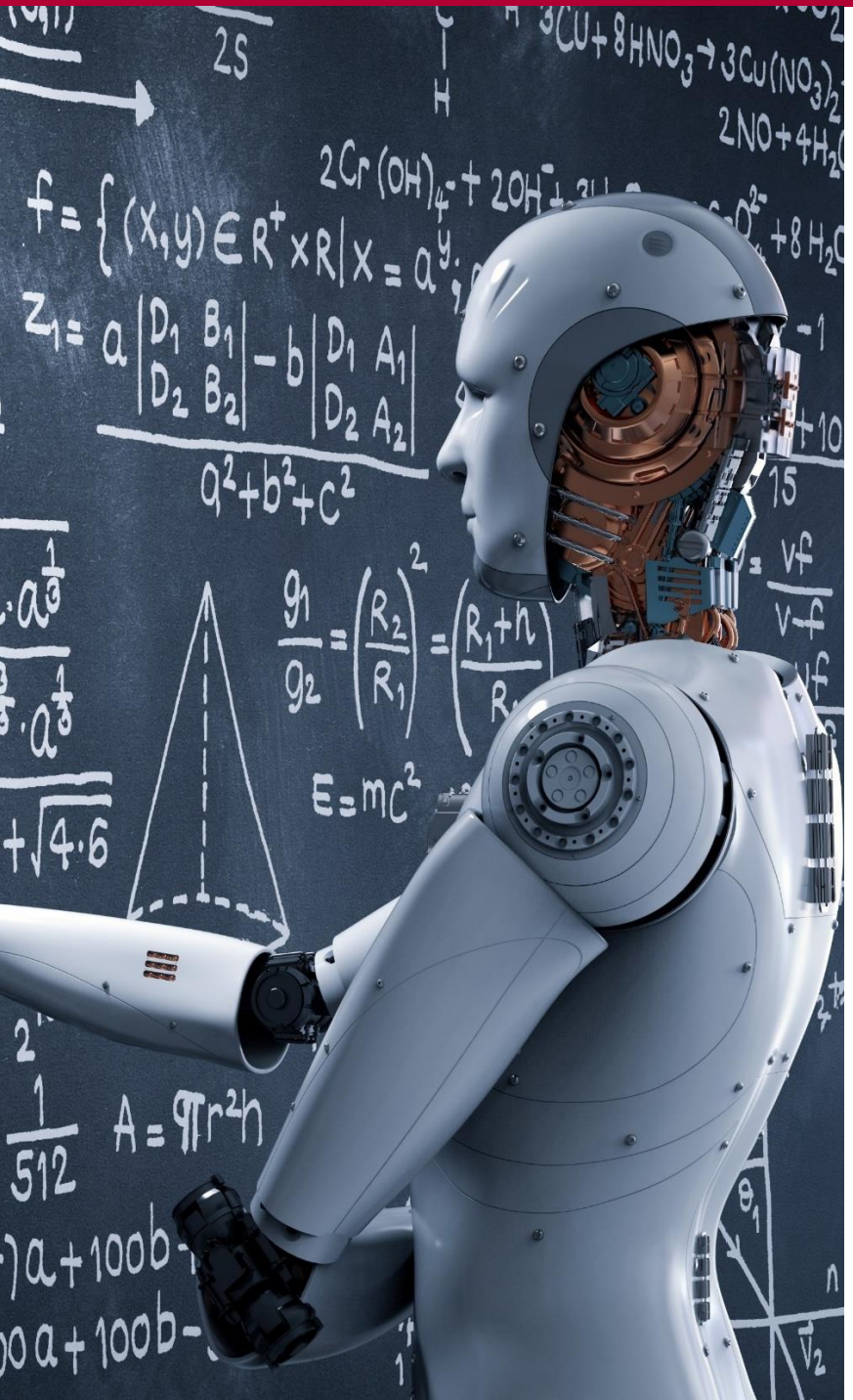

Research Center for
Information Management

Fraunhofer
FIT

Smart Sustainability Simulation Game

Case 1: Material Procurement - Unit 2
07.05.2024

FIM Research Center for Information Management
Fraunhofer Institute for Applied Information Technology FIT,
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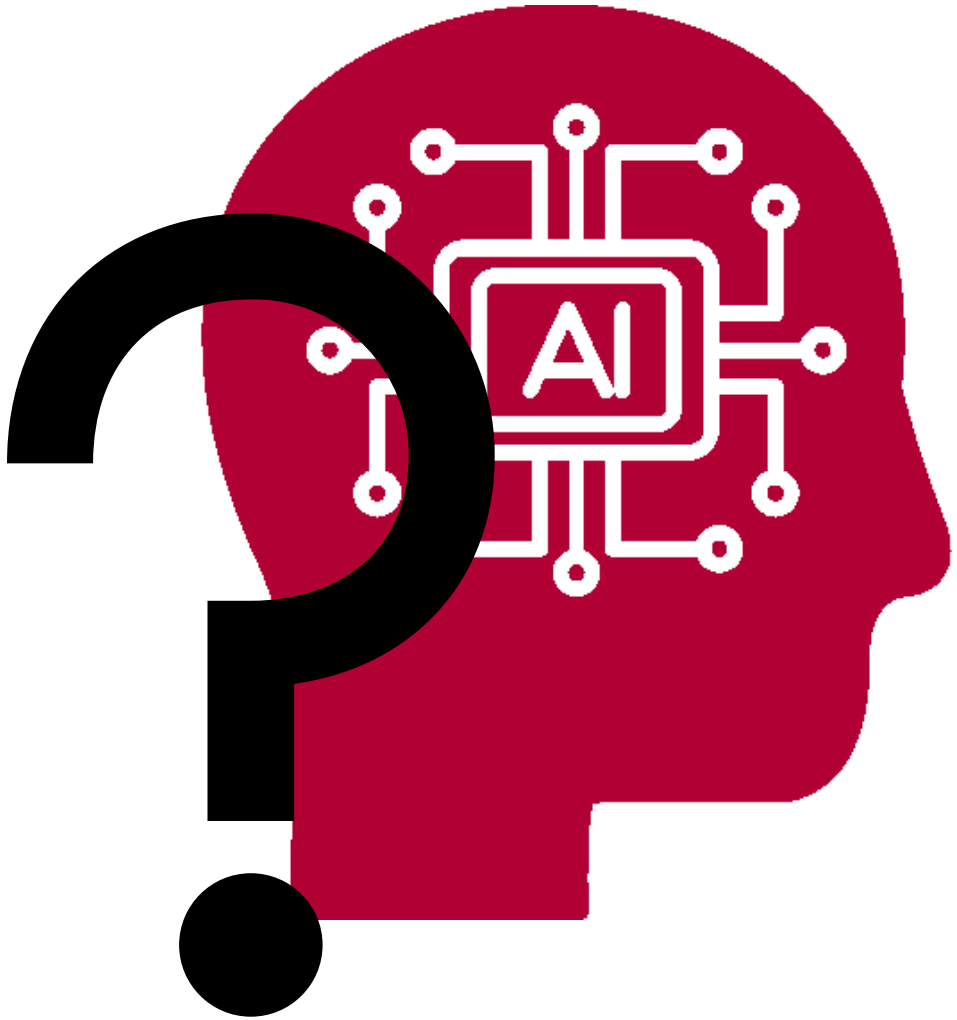
01

Organizational information

Time for Feedback



How was the first week?

Any Questions?

