LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

LMU MUNICH SCHOOL OF MANAGEMENT

Bringing AI into business management

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Solving management problems with artificial intelligence (AI)

2015 2017 2021

PhD UNI FREIBURG | UNI FREIBURG Carnegie Mellon University | Assistant professor ETH | LMU

What defines our research

1 Information

We solve management problems of **relevance** by using data science

2 Innovation

We develop **new** algorithms from the area of AI (statistics, computer science, etc.)

3 Impact

We evaluate the added value of our tools **rigorously** in management practice

ROADMAP

We see 3 challenges for bringing AI into business management

01 Missing accountability of AI decisions

- Clarify boundaries of AI interventions
- Implement governance structures
- Establish risk management frameworks

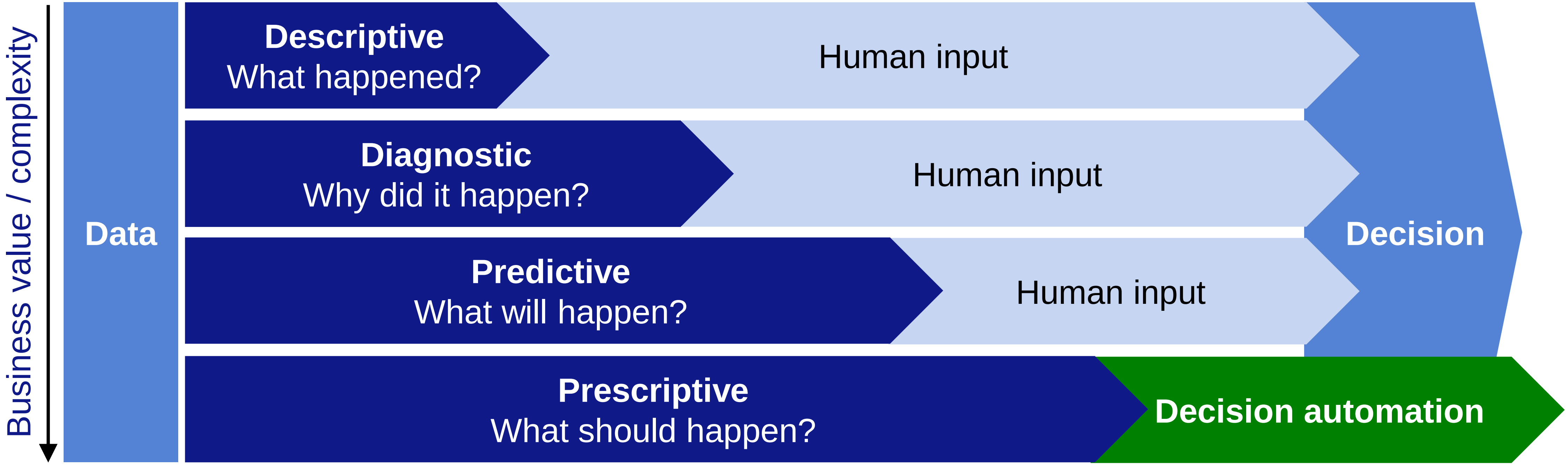
02 Incomplete frameworks for human-in-the-loop analytics

- Develop human-in-the-loop frameworks from user perspective
- **Promote frameworks for human learning and exploration**
- Advance prescriptive algorithms

03 Organizational inertia

- Appoint transformation workforce
- Encourage managers to explore and experiment
- Incentivize adoption

