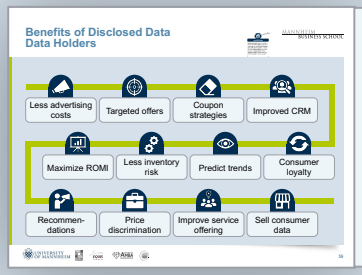
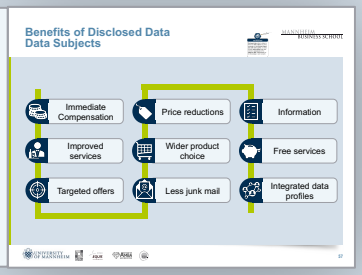




VS.



Opportunity Costs



Benefits of Protected Data

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Data Holder

- Limiting liabilities
- Limiting costs due to misused data
- Attracting privacy-savvy consumers
- May be revenue enhancing
- Less need for additional authentication processes

Data Subjects

- Being less transparent to firms (e.g., in terms of willingness-to-pay)
- Some foregone benefits are dispensable due to suitable alternatives

Costs of Protecting Data

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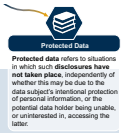

Data Holder

- Social losses due to incoherent privacy policies
- Second order effects (inefficient investments in data protection)

Data Subjects

- Cognitive costs (e.g., time spent on informing, on changing one's habits, etc.)
- Money spent for privacy enhancing technologies
- Opportunity costs

Framing the trade-off

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Privacy needs can be **satisfied without** significant **damage** to useful flows of **personal data**

Economics angle can **help** finding a **balance** between **information sharing** and **information hiding**

Expectations on **companies** might increase with regard to **protecting** individual **privacy**

Privacy technologies might change the framing of the **privacy debate**

The Economics of (Big) Data

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I What about Data?

II What about Economics?

III What about Economics of Data?

IV What about Privacy?

V What about Data Governance?

VI The Importance of Economics of (Big) Data

Four Growing Policy Challenges for Economics of Data and Analytics

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Incumbents **hoard data** and thereby harm competition, **reducing overall utility**

Across companies that handle data, **cyber-security levels differ severely**

Intransparent data markets **focus on data collection** while they **neglect privacy**

Threat of **fragmented global data markets** puts large gains at risk

Policy needs to be modernized to tackle current and future challenges!

Europe's Data Legislation - GDPR

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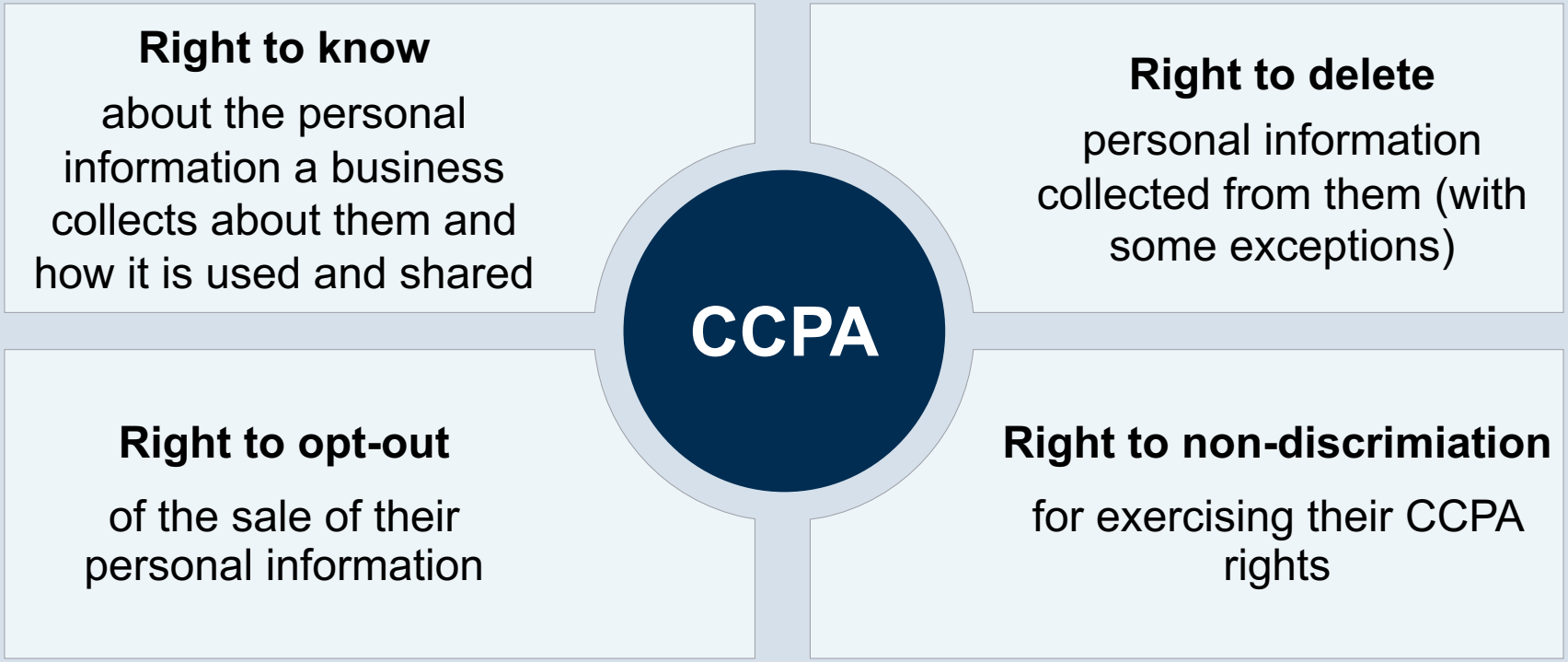
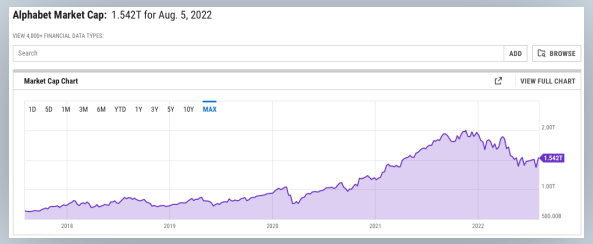
Right to **be informed**	Right to **restrict processing**
Right of **access**	Right to **data portability**
Right to **rectification**	Right to **object**
Right to **erasure**	Rights in relation to automated decision making and profiling