02

Case 1: Material Procurement - Unit 1

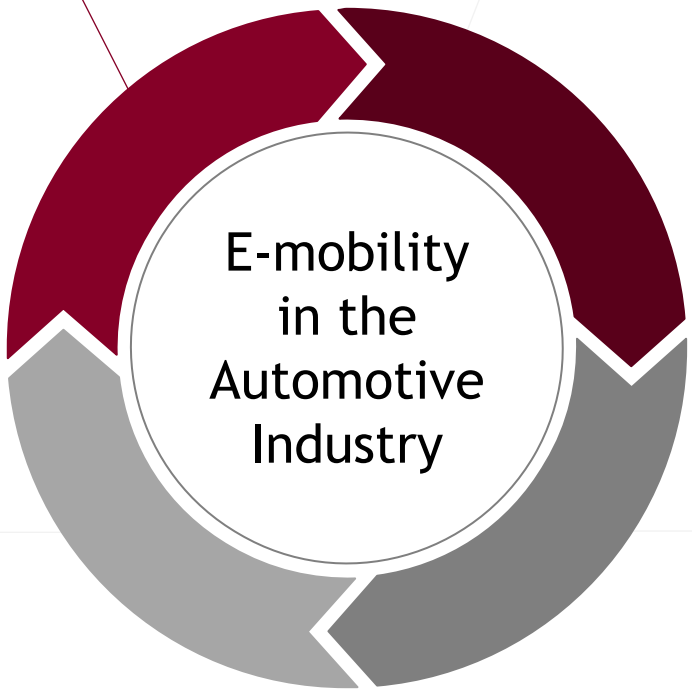
Overview of the cases

Recap

Case 1: Material procurement

- What materials should I buy and when?
- Value chain level: Procurement

→ Time Series Analysis



Case 2: Predictive Maintenance

- How often and when should I maintain my machine?
- Value chain level: Operations/production

→ Predictive Analytics

Case 4: Recycling

- How much effort do I put into recycling?
- Value chain level: After-sales-services

→ Process Mining

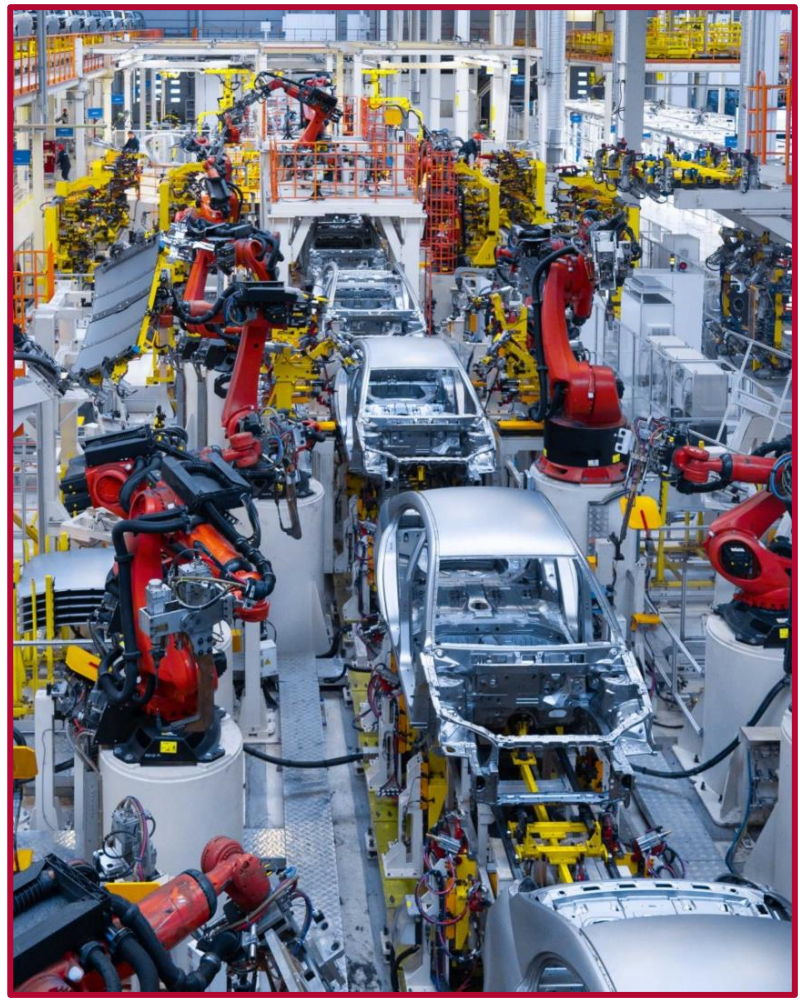
Case 3: Quality Management

- How to ensure good quality?
- Value chain level: Operations/production

→ Computer Vision

Case 1: Procurement department of Edison Cars AG

Recap



Change in demand

- Increasing end-consumer demand for low-emission vehicles
- The EU ban on the sale of new petrol and diesel cars by 2035

New product

- Board of Edison Cars AG made the strategic decision: Abandon current combustion-engine-based cars
- Switch to the production of electric car

Transformation of production

- Currently, the company is putting a lot of effort in transforming
- Development of a new production lines

Case 1: Procurement department of Edison Cars AG

Recap

The design of those **production lines** heavily **depends** on the **suppliers** of the resources that are required in the various production processes

- The procurement department was instructed to **choose suppliers** for each of the core resources
- **Production** of the new model **starts in 5 years**

- The CEO explicitly asked you to **not only** base your choice on **economic factors**
- Also consider **ecological and social implications**

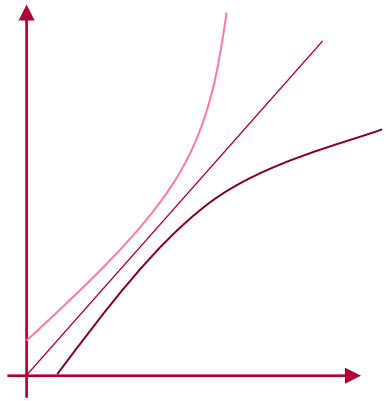
The company management sets a fixed budget for procurement activities

Time Series Analysis - Basics

Recap

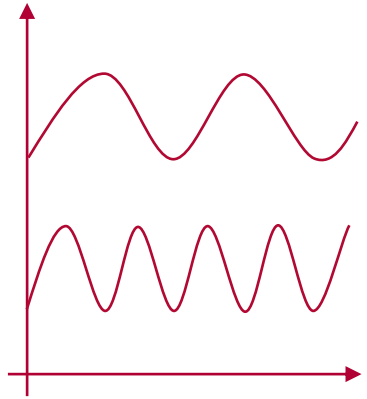
Time series analysis is concerned with the statistical description and short-term statistical prediction of time-ordered characteristic values of one or more metric characteristics using mathematical-statistical methods and model.

Trend Component



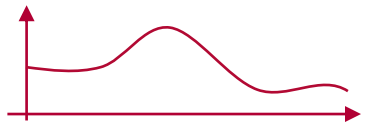
- Describes the long-term behavior of a time series
- It is often assumed that it grows monotonously or falls monotonously
- Freed from periodic influences

Seasonal component



- Describes a regularly recurring structure in the data
- Usually with fixed period length (e.g. seasons)

Irregular component



- Fluctuations that cannot be attributed to any of the above-mentioned components
- No systematic random behavior

Source: Eckstein (2016), Stier (1991)

Case 1: Description of steel suppliers

Recap

To this day, hardened steel is indispensable in the automotive industry, also when it comes to electric cars. It is the main part of the bodywork of a car. Per unit of the newly developed model, about 600 kg of steel are required.
Your team identified three potential suppliers:

East Metal Co.

- In the past, cheapest among the three options
- Struggling to comply with labor rights
- Reports on several cases of corruption
- Carbon emissions are at around 2,6 t[CO2]/t[steel]