What's next in AI for business decision-making: From predictions to decisions

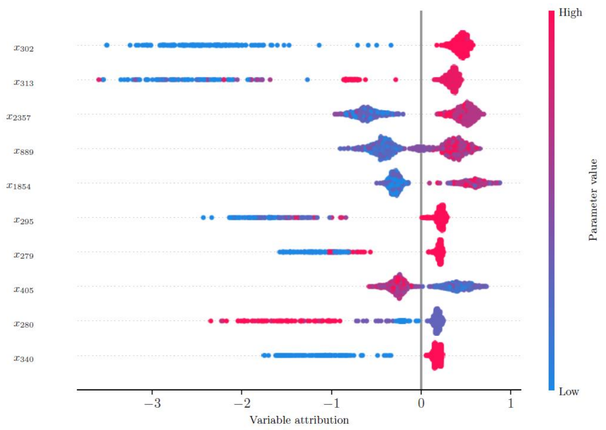


Explainable AI («XAI») can close the gap between predictions and decisions

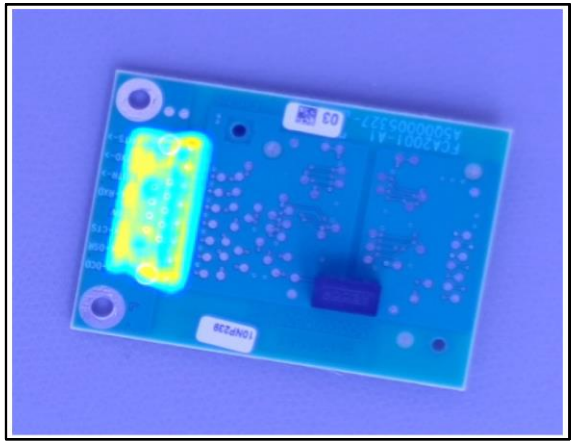
Explainable AI („XAI“)

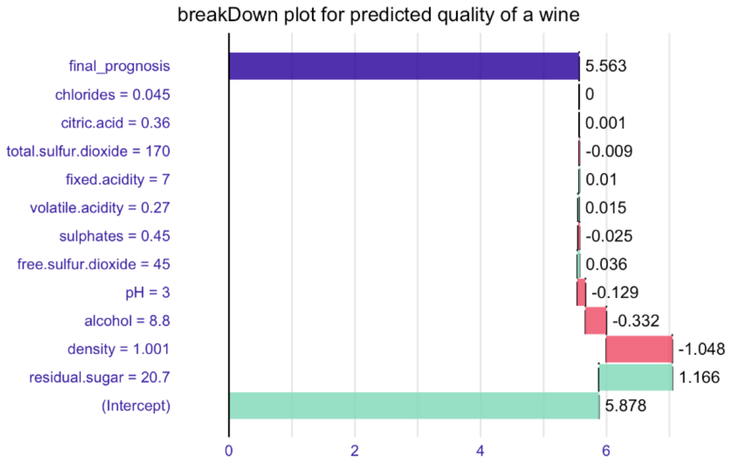
Explainable AI refers to tools that reduce the black-box nature of predictions and makes them more opaque

$$\boldsymbol{y} = \alpha + \beta_1 \boldsymbol{x}_1 + \ldots + \beta_k \boldsymbol{x}_k$$