US Data Legislation - CCPA



An Unsolved Issue
Data Concentration

Alphabet



⇆ yahoo!

"Facebook and its elite brethren will do anything to make sure they are not the next Yahoo or Radio Shack, killed by disruption and failure to innovate. This translates into paying obscene sums for technology that might challenge their dominance one day."

Steven Davidoff Solomon (2016), Professor at Berkeley

Consumer Data Ownership Concept

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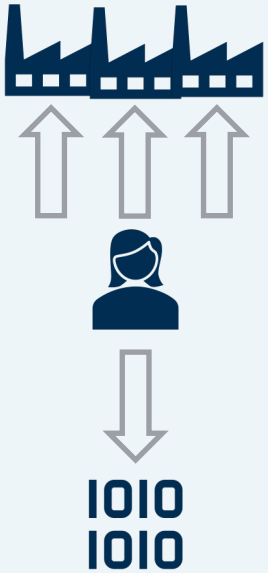
Status Quo

Consumer Data Ownership Concept



Consumer Data Ownership Concept Example

If Tesla owners would own their driving data

The Tesla creates drive recordings while in use

The Owner sells the data to Tesla and Waymo for a profit

Every firm's AI improves and cars become safer

Consumer Data Ownership Concept Feasibility

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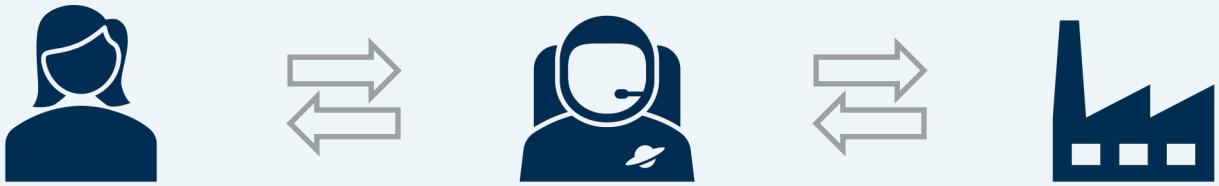
Intermediaries could match consumer data with multiple firms



Consumer provide intermediaries with their data and selling preferences

Intermediary matches selling preferences with firms in need for data

Firms gain access to wider data

Consumer Data Ownership Concept Simulation for Efficiency

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Data externalities describe what information of a data subject's data reveals about other data subjects' data.

1. Welfare fully captured by firms if "substitutable data" is of interest
2. Welfare fully captured by consumers if "complementary data" is of interest
3. Economically efficient for situations in which the firm is interested in specific data

! How the firm and consumers divide the surplus created by data depends on the presence of data externalities.

The Economics of (Big) Data

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I What about Data?