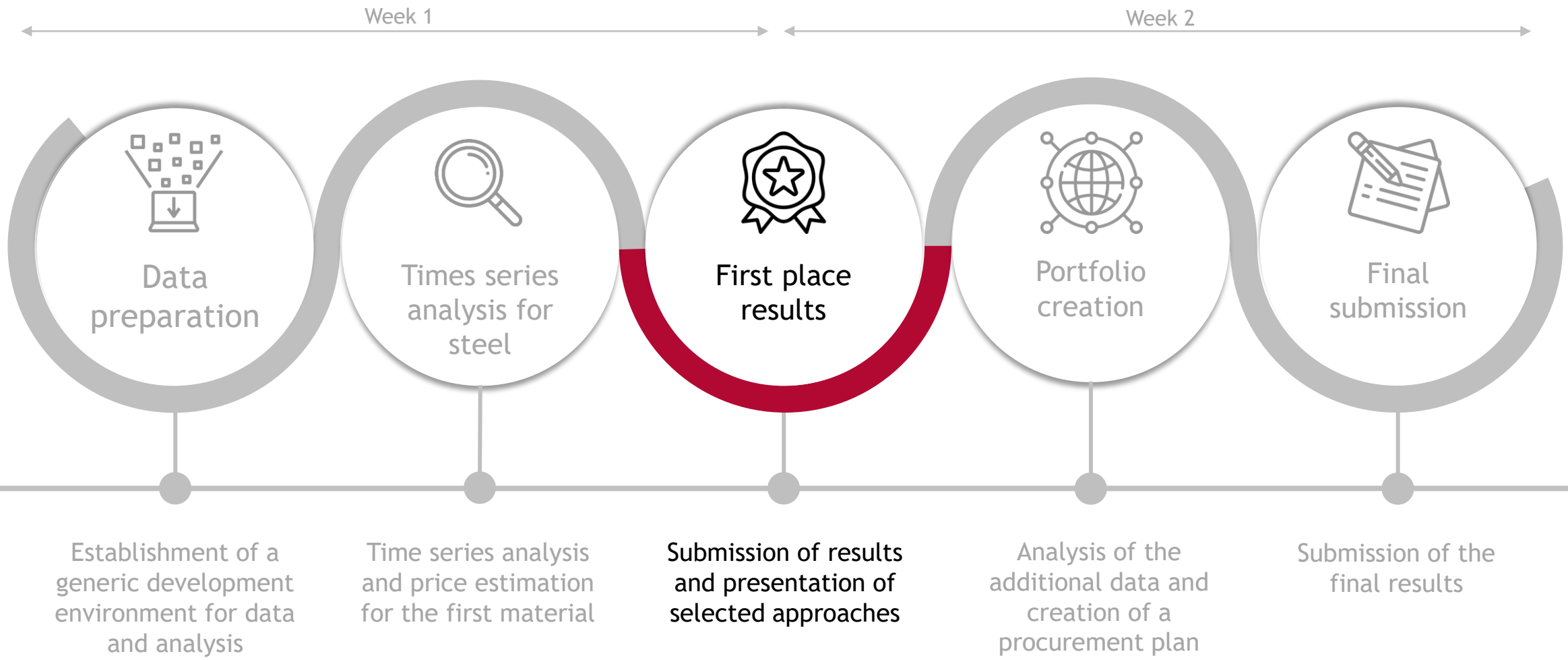
Sakura Steelworks

- Strong regulation of the production as well as governing processes
- Supplier faced problems with their supply chain but solved these problems by 2021
- Carbon emissions are at around 1,91 t[CO2]/t[steel]

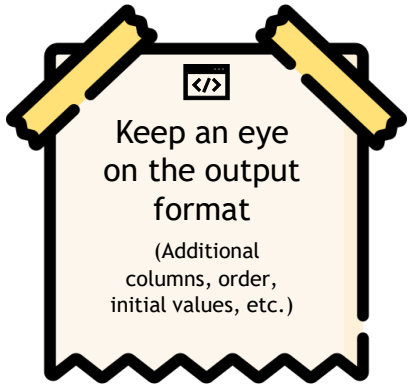
Black Forest Steel Co.

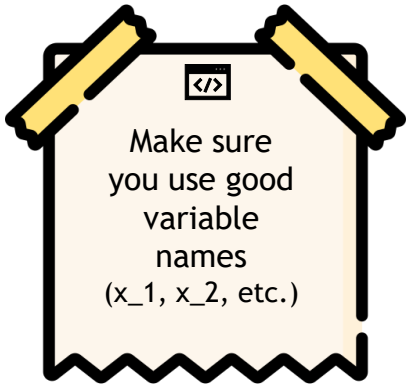
- Strong regulation of the production as well as governing processes
- Supplier has to buy CO2-certificates
- Carbon emissions are at around 1,81 t[CO2]/t[steel]

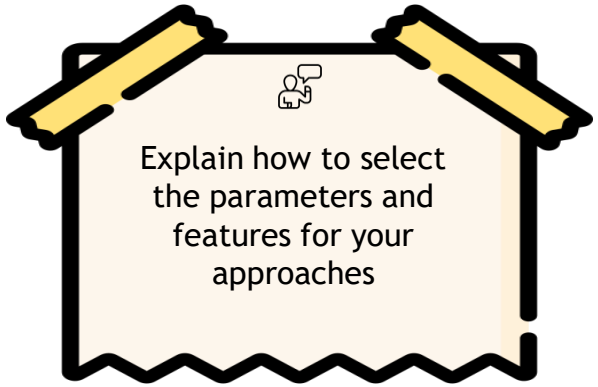
Case 1: Time schedule

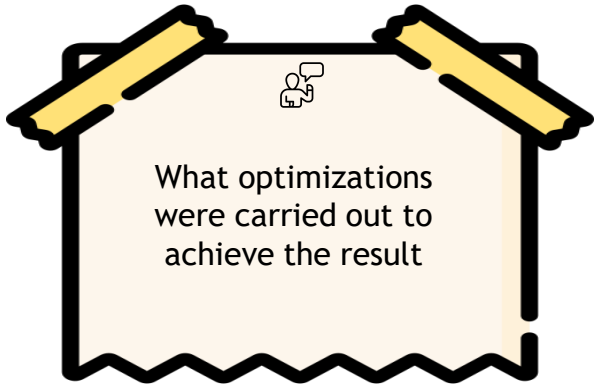


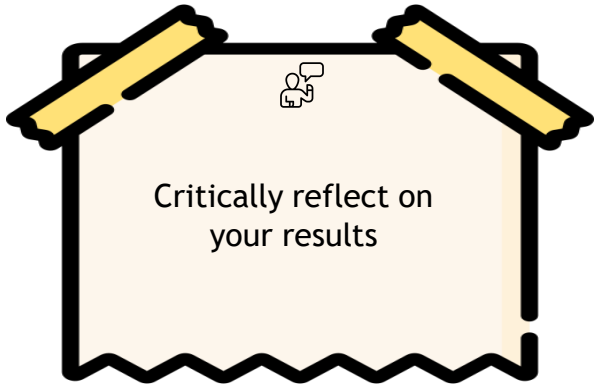
Case 1: Keep in mind



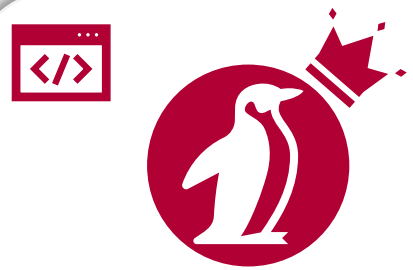








Case 1: Leaderboard – Unit 1



Team Penguin

MSE: ~847

Team 1

#Cars: ?

