Artificial Intelligence in Product Portfolio and Variety Management in Commercial Vehicle Industry

prostep ivip Symposium 2021

Jan Mehlstäubl - University of the Bundeswehr Munich
Felix Braun - MAN Truck & Bus SE
Prof. Dr. Kristin Paetzold - University of the Bundeswehr Munich

FORCuDE@BEV

BAYERISCHER FORSCHUNGSVERBUND ZUM CUSTOMIZED DIGITAL ENGINEERING FÜR BAYERISCHE KMU AM BEISPIEL DES ANTRIEBSSTRANGS ELEKTRISCHER FAHRZEUGE

Universität der Bundeswehr München
Institut für Technische Produktentwicklung

MAN

bayerische Forschungsstiftung

When you ususally think of a truck…

…you have a clear idea…

… the commercial vehicle market though, is characterized by a huge variance !

From small city trucks…

…to heavy-duty trucks…

…to fully-electric vehicles

From the motorway…

… through the fields…

… into the dirt

This vast portfolio with multiple rules & objects, calls for more than manual analysis

A complex product portfolio with numerous different variants is required

Development and maintenance highly dependent on manual processes by experts

Countless variants

Ramified Bill-of-Materials

Challenging Excel files

Multi-layered error protocols

With a product portfolio this complex, we have to built state-of-the-art IT solutions to handle all variants!

Objectives of the Research Project

Systematic use of AI to support activities and decisions in product portfolio and variety management in commercial vehicle industry

Milestone 1

Understanding of the use of AI in the context of product portfolio and variety management

Milestone 2

Valuable and feasible use cases of AI in product portfolio and variety management

Milestone 3

Implementation of selected use cases and summary of the results and findings in a framework

Institute for Technical Product Development

Value creation in development:
Design and use of data and information flows

Action support
Organizing, structuring &
coordinating data and information flows

Knowledge transfer
Integrating developers as an active
element in data and information flows

- Developing methods for the comprehensive presentation and use of data and information flows

- Providing a holistic view of development processes

- Developing mechanisms and methods to
  - promote communication
  - ensure coordination
  - provoke collaboration

Digital Engineering | Product Development meets Digitalization

"Digital Engineering deals with the holistic use of digital methods and tools in product development."

Product Development

- Requirements Management
- Process Management
- Configuration Management
- **Product Portfolio Management**
- **Variety Management**
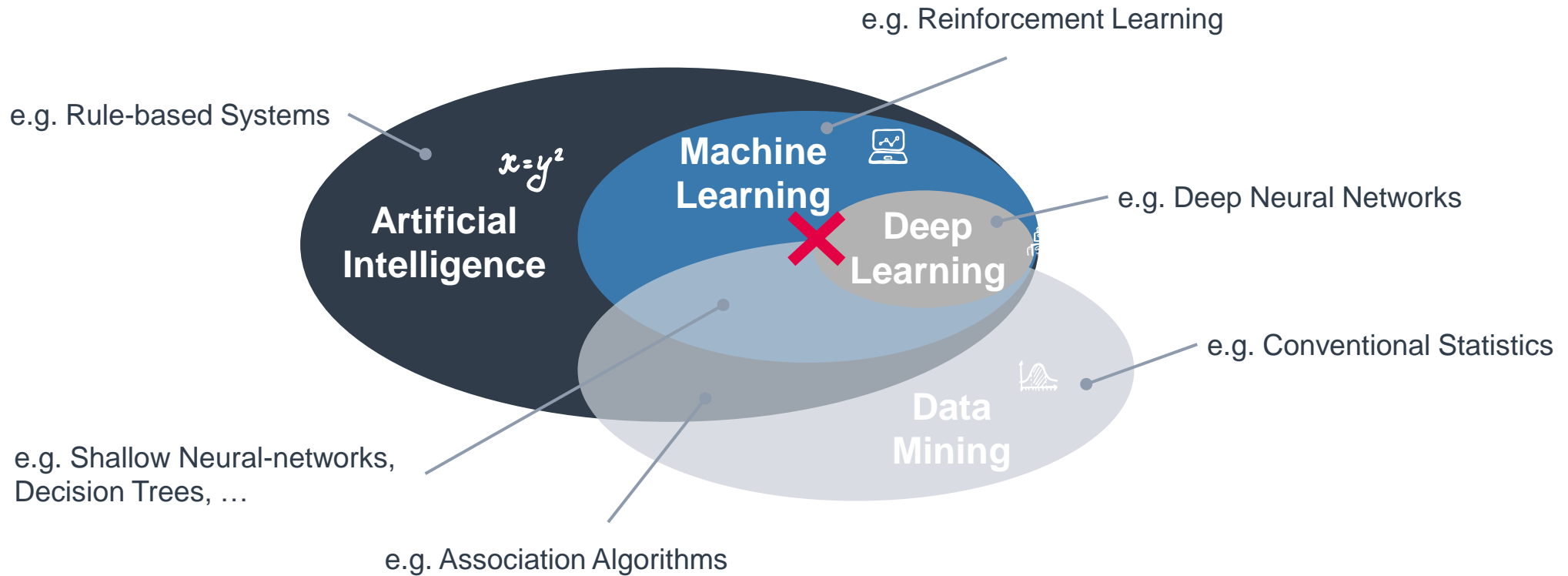- Product Verifikation & Validation

+

Digitalization

- Model-based Systems Engineering
- Process Modelling
- Virtual Engineering
- Network Theory
- **Artificial Intelligence**

What Artificial Intelligence means to us?

e.g. Reinforcement Learning

e.g. Rule-based Systems

$x=y^2$

Machine Learning

Artificial Intelligence

Deep Learning

e.g. Deep Neural Networks

e.g. Conventional Statistics

Data Mining

e.g. Shallow Neural-networks, Decision Trees, …

e.g. Association Algorithms

Reference: StackExchange Forum: Distinction between AI, ML, Neural Networks, Deep learning and Data mining.

"Artificial intelligence (AI) applies advanced analysis and logic-based techniques, including machine learning, to interpret events, support and automate decisions, and take actions" – Gartner Inc.
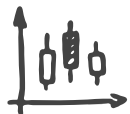
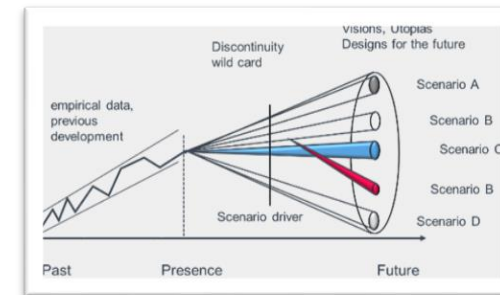# Why Artificial Intelligence in Product Portfolio and Variety Management?