SHAP value method

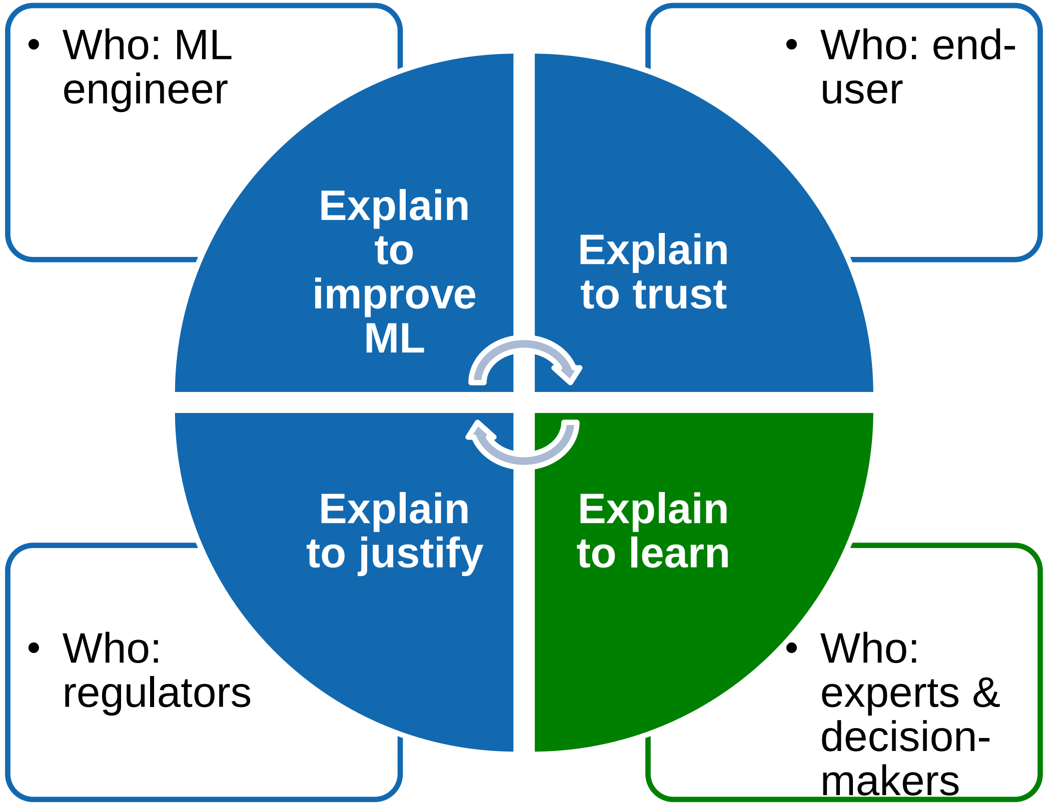




IF a patient	(has an age $\leq$ 60 **AND** a weight $\leq$ 80 kg **AND** has mild symptoms)
OR	(has an age $\leq$ 40 **AND** a weight $\leq$ 80 kg **AND** has severe symptoms)
OR	(has an age $\leq$ 30 **AND** a weight $\leq$ 100 kg **AND** has severe symptoms)
THEN	treat with drug

XAI can have various motivations – but: it can also promote human learning through "learn-to-explain"

Why to aim for explainability?



Enabling better decision-making for industrial problems

Mining company data for human learning

- **Problem**: existing company data is vast and often not systematically processed
- **Complication**: most company data not in tabular form but as text (e.g., reports, invoices, etc.)
- **Solution:** knowledge extraction from raw text

Promotes human learning but managers remain fully in driver seat

Generating new evidence for human-in-the-loop decisions

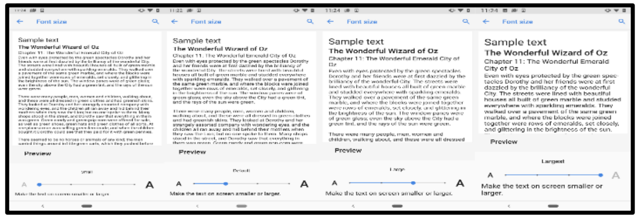
- **Problem**: company data is digitized but monitoring does not inform best actions
- **Complication**: high-dimensional, non-linear data
- **Solution:** explainable AI (XAI) to create new evidence as a decision aid

Guides human decisions-making by prioritizing decisions and improving task performance (+trust)

XAI can cluster development aid projects to generate real-time monitoring and promote human learning

Aim

3.2 million texts



Monitoring system

Meaning

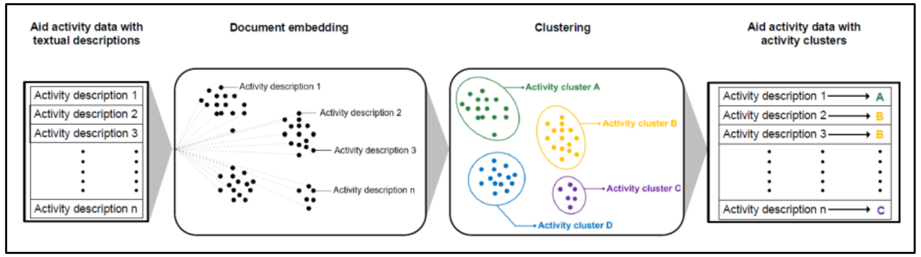
173 activity clusters

Input Data:

3.2 million textual descriptions of global aid activities from the Creditor Reporting System (CRS)

Includes:
- Financial volume
- Recipient country
- Year
- Donor organization

Machine learning framework



Output Data:

173 “activity clusters” labeling the aid activities with their underlying topic

Examples:
- Maternal healthcare
- Primary education
- Solar energy
- Biodiversity

Using explainable artificial intelligence to improve process quality: Evidence from semiconductor fabrication