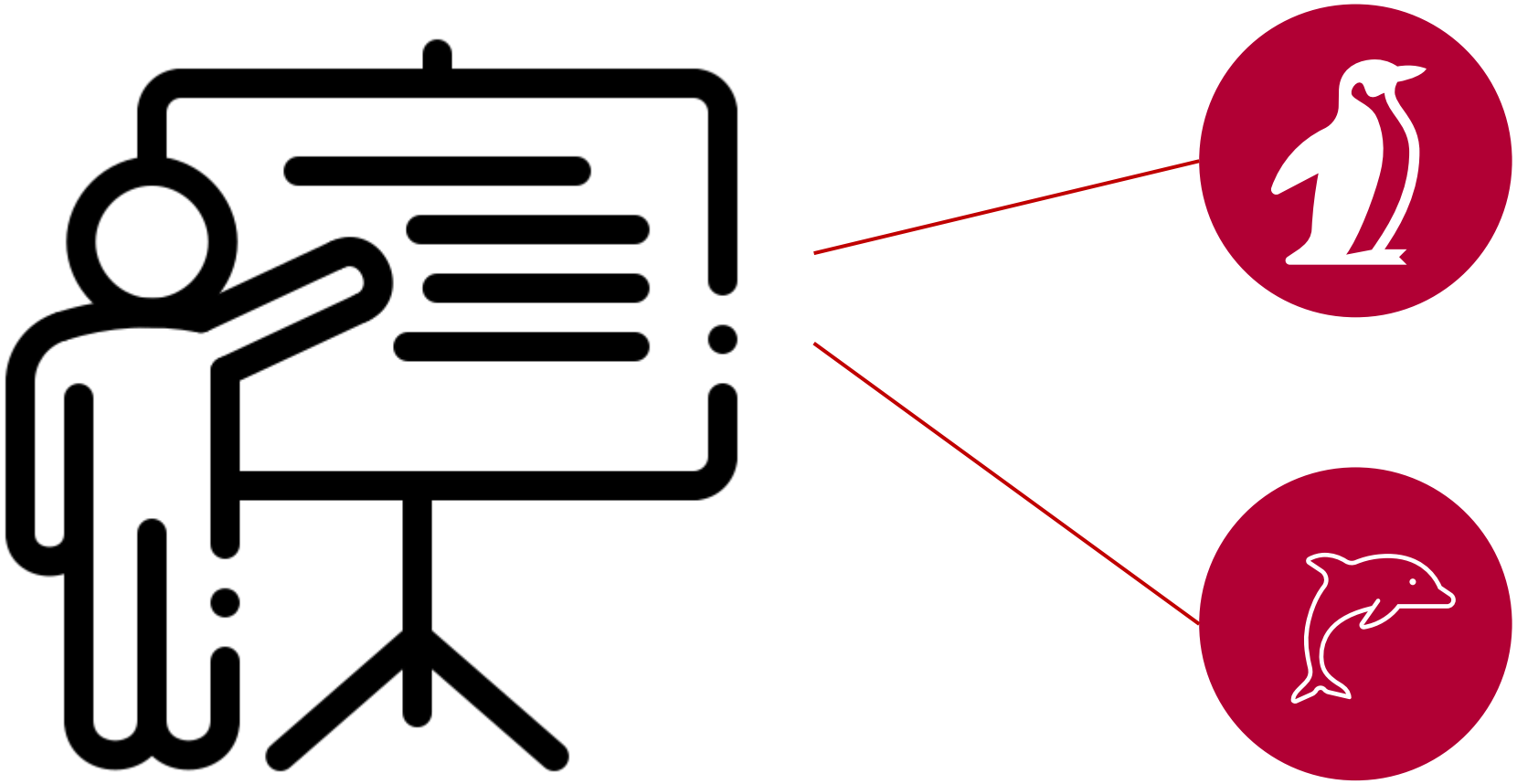
Team 1

CO_2: ?

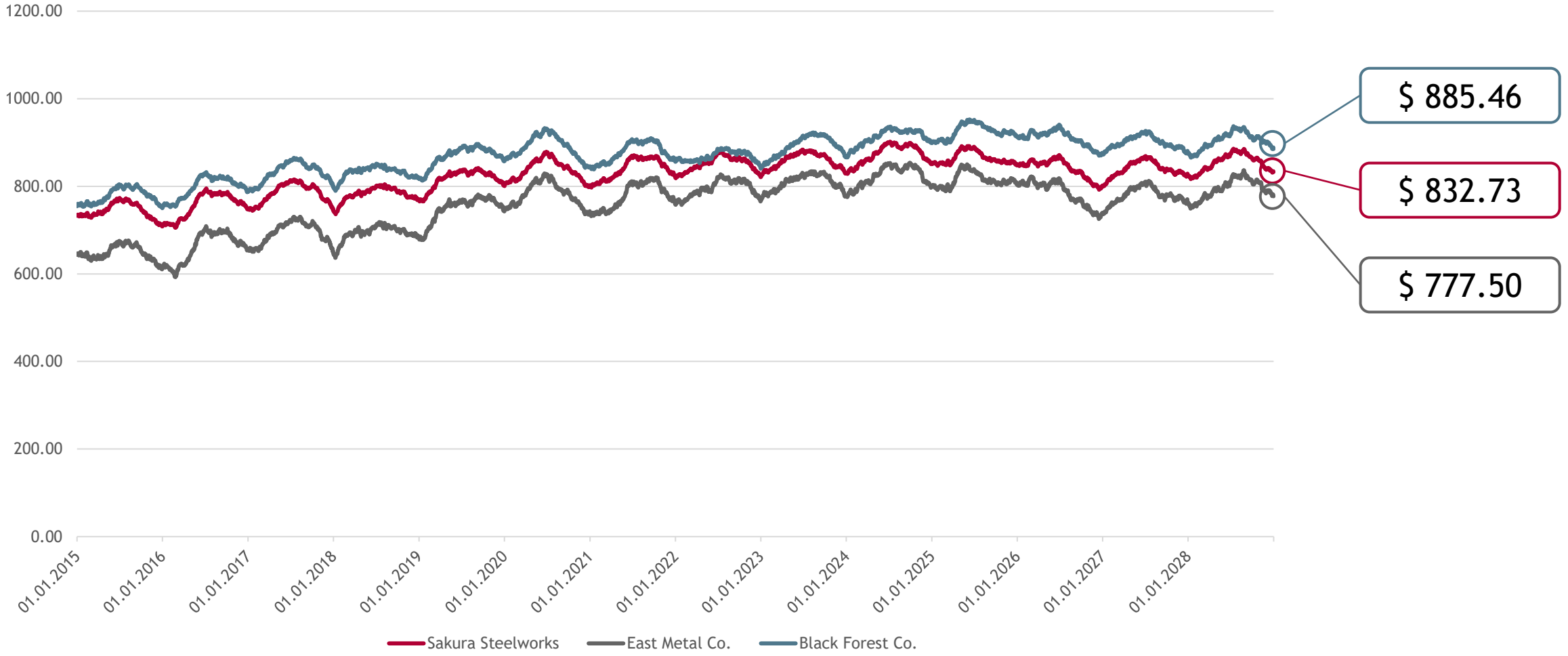
Team 1

Impact: ?

Case 1: Presentation of results



Case 1: Final steel prices

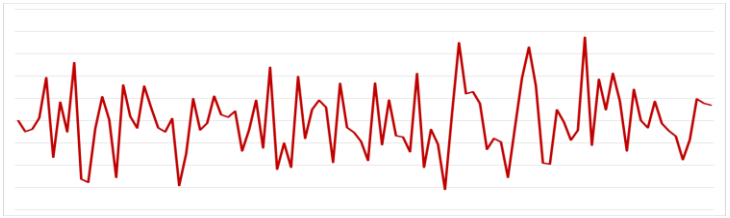


03

Case 1: Material Procurement - Unit 2

Case 1: Common challenges in analyzing data

1 Noise

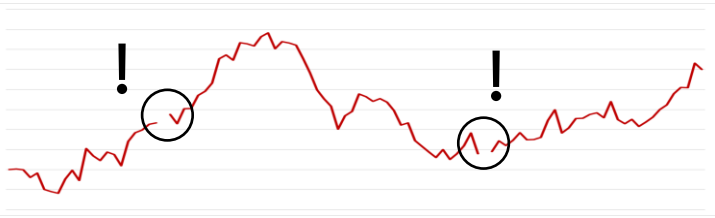


Random or unpredictable component of a data set that does not represent the underlying signal or pattern

2 Outliers

Outliers are data points that are significantly different from other observations in a data set