Analysis of huge data sets

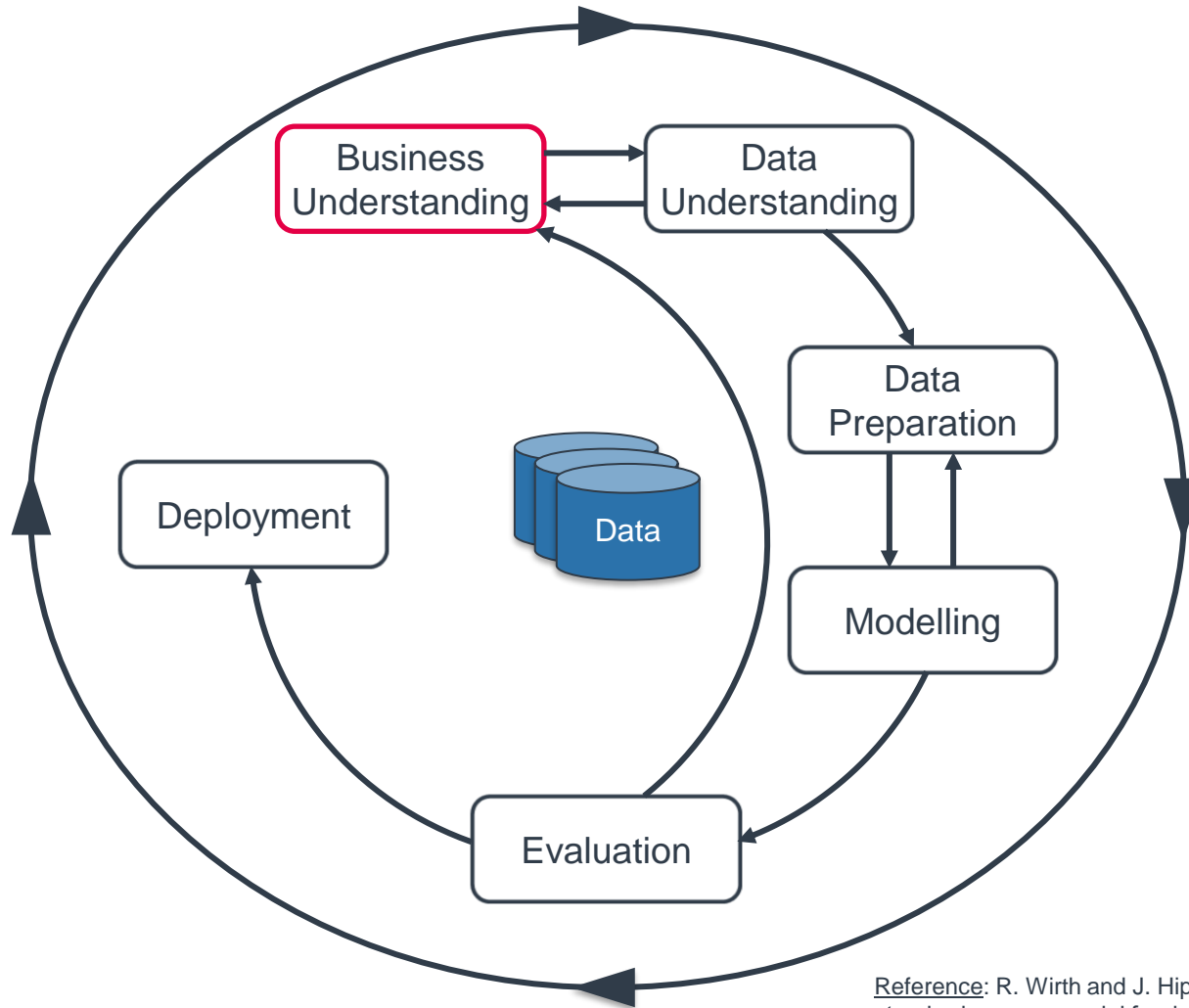Identification of complex relations

Interpretation of new conditions

Predicting trends

Intelligent, data-driven solutions have great potential to support decisions and activities in product portfolio and variety management.

Methodological Procedure | Business Understanding

Reference: R. Wirth and J. Hipp, "CRISP-DM: Towards a standard process model for data mining" (2000)

- **What knowledge is available about AI and what is the attitude towards this new technology?**

- **What are the challenges that need to be overcome for the application of AI?**

- **Which fields of action can be supported by AI methods?**
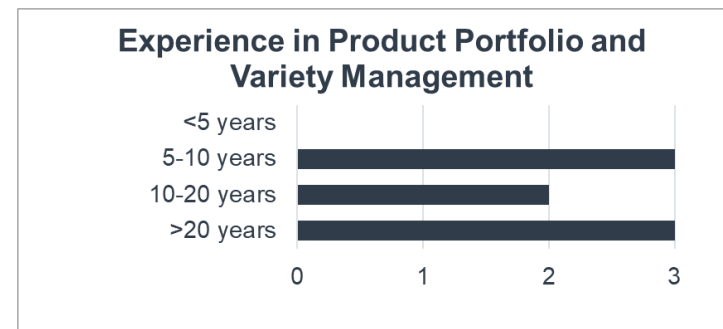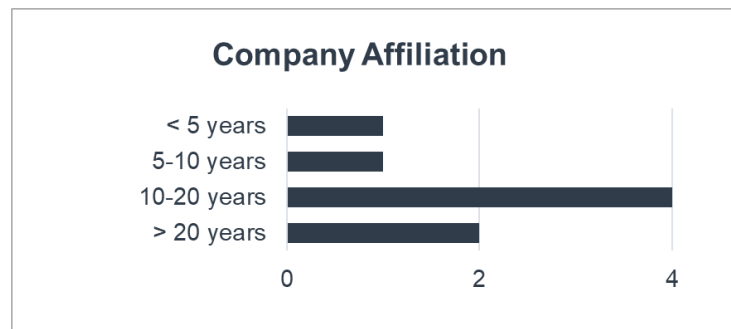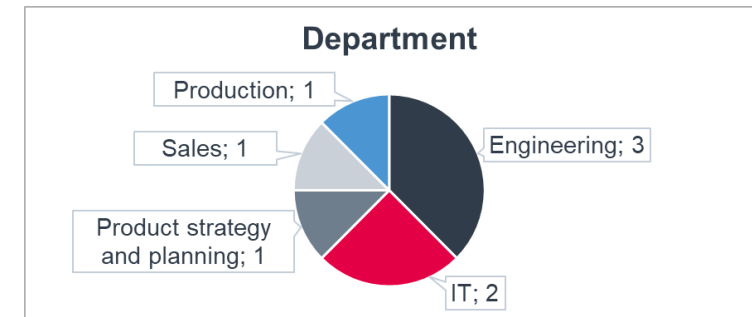
Interview Study | Set-up and Respondents

Number of respondents: 8 Persons

Interview duration: 1 h

Interview period: December 2020 - January 2021

Characteristics of the participants:

- Management level
- Experts in product portfolio and variety management
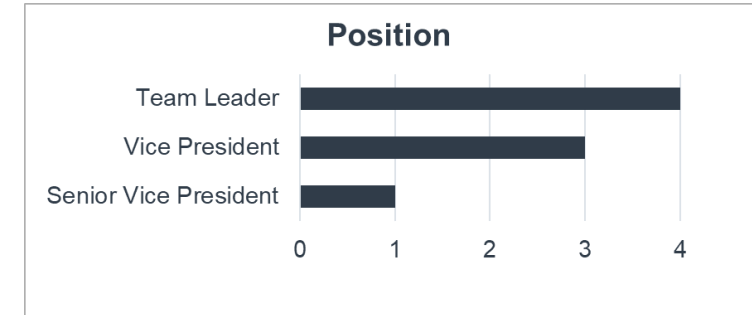
Position

Team Leader	4
Vice President	3
Senior Vice President	1

0 1 2 3 4

Department

- Production; 1
- Sales; 1
- Product strategy and planning; 1
- IT; 2
- Engineering; 3