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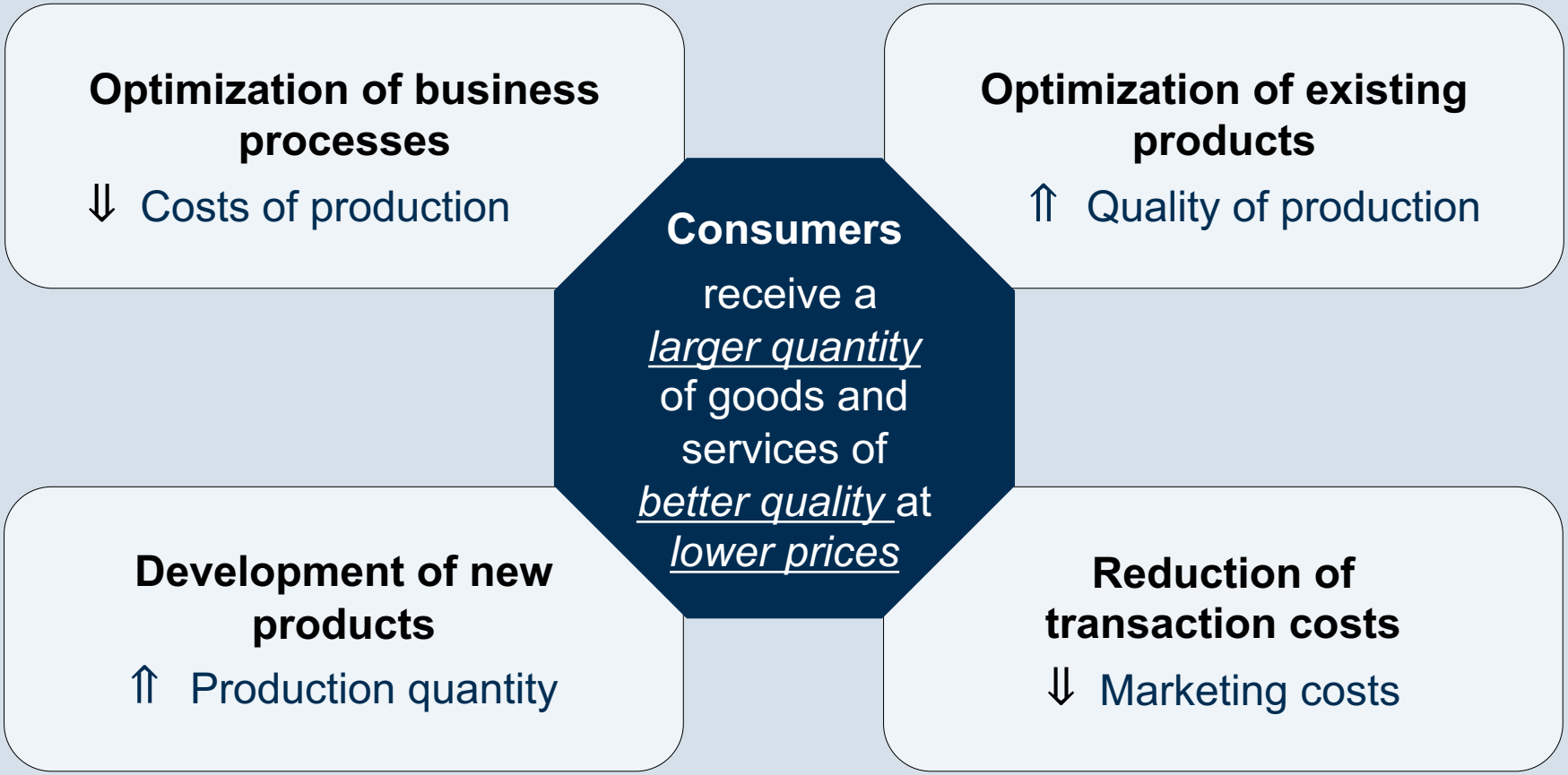
What for?
Outcomes of Economics of Big Data