3 Missing data



Absence of a value or information for one or more variables in a data set

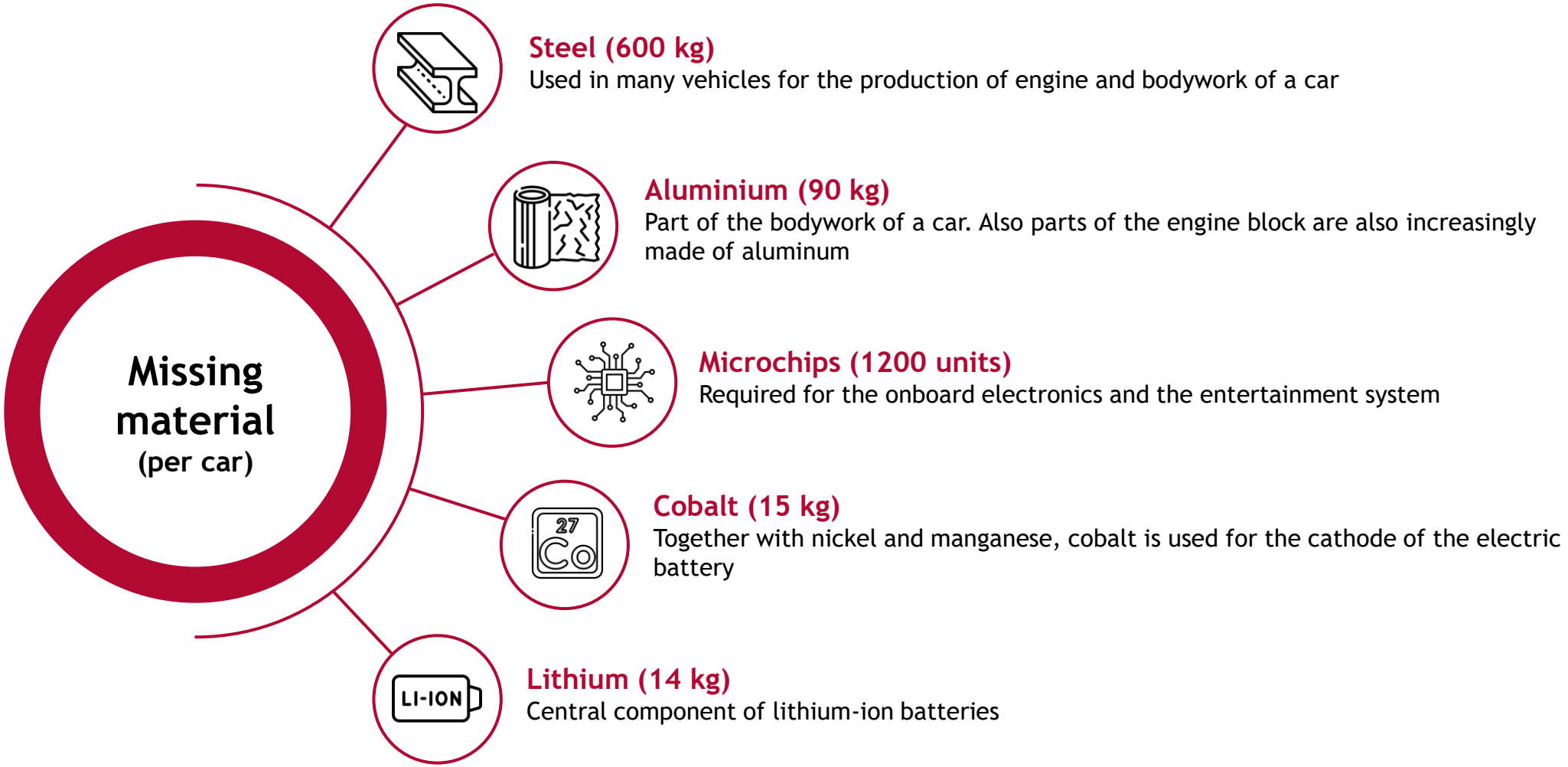
4 Change in trend

Shift or reversal in the pattern or direction of the data over time, indicating a change in the underlying process or mechanism governing the data

5 Jumps in data

Sudden, discrete changes in the magnitude or level of a data series, which can be caused by various factors such as measurement errors, natural disasters, or interventions

Case 1: Missing materials



Steel (600 kg)
Used in many vehicles for the production of engine and bodywork of a car

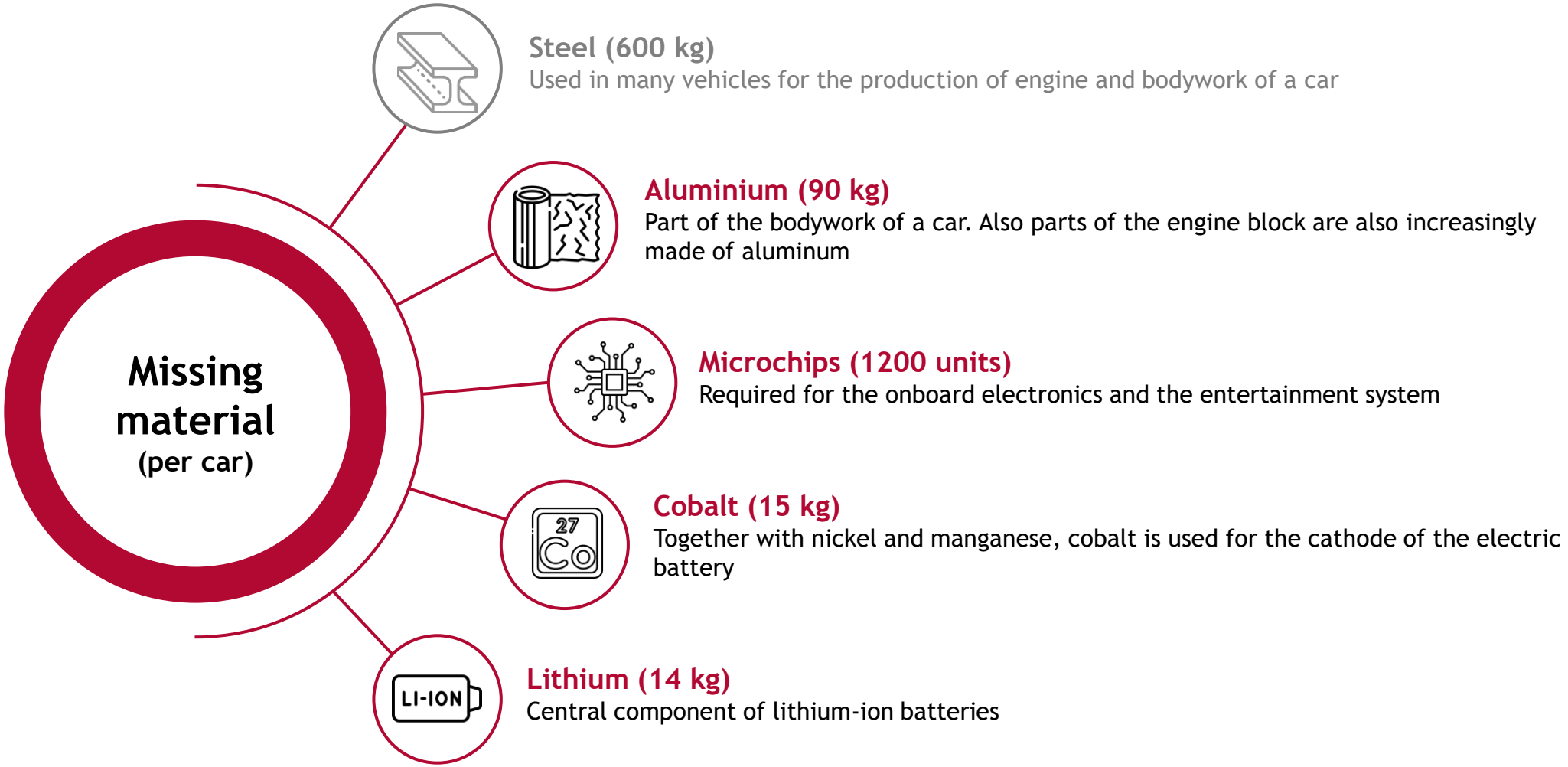
Aluminium (90 kg)
Part of the bodywork of a car. Also parts of the engine block are also increasingly made of aluminum

Microchips (1200 units)
Required for the onboard electronics and the entertainment system

Cobalt (15 kg)
Together with nickel and manganese, cobalt is used for the cathode of the electric battery