Company Affiliation

< 5 years	1
5-10 years	1
10-20 years	4
> 20 years	2

0 2 4

Experience in Product Portfolio and Variety Management

<5 years	0
5-10 years	3
10-20 years	2
>20 years	3

0 1 2 3

Product Portfolio and Variety Management in Commercial Vehicle Industry
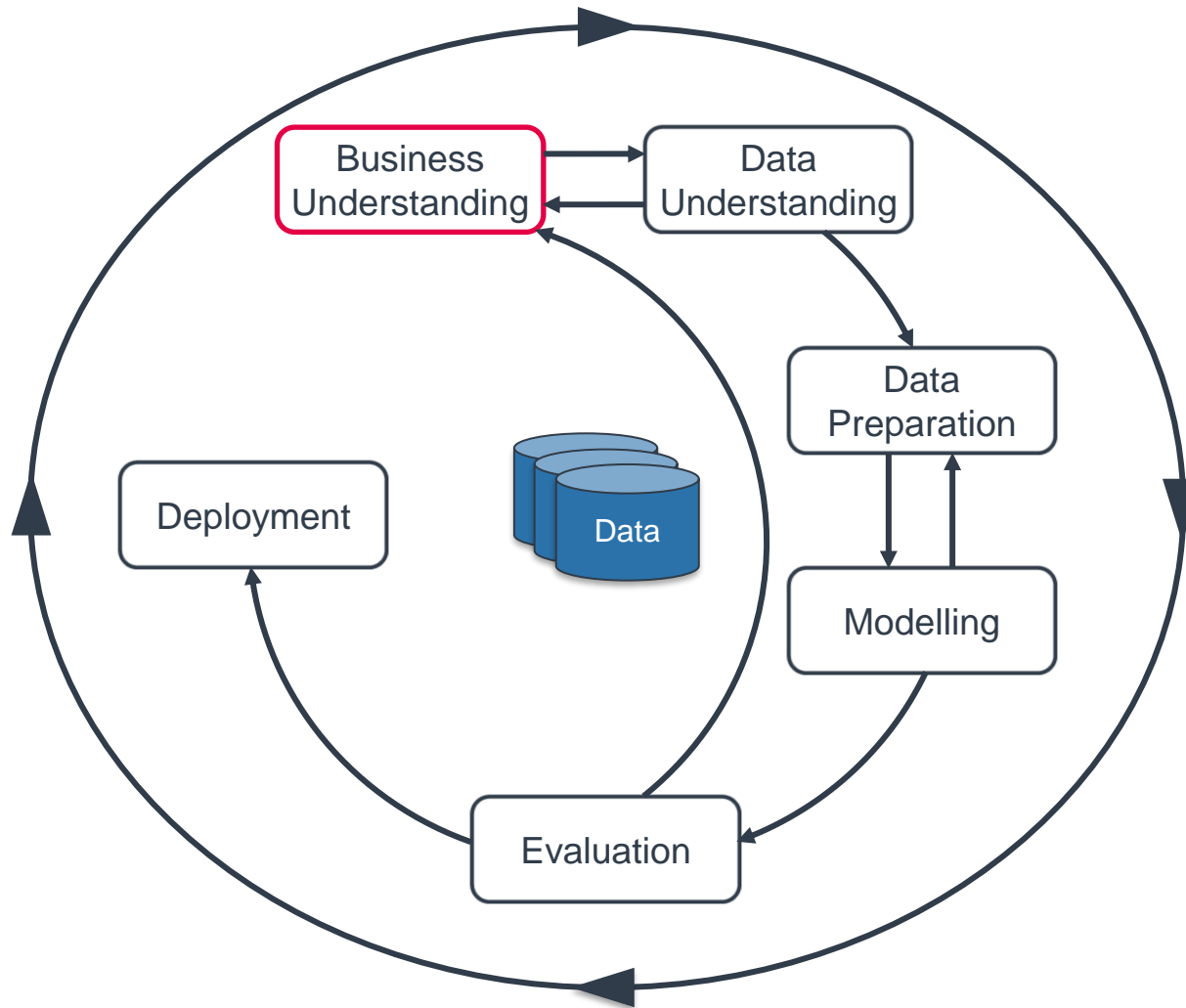
- **What knowledge is available about AI and what is the attitude towards this new technology?**

- What are the challenges that need to be overcome for the application of AI?
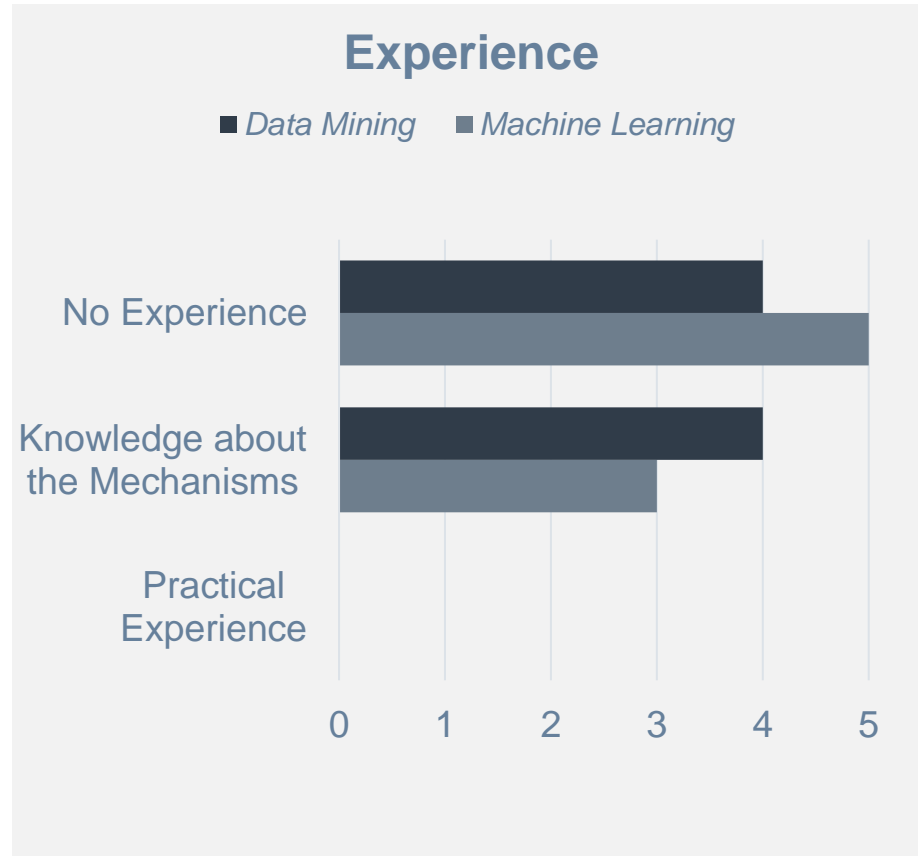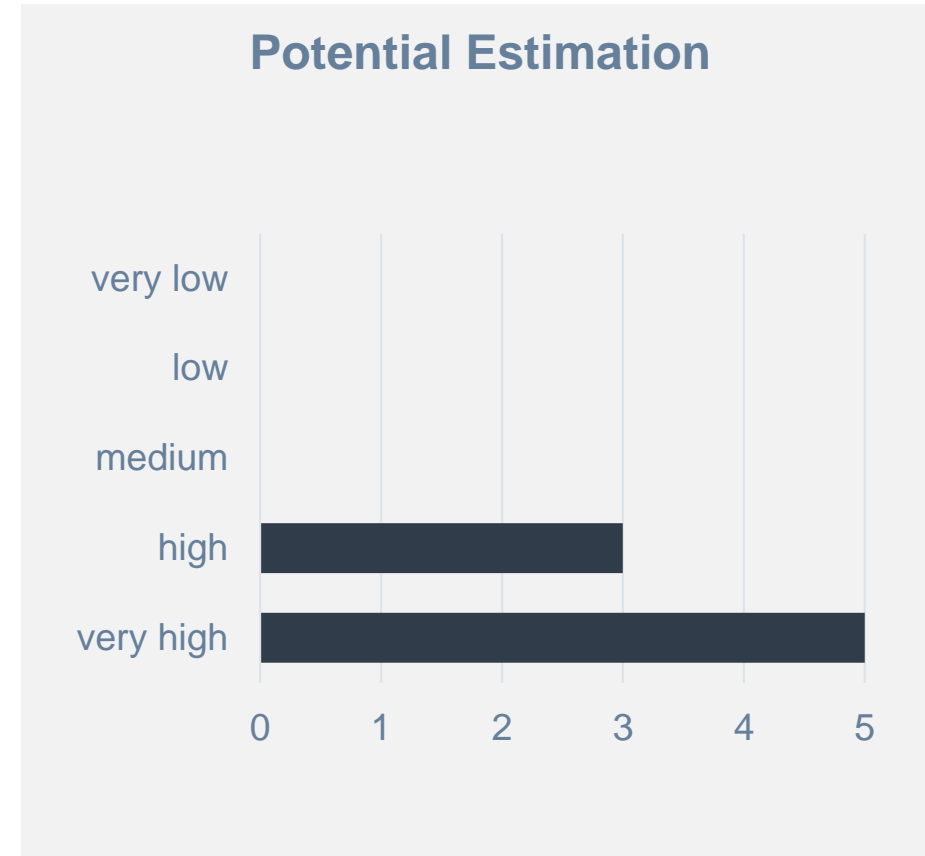
- Which fields of action can be supported by AI methods?