Forecast for Valuation of Open-Data-Market in the EU

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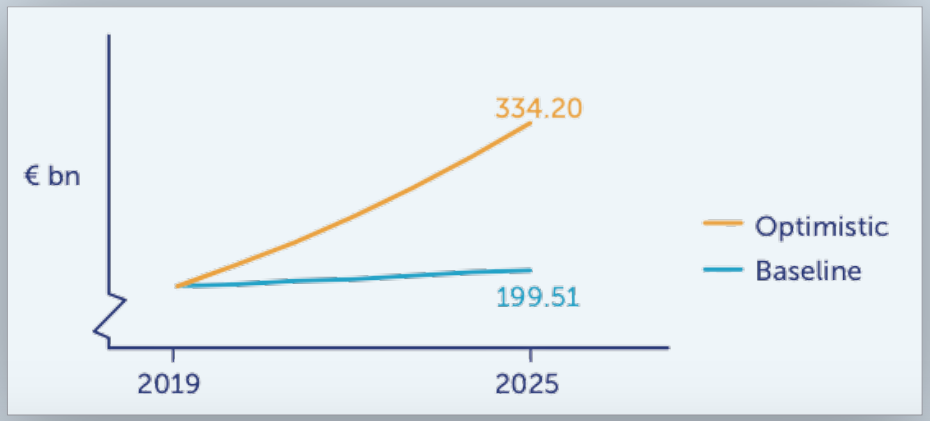
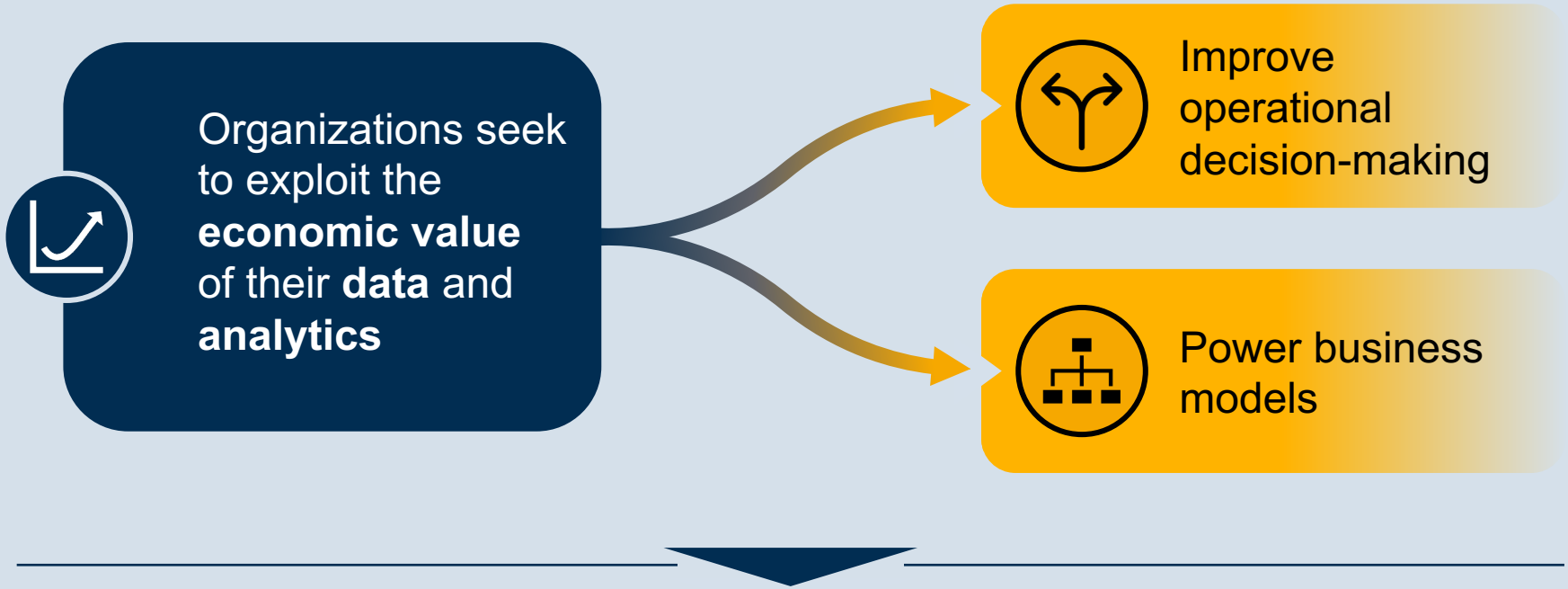


Year	2019	2020	2021	2022	2023	2024	2025
GDP in € billion for EU27+	15 539.24	15 694.63	15 898.66	16 121.24	16 346.94	16 575.80	16 807.86
ECB: expected real GDP growth in %	1.10	1.00	1.30	1.40	1.40	1.40	1.40
Baseline: open data market size in € billion for EU27+	184.45	186.30	188.72	191.36	194.04	196.75	199.51

Summary



Applying economic concepts to data and analytics may help organizations as they seek to **prioritize** and **optimize** their **data** and **analytic investments**.