Lithium (14 kg)
Central component of lithium-ion batteries

Case 1: Missing materials



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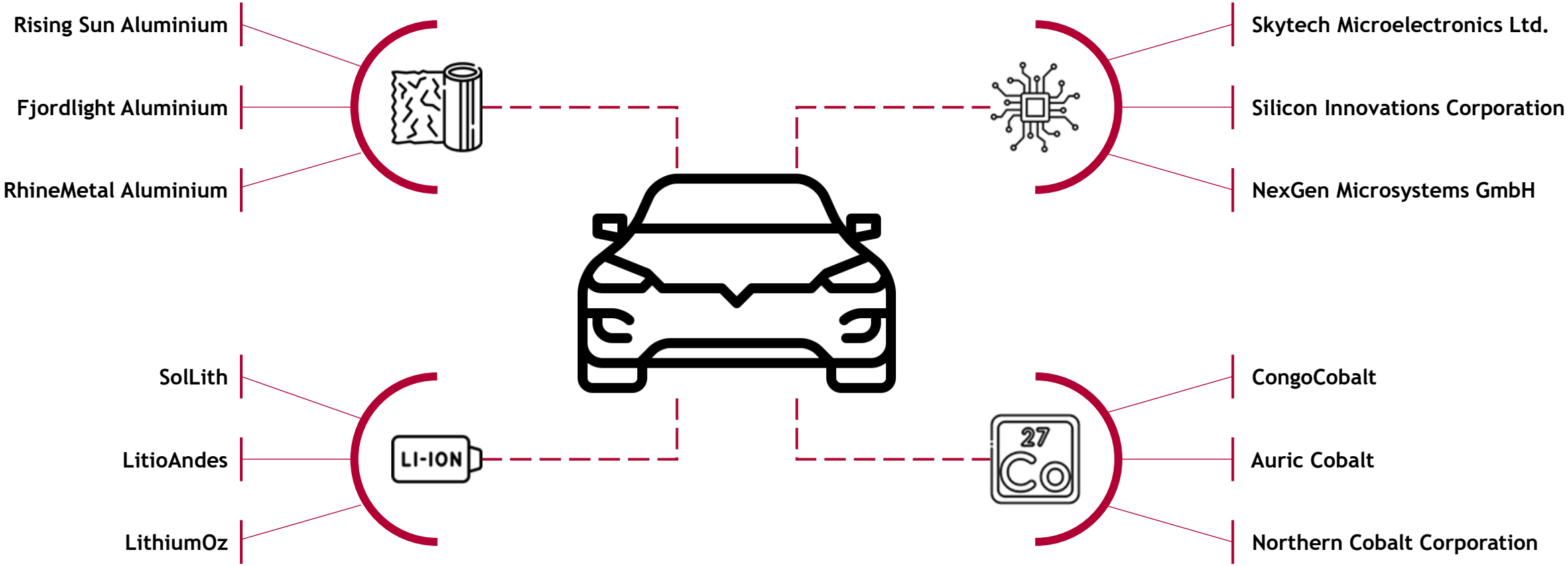
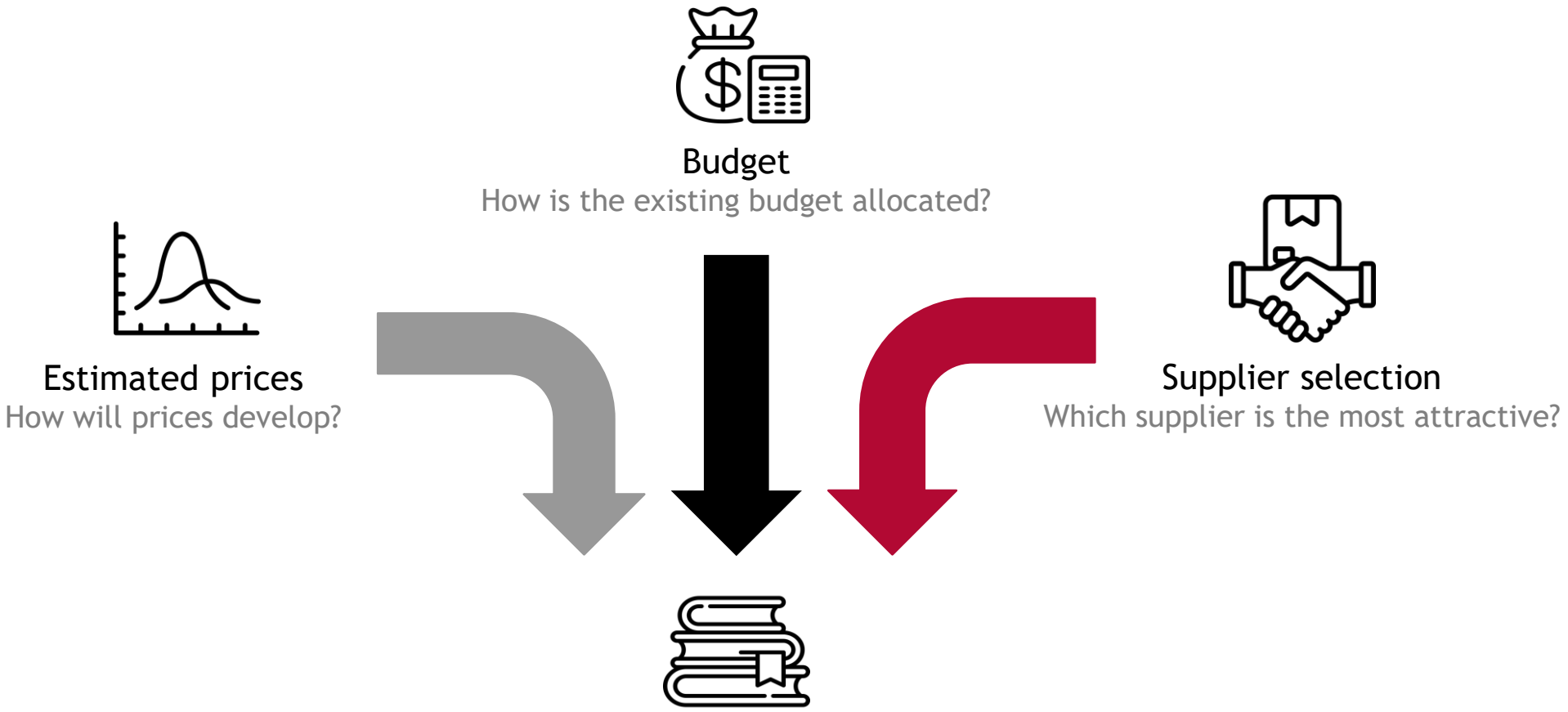


Task

Calculate the daily prices for aluminum, microchips, lithium, and cobalt for the next 4,5 years by performing a time series analysis. Decide which supplier you would like to select and how much material you would like to buy by the deadline in 4,5 years.

Case 1: Final portfolio



Case 1: Linear Programming

Definition

Linear programming is a mathematical method for optimizing a linear objective function subject to linear constraints and is commonly used in business, economics, and engineering for decision making and resource allocation.

Basic structure

$$z = 2x + y$$

Objective Function: The objective function in linear programming is a mathematical expression that defines the quantity to be maximized or minimized.

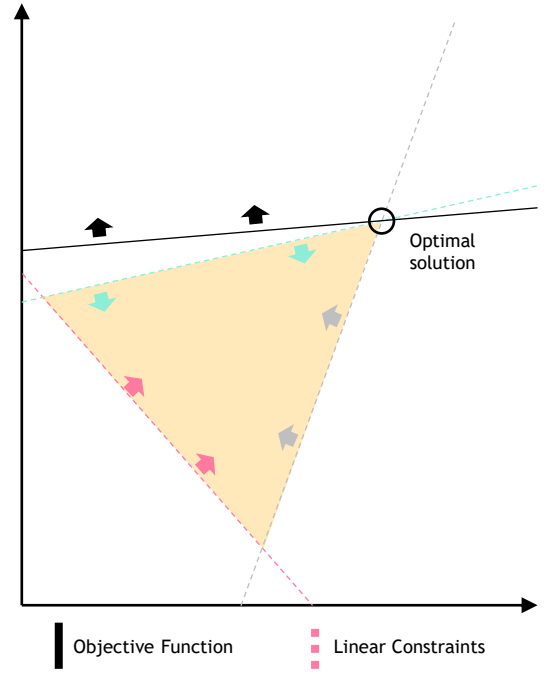
$$\begin{aligned} 4x + 2y &\leq 56 \\ 2x - 4y &\leq 64 \\ 3x - 3 &\geq -20 \\ x &\geq 0 \\ y &\geq 0 \end{aligned}$$

Linear Constraints: Linear constraints in linear programming are mathematical expressions that restrict the values of the decision variables to feasible ranges. These constraints can be either equalities or inequalities, and they reflect the limitations or requirements on the problem.

$$x, y \in R$$

Decision Variables: Decision variables are the unknowns in the linear programming problem that we want to determine.

Visualization



Information

More information at:

https://realpython.com/linear-programming-python/

Case 1: Linear Programming

Target function

The objective is to **maximize** the profit generated by selling products A and B. The profit per unit is **10€ for product A** and **15€ for product B**.

Basic structure

Production information

- Two machines are needed for the production
- The production time per unit is **2 hours for product A** and **3 hours for product B** on machine 1
- **1 hour for product A** and **2 hours for product B** on machine 2
- The company has **50 hours** of production time on machine 1 and **40 hours** on machine 2

Results

Case 1: Linear Programming

Target function

The objective is to **maximize** the profit generated by the sale of products A and B. The profit per unit is **€ 10 for product A** and **€ 15 for product B**.