Experience and Potentials of Artificial Intelligence

Experience

■ *Data Mining* ■ *Machine Learning*

No Experience	Data Mining: 4, Machine Learning: 5
Knowledge about the Mechanisms	Data Mining: 4, Machine Learning: 3
Practical Experience	0, 0

(x-axis: 0 1 2 3 4 5)

Potential Estimation

very low	
low	
medium	
high	3
very high	5

(x-axis: 0 1 2 3 4 5)

> **Little or no experience**

> **Huge expectations**

Positioning AI in Product Portfolio and Variety Mgmt. in the Hype Cycle

**Guru problem: A few companies apply artificial intelligence efficiently.
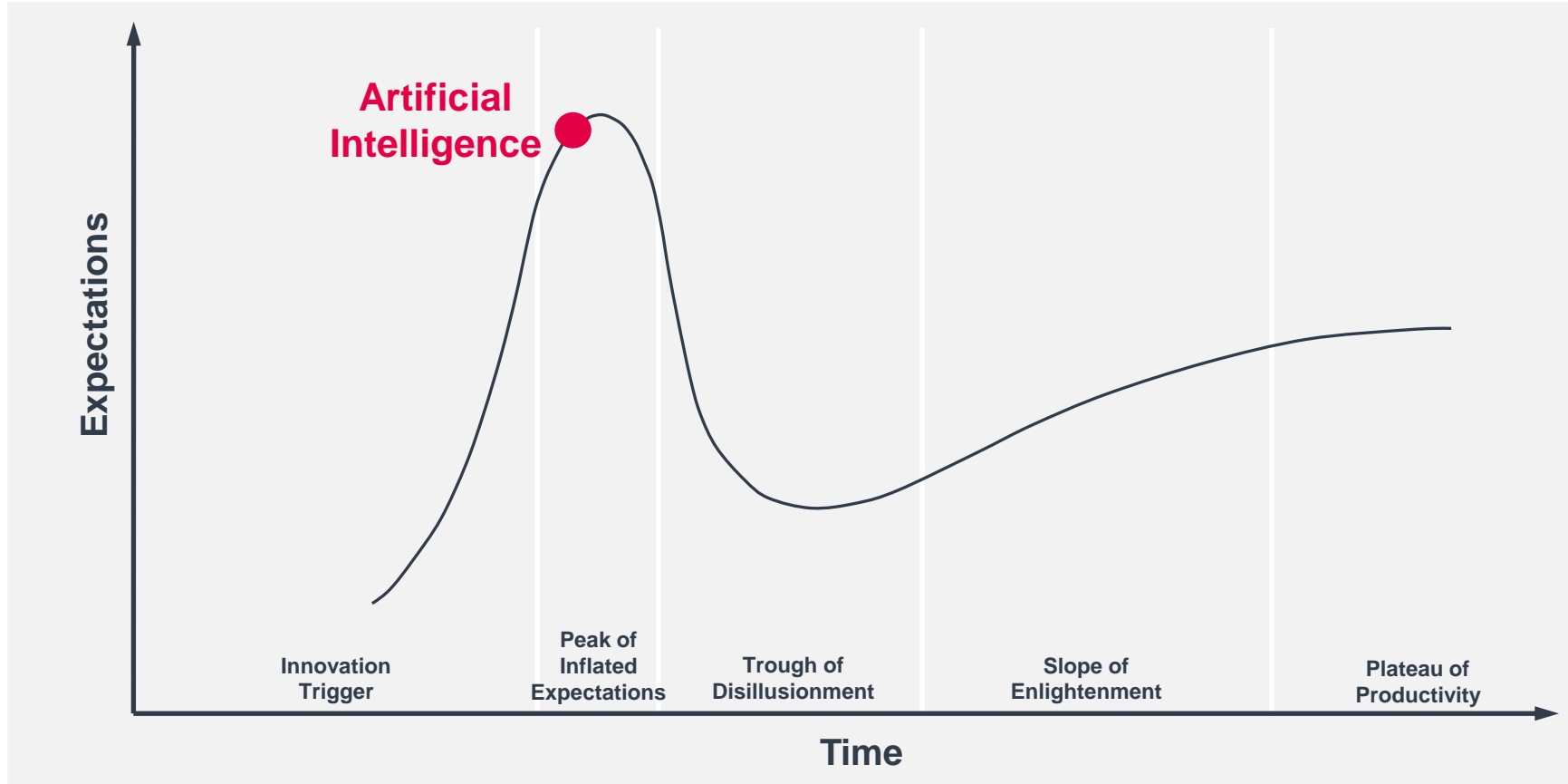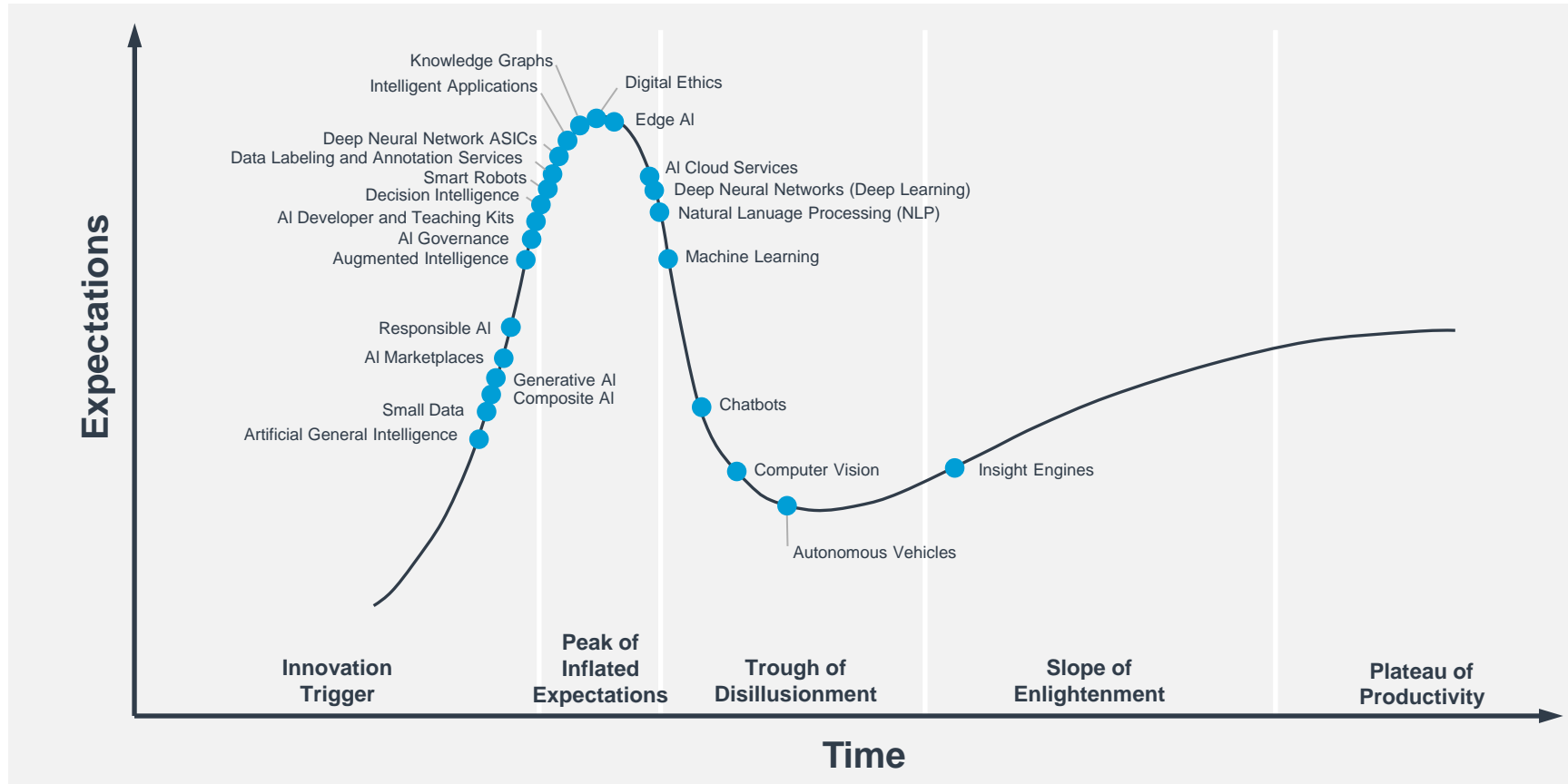However, in product development we have especially challenging circumstances!**

Hype Cycle for Artificial Intelligence 2020 📈

Expectations (y-axis) vs **Time** (x-axis)

Labels on curve:
- Knowledge Graphs
- Intelligent Applications
- Digital Ethics
- Edge AI
- Deep Neural Network ASICs
- Data Labeling and Annotation Services
- AI Cloud Services
- Smart Robots
- Deep Neural Networks (Deep Learning)
- Decision Intelligence
- Natural Lanuage Processing (NLP)
- AI Developer and Teaching Kits
- AI Governance
- Machine Learning
- Augmented Intelligence
- Responsible AI
- AI Marketplaces
- Generative AI
- Composite AI
- Small Data
- Chatbots
- Artificial General Intelligence
- Computer Vision
- Insight Engines
- Autonomous Vehicles

Phases:
Innovation Trigger | Peak of Inflated Expectations | Trough of Disillusionment | Slope of Enlightenment | Plateau of Productivity

However, we are not far behind the common AI cycle!