Motivation

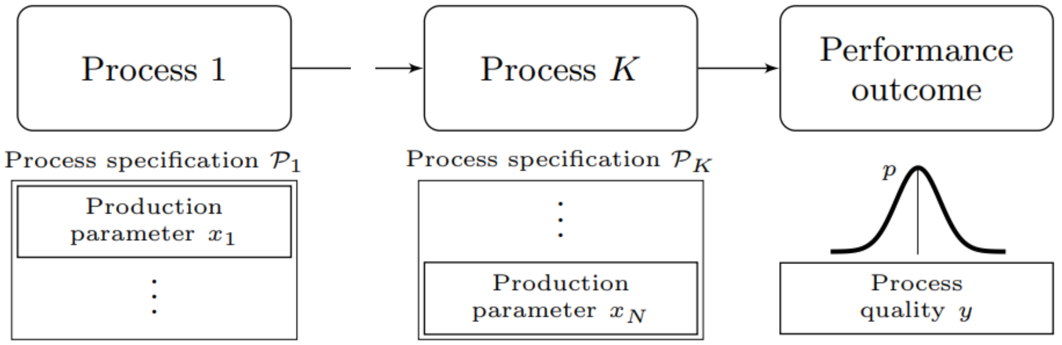
- Nonconformance is a key cost driver in manufacturing
- 10% to 15% of operating expenses
- Extensive sensor measurements but identifying quality drivers challenging

Proposed framework

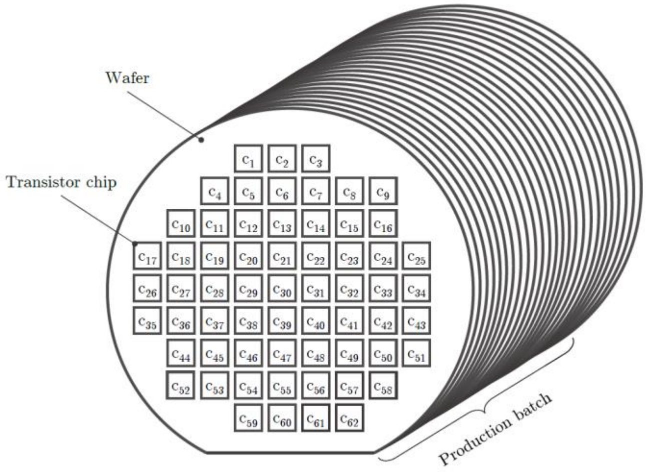
- New data-driven framework based on **“explainable AI”**
- Designed for complex, non-linear relationships between quality drivers and quality variation