Basic structure

$$\max \; 10\,a + 15\,b$$

Objective Function: Maximize the profit

$$2\,a + 3\,b \leq 50$$
$$a + 2\,b \leq 40$$
$$a \geq 0$$
$$b \geq 0$$

Linear Constraints:
- **Machine capacity**
- **Production capabilities**

$$a, b \in \mathbb{Z}$$

Decision Variables

Production information

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Linear Constraints:
- **Machine capacity**
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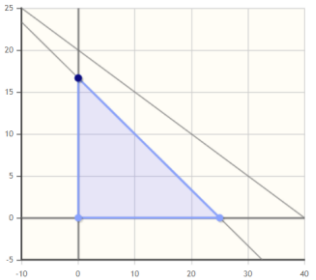
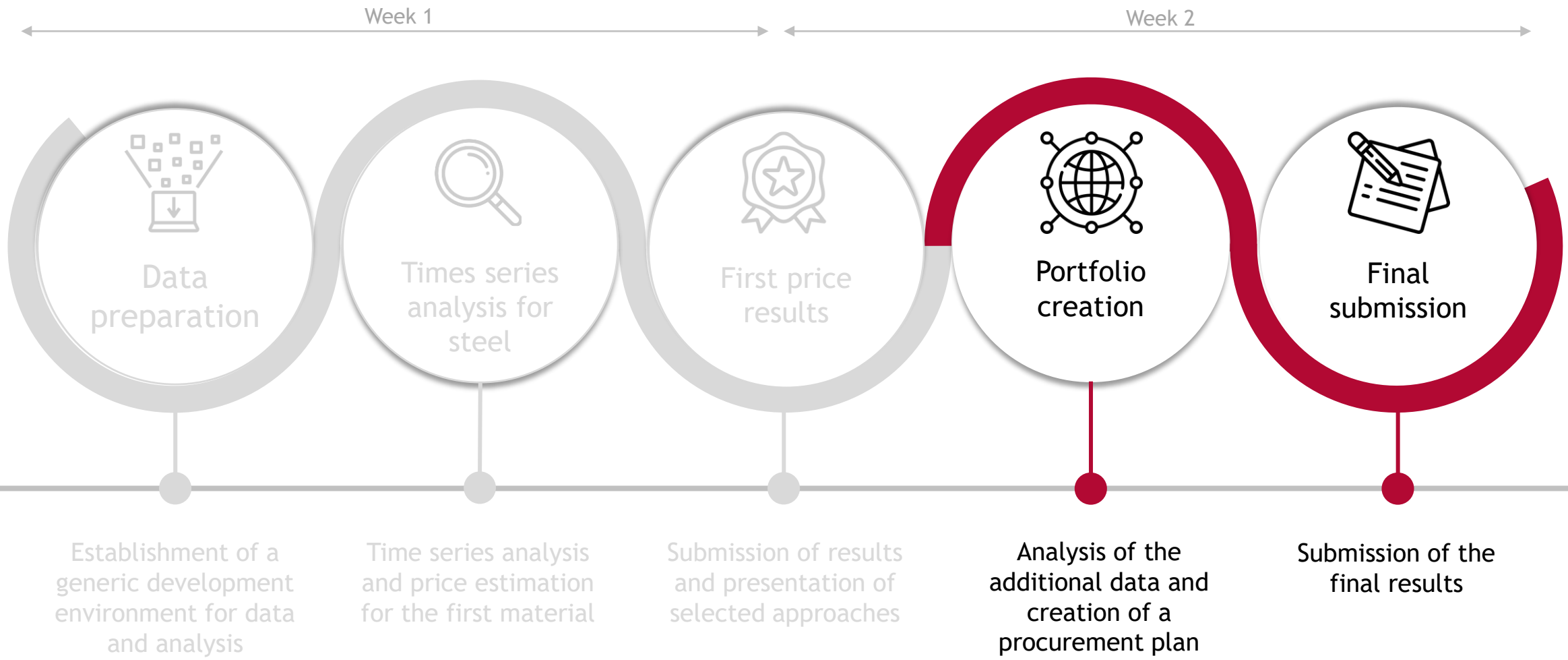
Results



- a = 10
- b = 10
- Profit = € 250

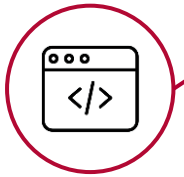
Case 1: Time schedule



Case 1: Input

Worksheet
Contains description of the task and the exact submission details

Code Template (if necessary)
Provides framework for the development and provides basic functionality



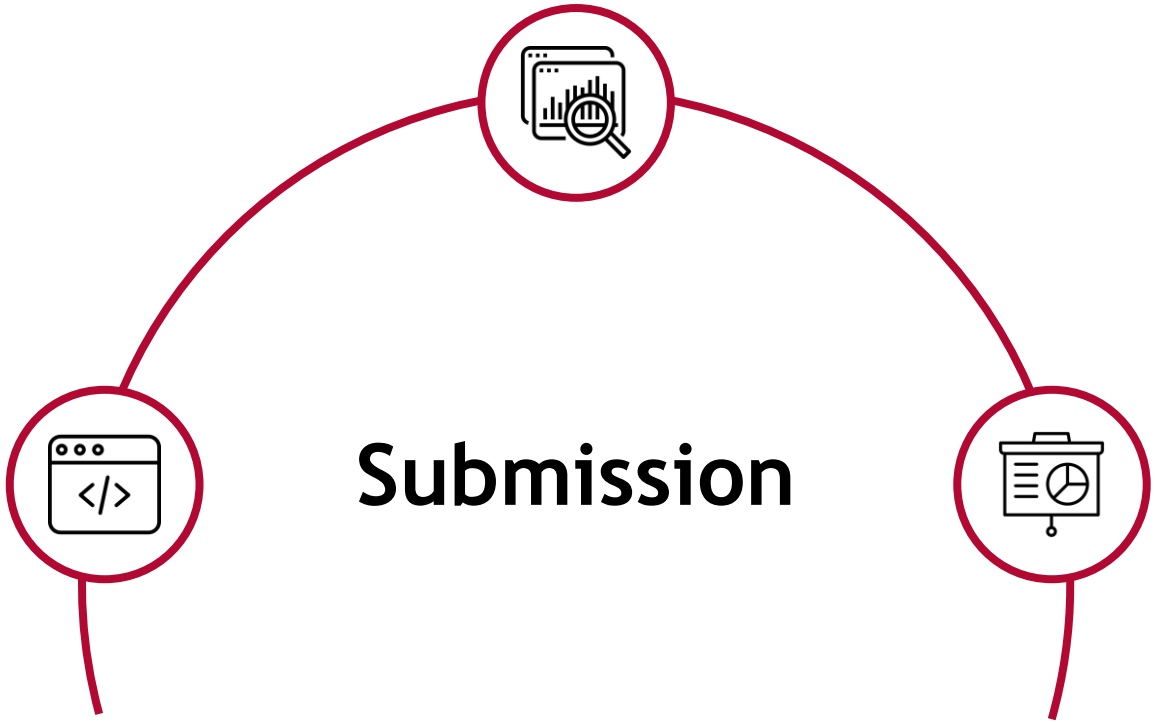
Task completion

Data
Represents different phenomena and interrelationships

Case 1: Submission

The following documents must be emailed to s3g@fim-rc.de as one zip folder by 02:00 PM on 13.05.2023:

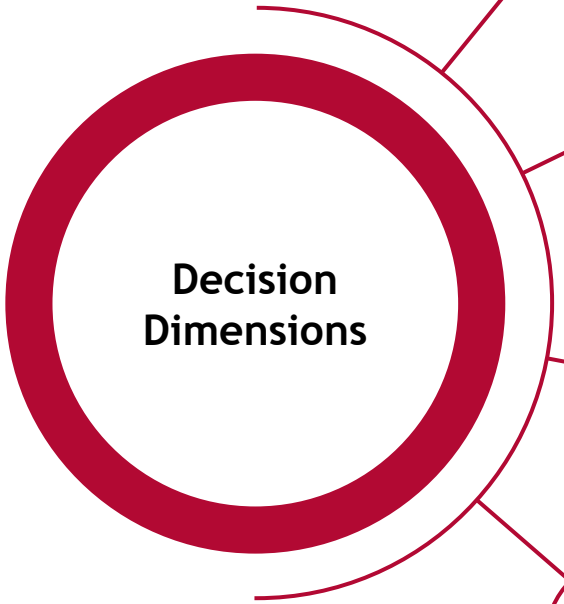
Time series data
Complete time series (original prices + forecasted prices) as continuous time series in CSV format