Product Portfolio and Variety Management in Commercial Vehicle Industry
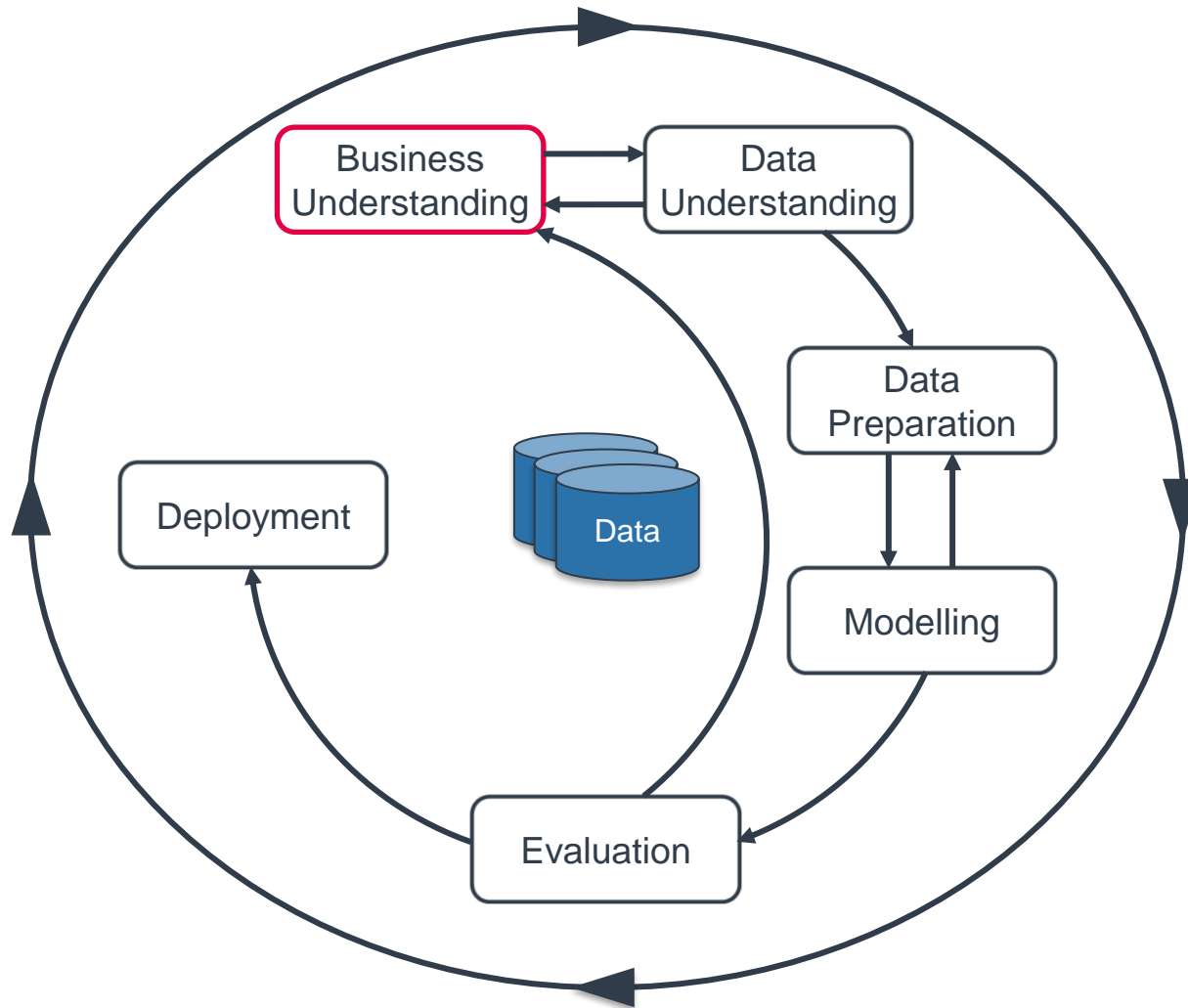
- What knowledge is available about AI and what is the attitude towards this new technology?

- **What are the challenges that need to be overcome for the application of AI?**

- Which fields of action can be supported by AI methods?

Challenge Categories

Challenge Categories

	Knowledge (n=7)	Corporate Culture and Strategie (n=5)	Data (n=6)
	10	10	7

The challenges can be grouped into the categories of knowledge, corporate culture and strategy, and data.

Knowledge, Corporate Culture and Strategy, Data | Challenges

Knowledge

Opportunities	5
Implementation	4
Interpretation of the Results	1

(axis: 0, 1, 2, 3, 4, 5)

Corporate Culture and Strategy

Value Proposition unclear	3
Capacity Needs	3
Willingness to Use	2
Innovation Culture	1
Willingness for Training	1

(axis: 0, 1, 2, 3, 4, 5)

Data

Data Procurement	2
Data Understanding	1
Data Quality	1
Data Availability	1
Data Structure	1
Data Generation	1

(axis: 0, 1, 2, 3, 4, 5)

➤ **Commercial vehicle industry is currently struggling with the barriers to entry**
➤ **They must build up expertise, create free capacity, and face up to AI**

Product Portfolio and Variety Management in Commercial Vehicle Industry

- **What knowledge is available about AI and what is the attitude towards this new technology?**

- **What are the challenges that need to be overcome for the application of AI?**