Prescriptive framework must adapt to constraints of real-world setting

Manufacturing system



Production output



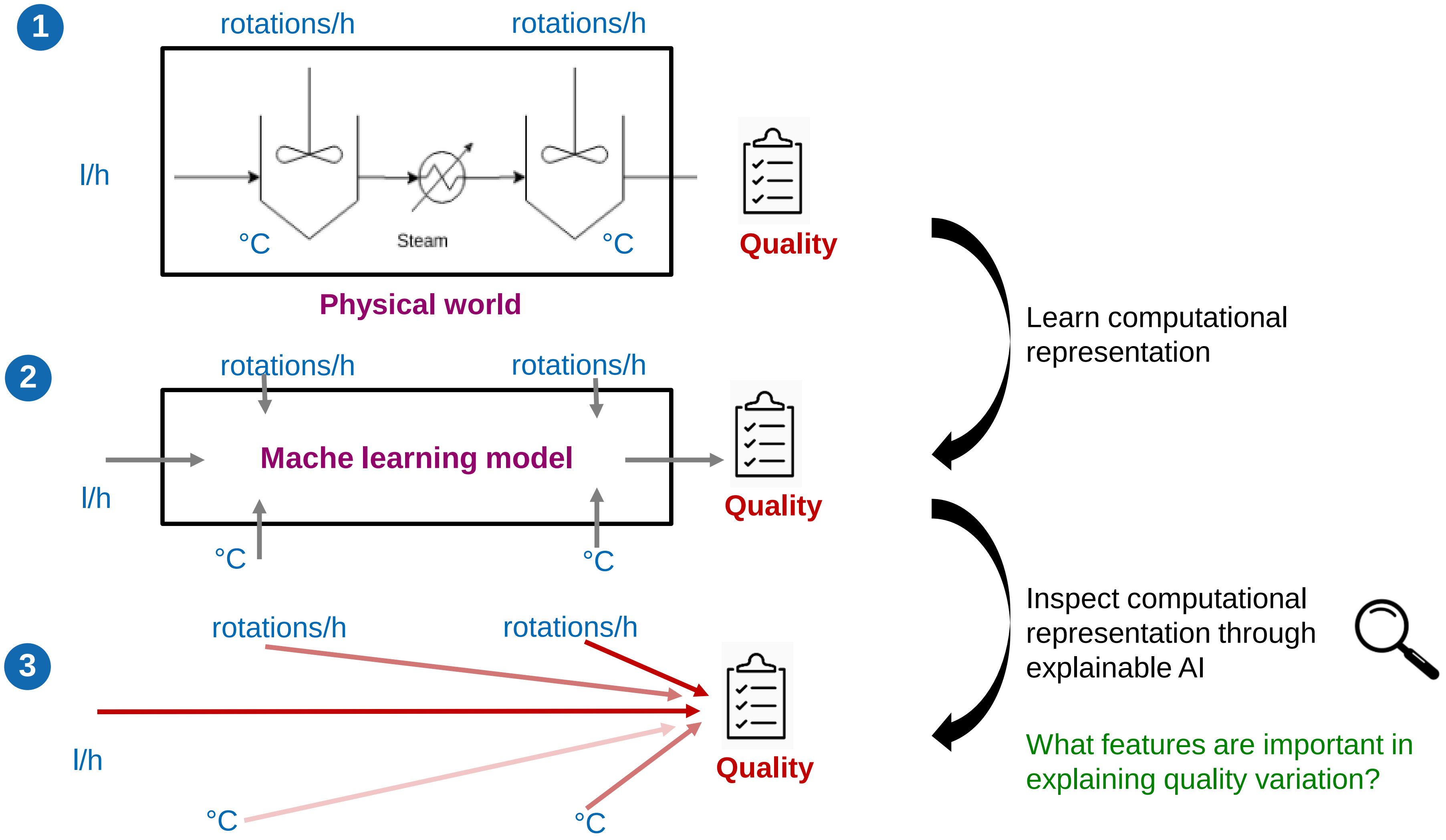
Challenges

- High-dimensional setting
- Complex non- linearites driving process quality