Code
Code file(s) for reproducing your results, with installation instructions if necessary

Presentation
A PowerPoint presentation explaining your decisions

Case 1: Dimensions of decision-making



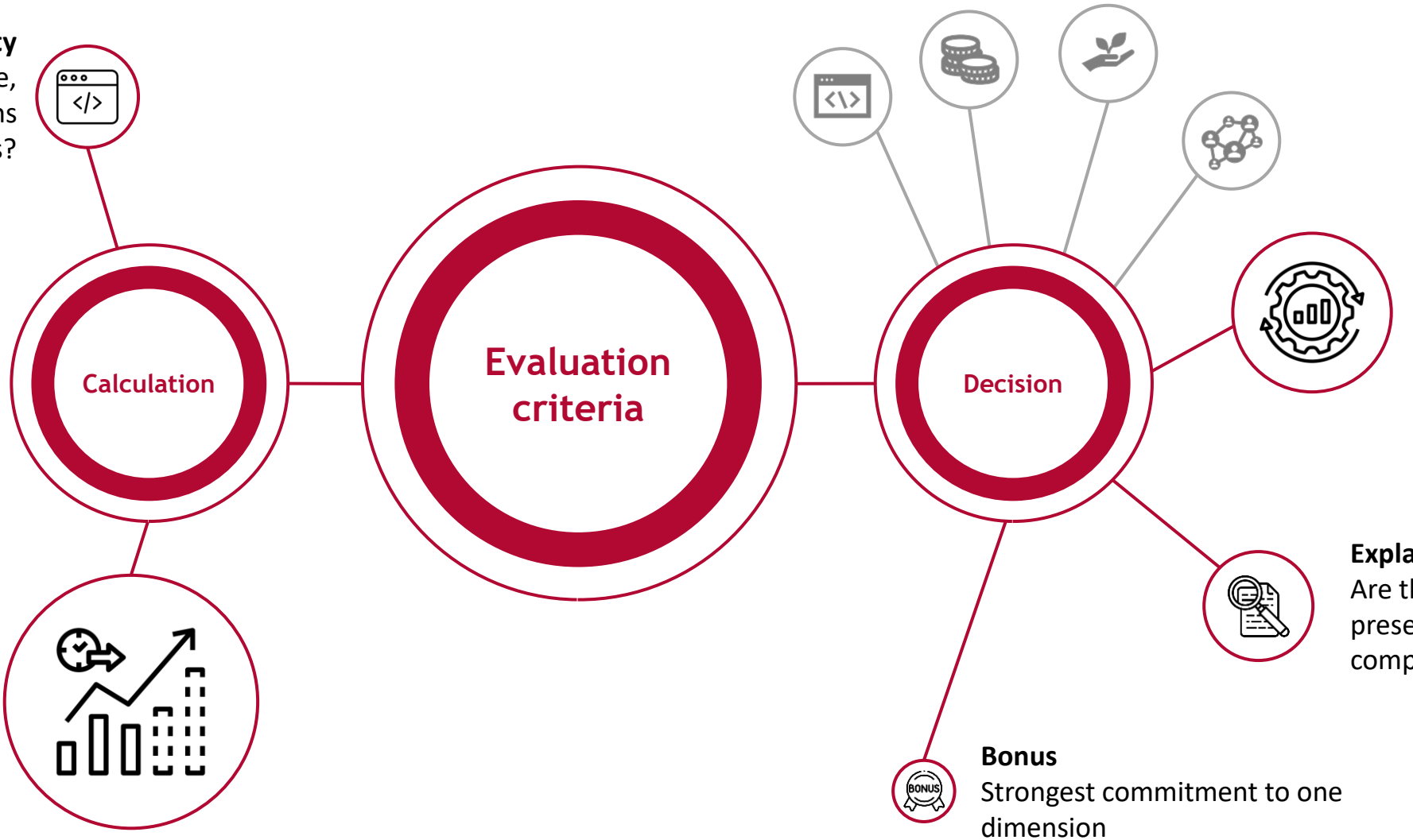
Technical
Evaluates the accuracy of the results. The large is the average price deviation between estimate and reality

Economical
Evaluates economic benefits. We measured over the number of cars that can be produced with the available funds

Ecological
Evaluates the environmental sustainability. Measures how much CO2 was emitted for the procurement

Social
Evaluates the social sustainability. Measures working conditions and social impact

Case 1: Evaluation criteria



Code Quality
Is the code executable, readable and contains comments?

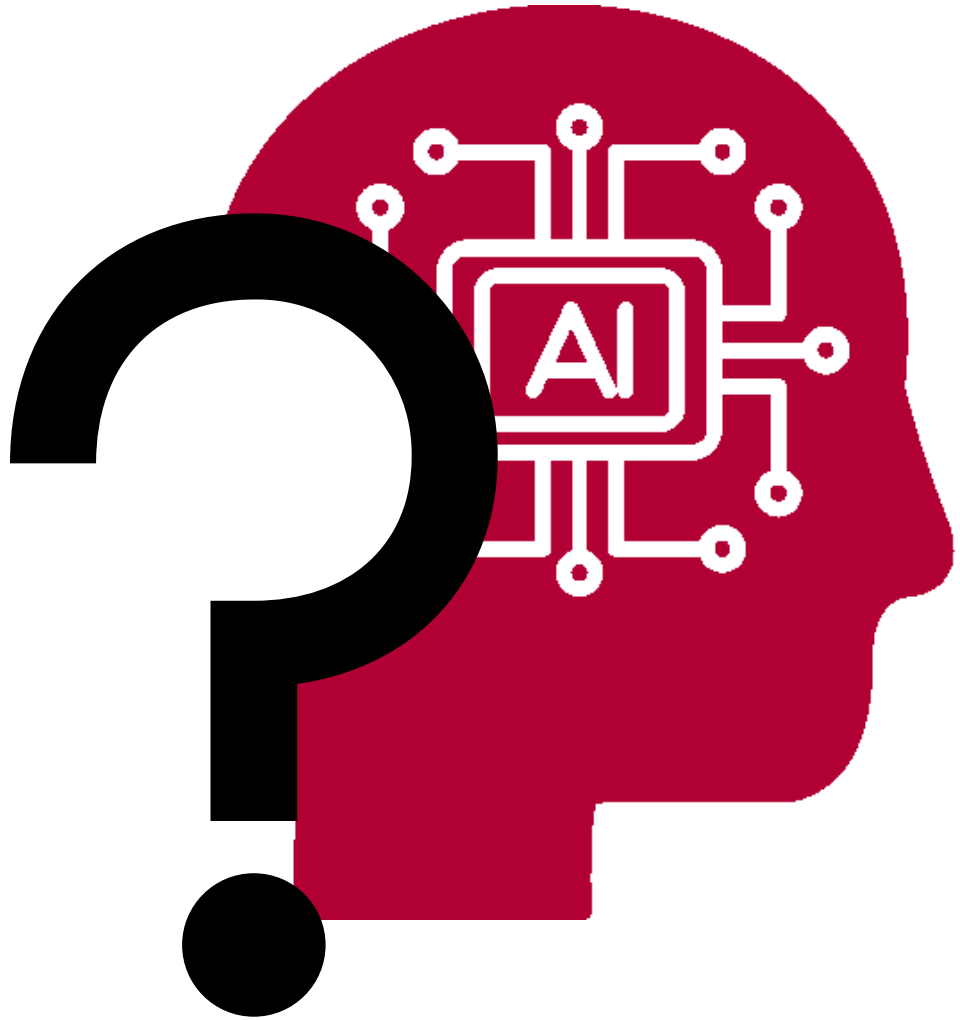
Prediction Quality
How closely do the predictions match reality?

Optimization results
Is an optimal decision made based on the price prediction and evaluation dimensions?

Explanation
Are the decisions made presented in a comprehensible way?

Bonus
Strongest commitment to one dimension

Case 1: Any Questions?



Any Questions?