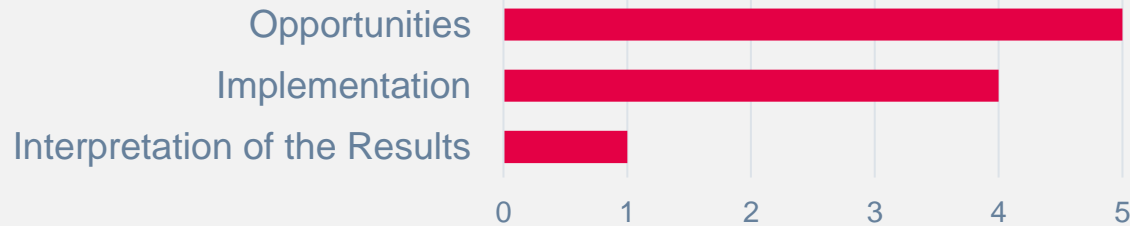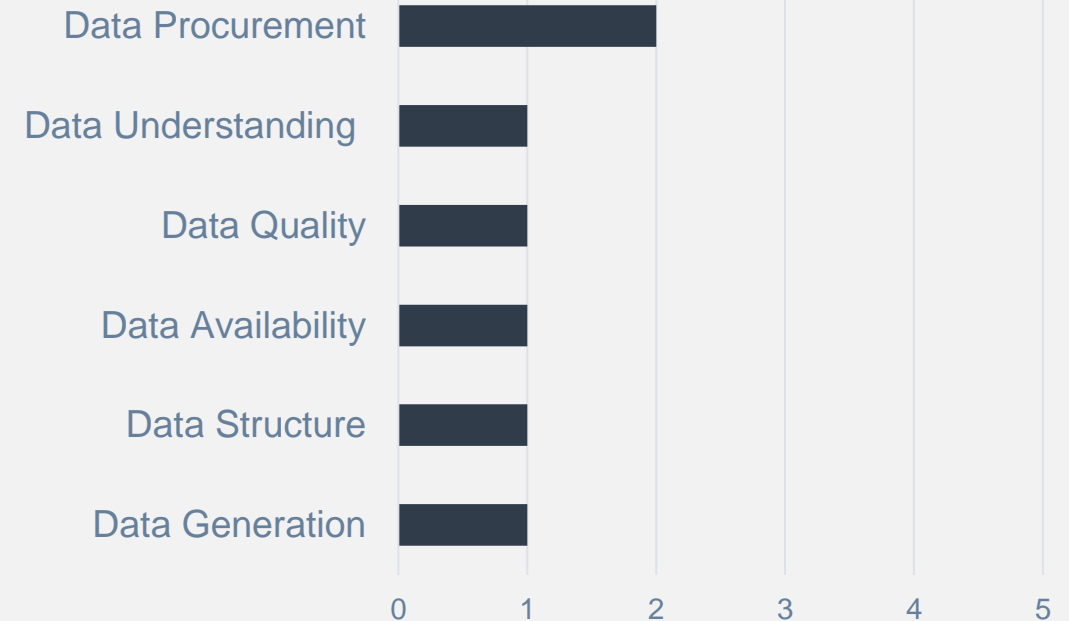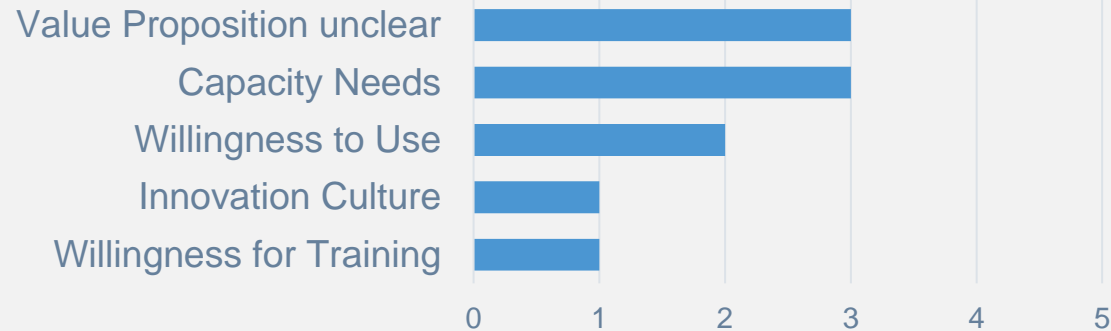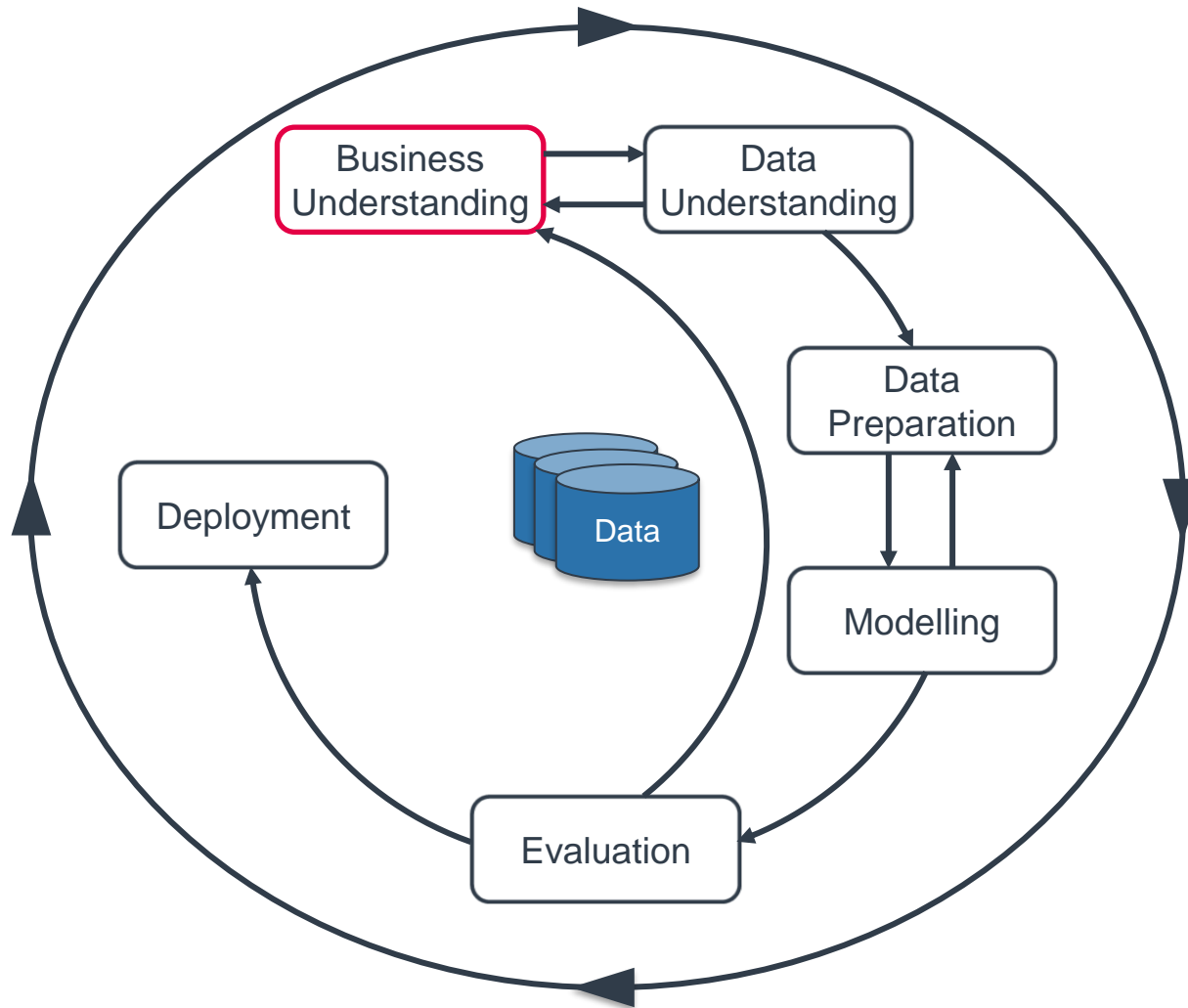- **Which fields of action can be supported by AI methods?**