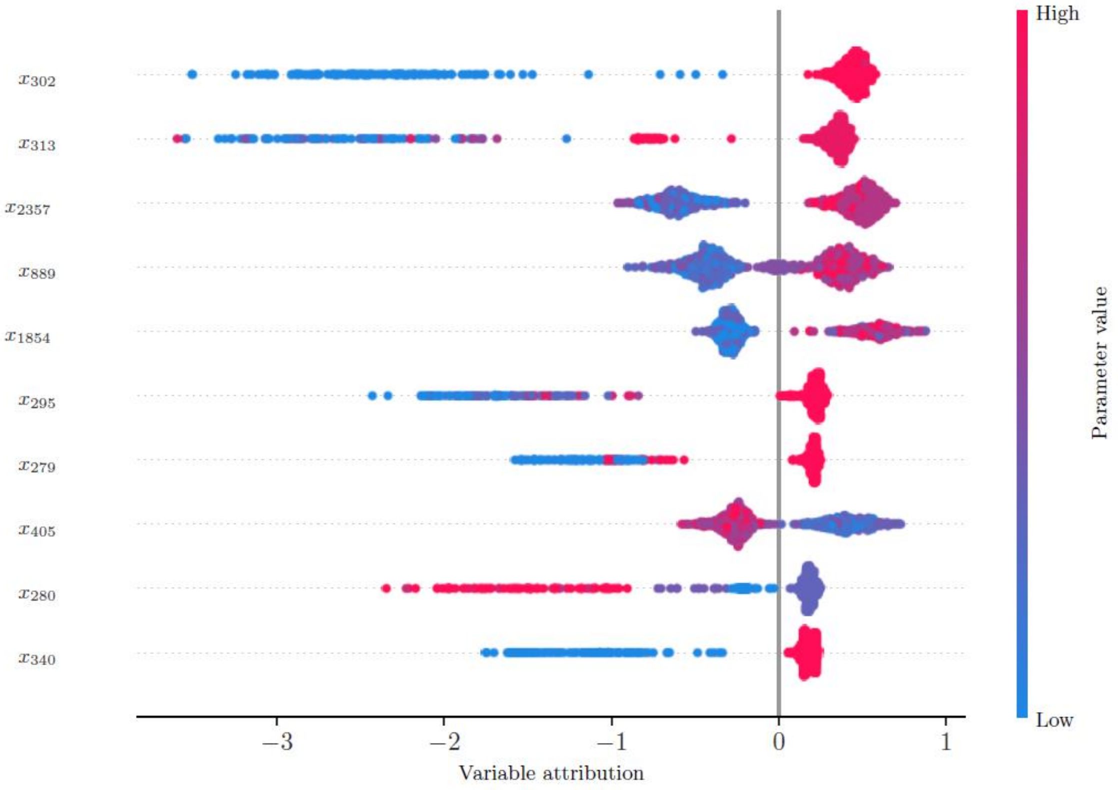
But: state-of-the-art are linear models

METHOD

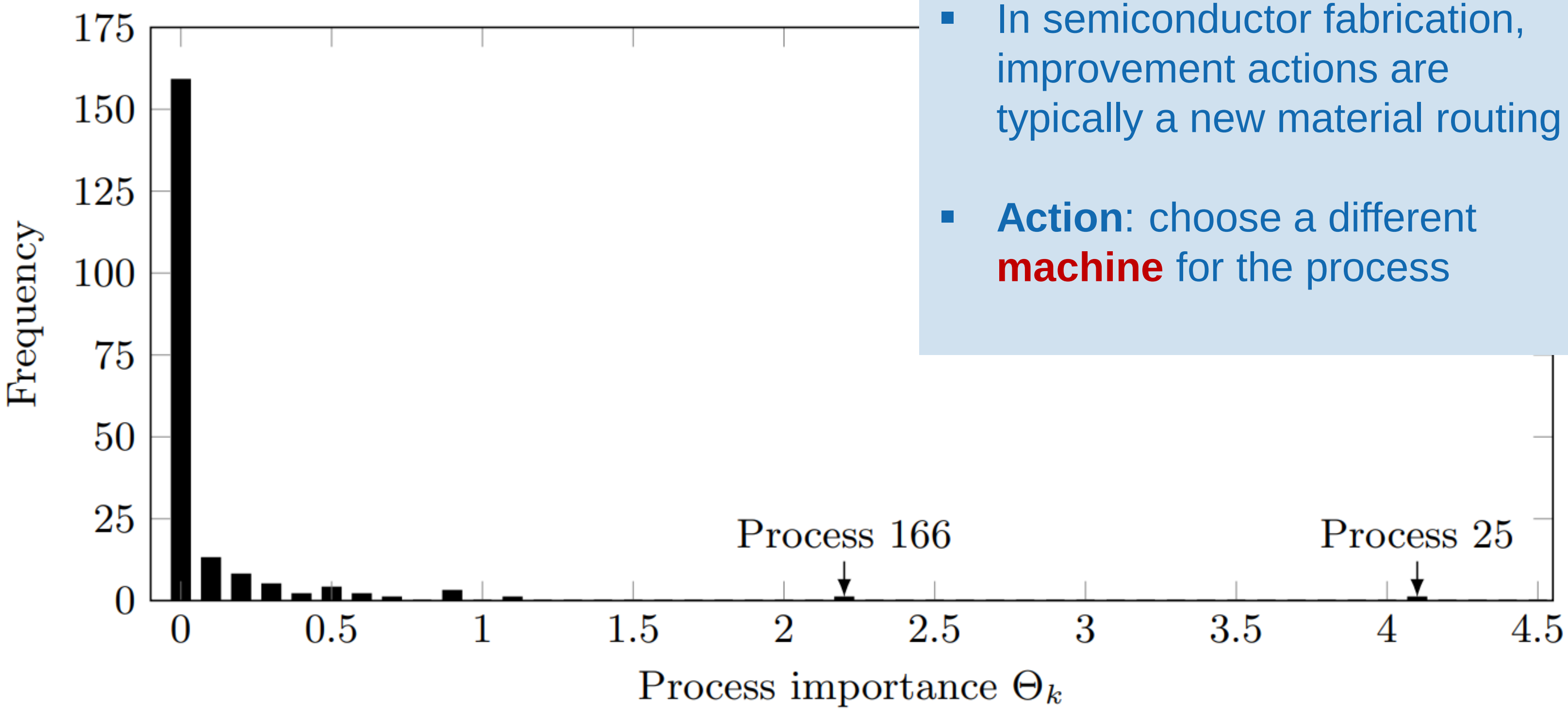
Learning a ‘digital twin’ to identify quality drivers and remove root causes



Feature attribution at parameter level (=“standard SHAP plot”)