Application of AI in Product Portfolio and Variety Management from Science

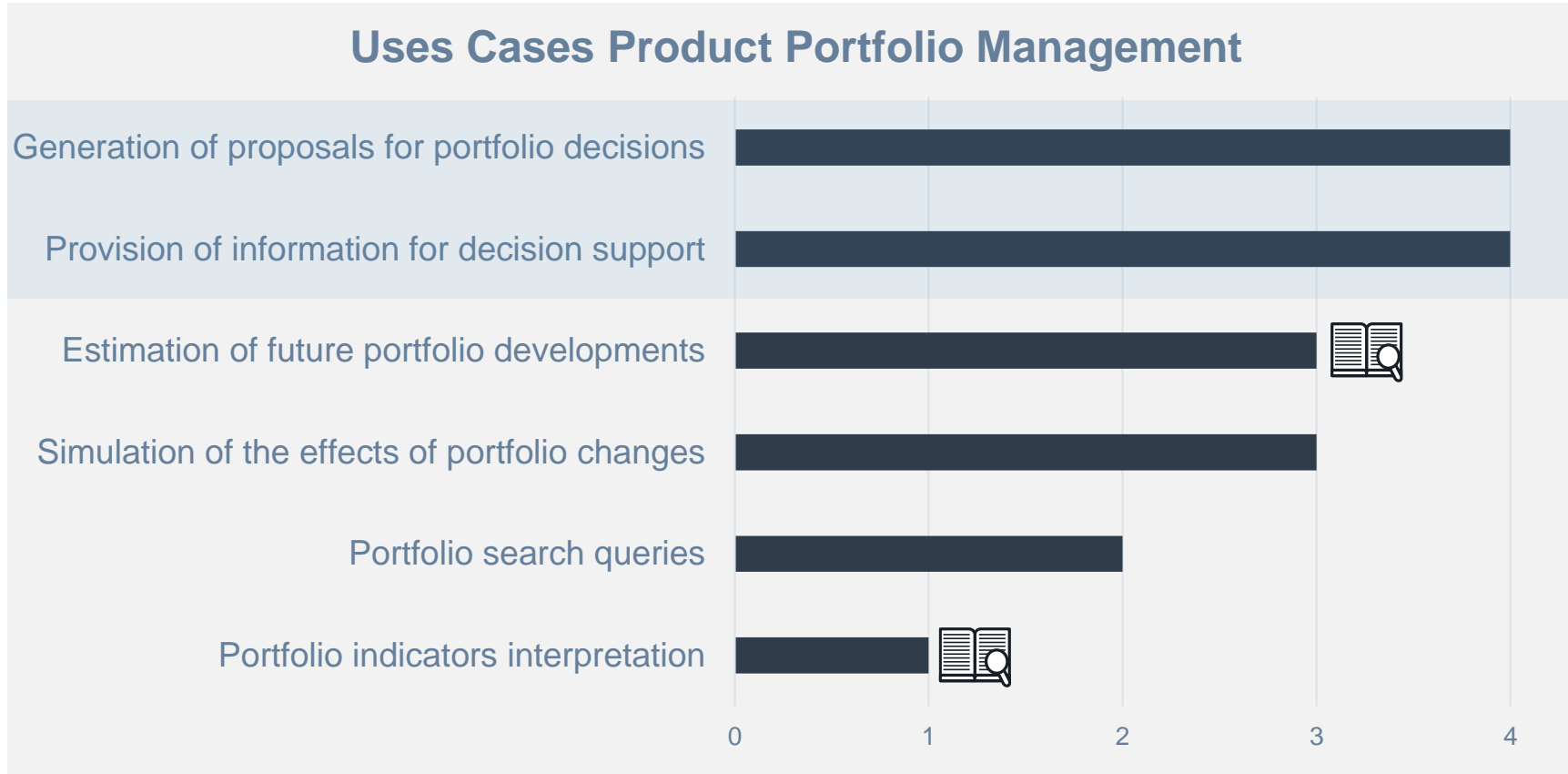| Discipline	Activity	Use Case
Product Portfolio Management	Market Analysis	Market Segmentation
		Segment Allocation
		Requirement Correlations
		Estimation of Purchase Decisions
		Assessment of the Payment Willingness for Product Features
	Portfolio Structure Analysis	Determination of Correlations between Portfolio and Company Key Indicators
	Future Planning	Forecasting Demand Trends
		Profit Forecasting
Variety Management	Variety Generation	Correlations between Customer Requirements and Product Features
		Correlations between Functions and Components
		Sequential Correlations between Product Features
	Variety Avoidance	Correlations between Product Features
		Significant Product Features of the Product Families
		Significant Product Features for the Price
		Price of New Product Feature Combinations
	Variety Control	Support Production Planning
	Variety Reduction	Product Standardisation

Reference: Mehlstäubl, Jan; Braun, Felix; Paetzold, Kristin: Data Mining in Product Portfolio and Variety Management - Literature Review on Use Cases and Research Potentials

Use Cases from Industry | Overview
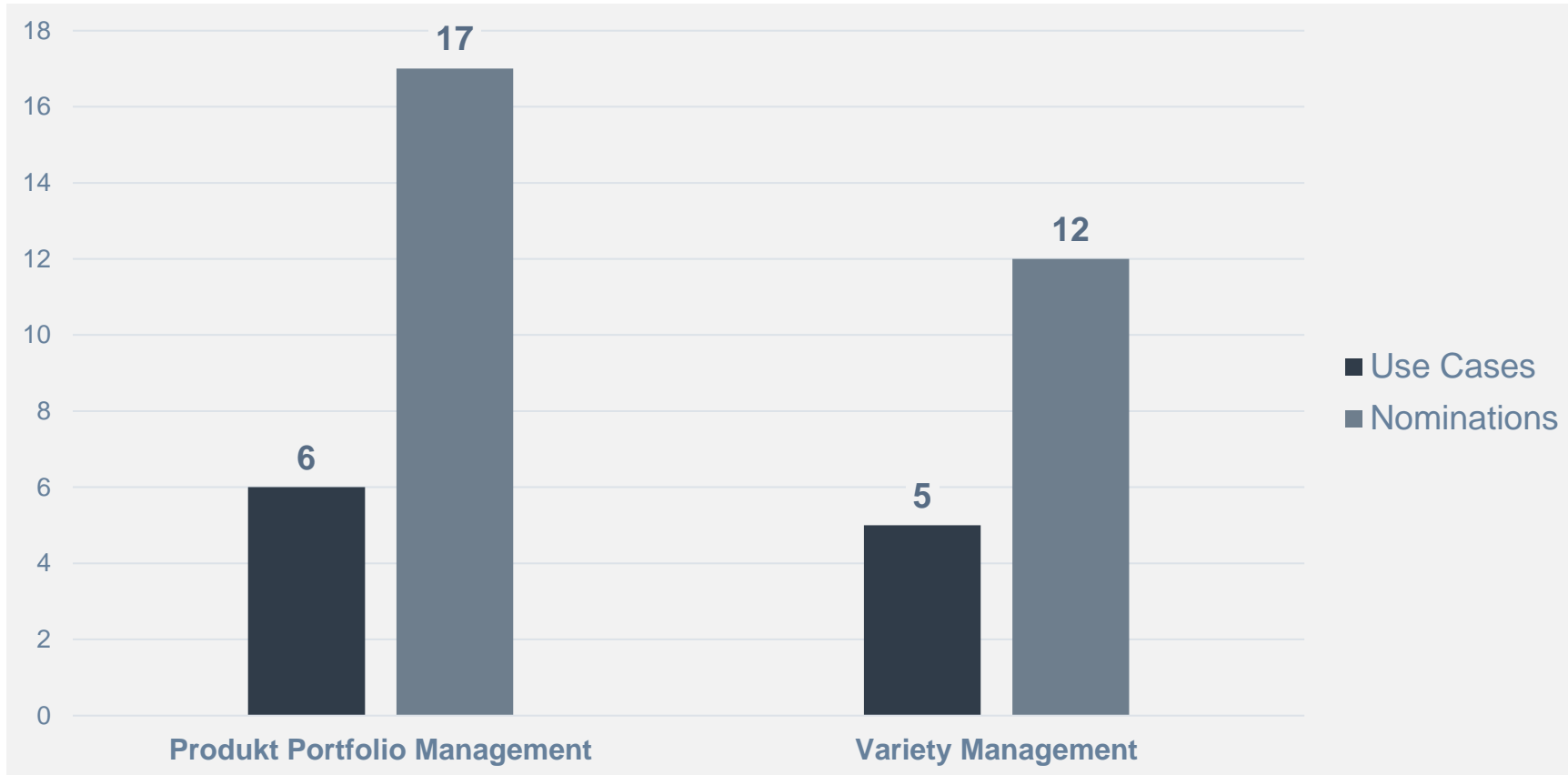
Valuable use cases for AI were identified in both
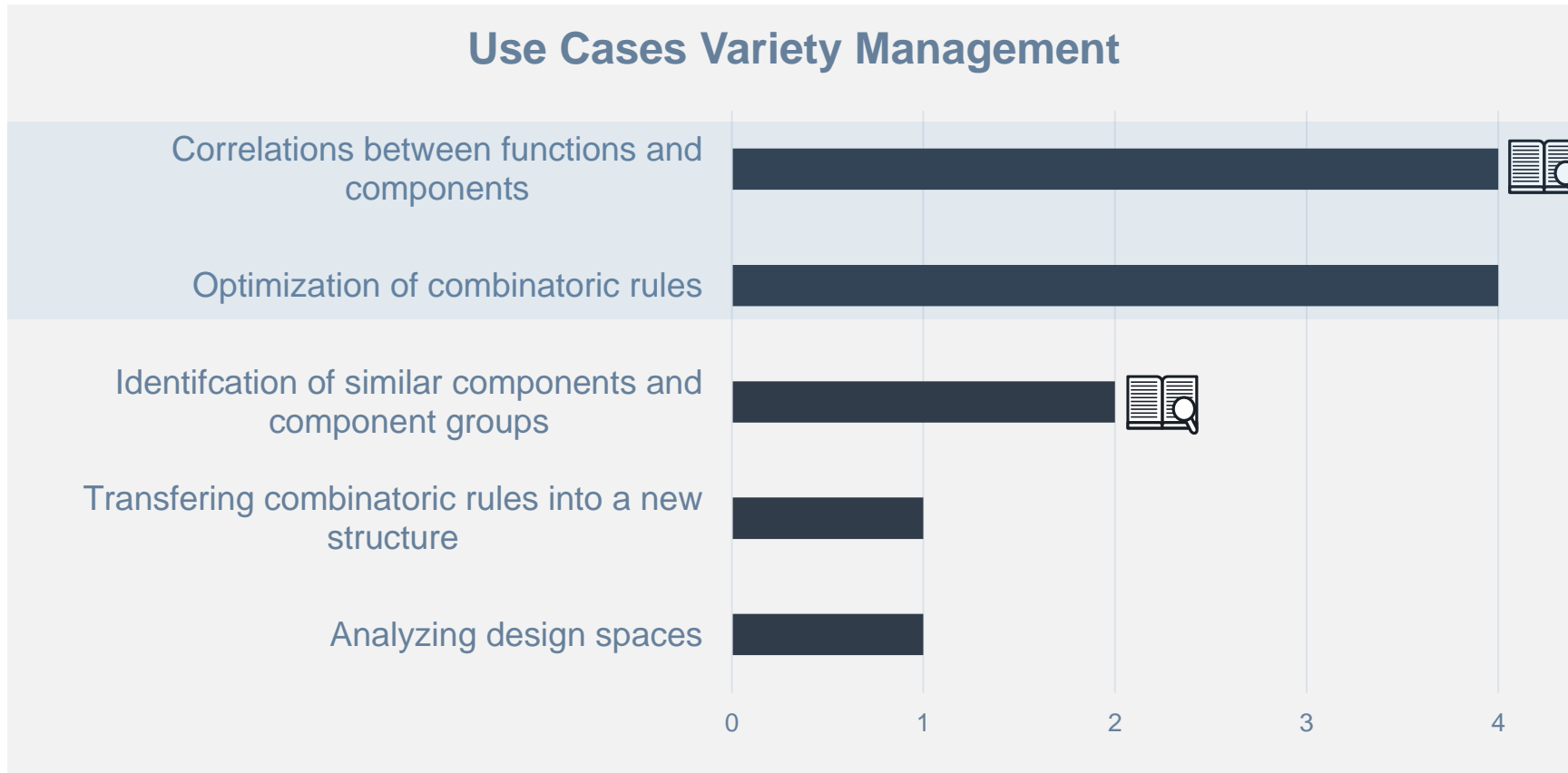product portfolio and variety management.

Use Cases from Industry | Product Portfolio Management

Uses Cases Product Portfolio Management

📖🔍 also in literature

Use Case	Value
Generation of proposals for portfolio decisions	4
Provision of information for decision support	4
Estimation of future portfolio developments 📖🔍	3
Simulation of the effects of portfolio changes	3
Portfolio search queries	2
Portfolio indicators interpretation 📖🔍	1

0   1   2   3   4

Generation of proposals for portfolio decisions and provision of information were the most frequently mentioned.

Use Cases from Industry | Variety Management

Use Cases Variety Management

📖🔍 also in literature

Use Case	Value
Correlations between functions and components	4 📖🔍
Optimization of combinatoric rules	4
Identifcation of similar components and component groups	2 📖🔍
Transfering combinatoric rules into a new structure	1
Analyzing design spaces	1

(axis: 0, 1, 2, 3, 4)

Identification of correlations between functions and components as well as the optimization of combinatorial rules were most often expressed.

Next Steps in the Research Project
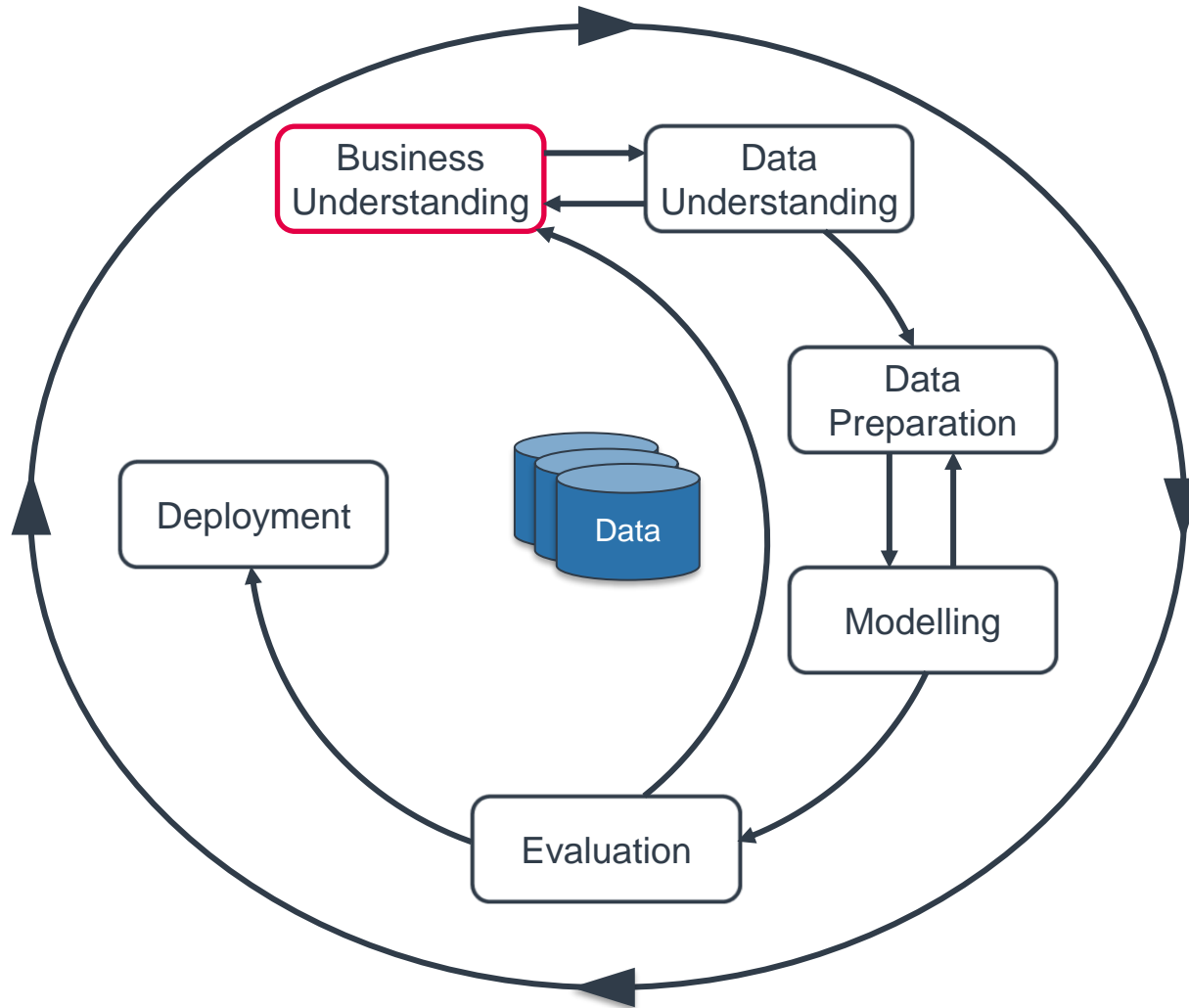
- **Identification** of **evaluation criteria**

- **Assessment** and **selection of** the most promising **use cases**

- **Implementation** of selected **use cases**

- **Summary of the results** in a framework

Thank you for your attention! 👍

Jan Mehlstäubl

Research Associate at the Insitute for Technical Product Development

University of the Bundeswehr Munich

jan.mehlstaeubl@unibw.de

Felix Braun

Head of the Department for Virtual Product Development

MAN Truck & Bus SE

felix.braun@man.eu

Prof. Dr.-Ing. Kristin Paetzold

Head of the Institute for Technical Product Development

University of the Bundeswehr Munich

kristin.paetzold@unibw.de