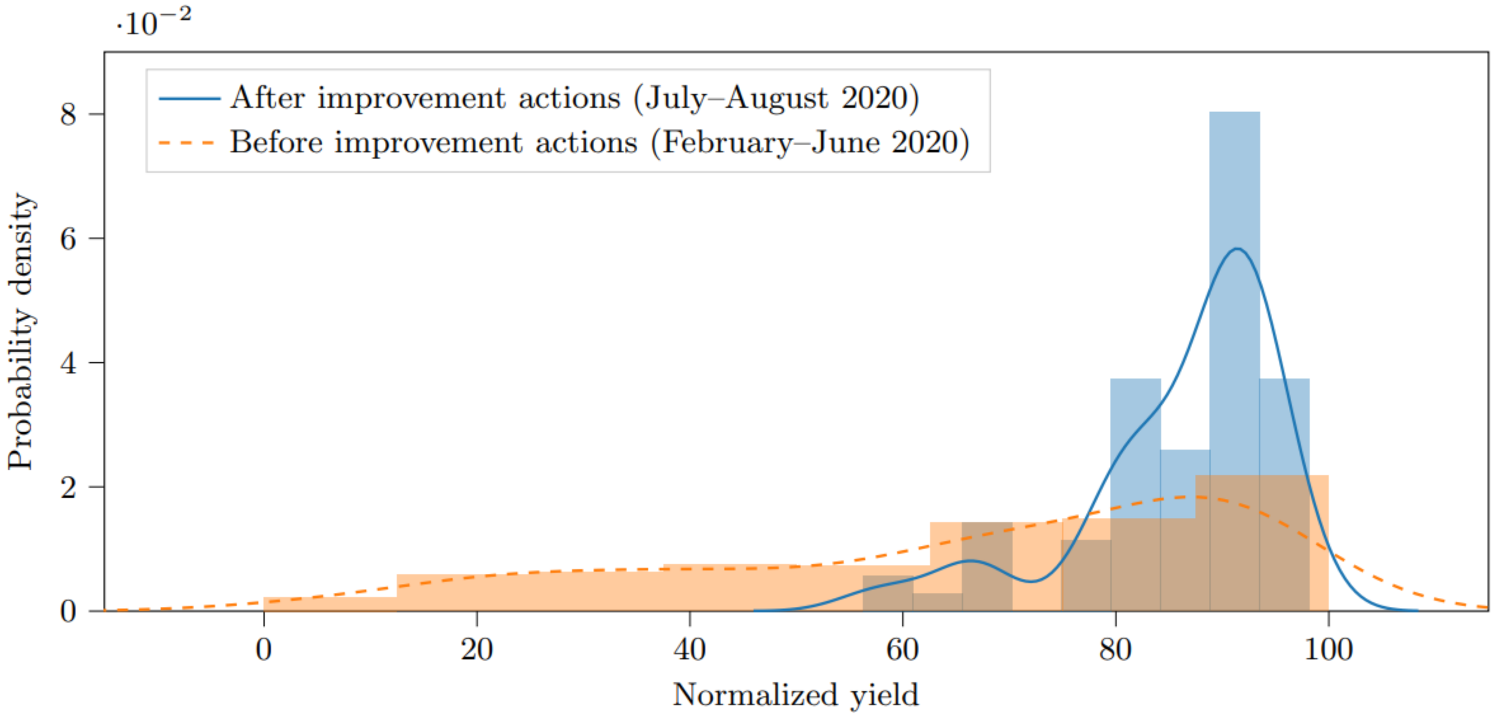


Process importance identifies processes with large contribution to quality variation ("quality drivers")



- In semiconductor fabrication, improvement actions are typically a new material routing
- **Action**: choose a different **machine** for the process

Actual roll-out in July-August 2020 shows significant yield improvements



Yield loss reduced by **51.3%** ($p < 0.001$)

Explainable AI as an effective human-in-the-loop approach

Limitations / robustness

- Explainable AI finds **correlation, not causations**
→ requires rigorous experimental testing
- Can only select improvement actions that are **captured in the data** (i.e., observed and with variation)
→ manufactures introduce controlled variation (Design of Experiments; Fisher 1935)
- **Robust results** (same conclusion with other machine learning models)

Conclusion

- One of first papers on explainable AI in Management Science
- Promotes human learning: AI identified quality drivers that were **previously unknown** to the process engineers
- Applicability to other domains (drivers of customer churn, health outcomes, etc.)

ROADMAP

XAI is well aligned to address AI hurdles around the technological, managerial, and organizational level

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Artificial intelligence | Impact