MASTER'S THESIS · MANAGEMENT M.SC.

# Mapping and expert evaluation of AI-based innovation management methods

*Development of a method radar to support decision-making in German SMEs*

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MANAGEMENT SUMMARY

# This thesis translates the fragmented AI method landscape into an expert-validated method radar for innovation managers in German SMEs

## PROBLEM

01

### Lack of structured method overview

Despite AI's high potential for innovation management, German SMEs lack a consolidated overview of existing AI-based IM-Methods.

## APPROACH

02

### Three-stage exploratory sequential design

Method identification along an SSLR, evaluation via an online expert survey ($N$ = 33) and synthesis into an interactive method radar.

## RESULT

03

### 23 methods identified, 13 evaluated & 1 radar developed

Structured overview of AI-based IM-Methods, including 8 Act methods as a universal entry pool for German SMEs.

## CONTRIBUTION

04

### Decision support for practice and research infrastructure

Practical decision-support instrument for German SMEs and extendable foundation for cumulative TIM research.

# AI offers a critical lever for innovation management in German SMEs, yet practitioners lack a structured method overview to leverage it

**01**

### SMEs are Germany's economic backbone

Account for 99.2 % of all enterprises, employ 53.1 % of the workforce, and contribute 41 % of gross value added.

**02**

### Innovation is essential, yet resources are scarce

SMEs must continuously innovate while operating under resource constraints compared to large corp.

**03**

### AI emerges as a strategic lever

AI improves time efficiency, reduces labor requirements, and enables the analysis of big data volumes.

**04**

### AI has become a central focus of TIM research

A substantial body of work has emerged on AI applications along the innovation process.



**05**

### Yet practitioners still lack a structured method overview

Terminological fragmentation merges constructs of different hierarchical levels, preventing the emergence of a consolidated overview of pure AI-based IM-Methods.

# A proprietary definition of AI-based IM-Methods with four cumulative criteria establishes the conceptual scope required for a systematic identification of methods

## DEFINITION

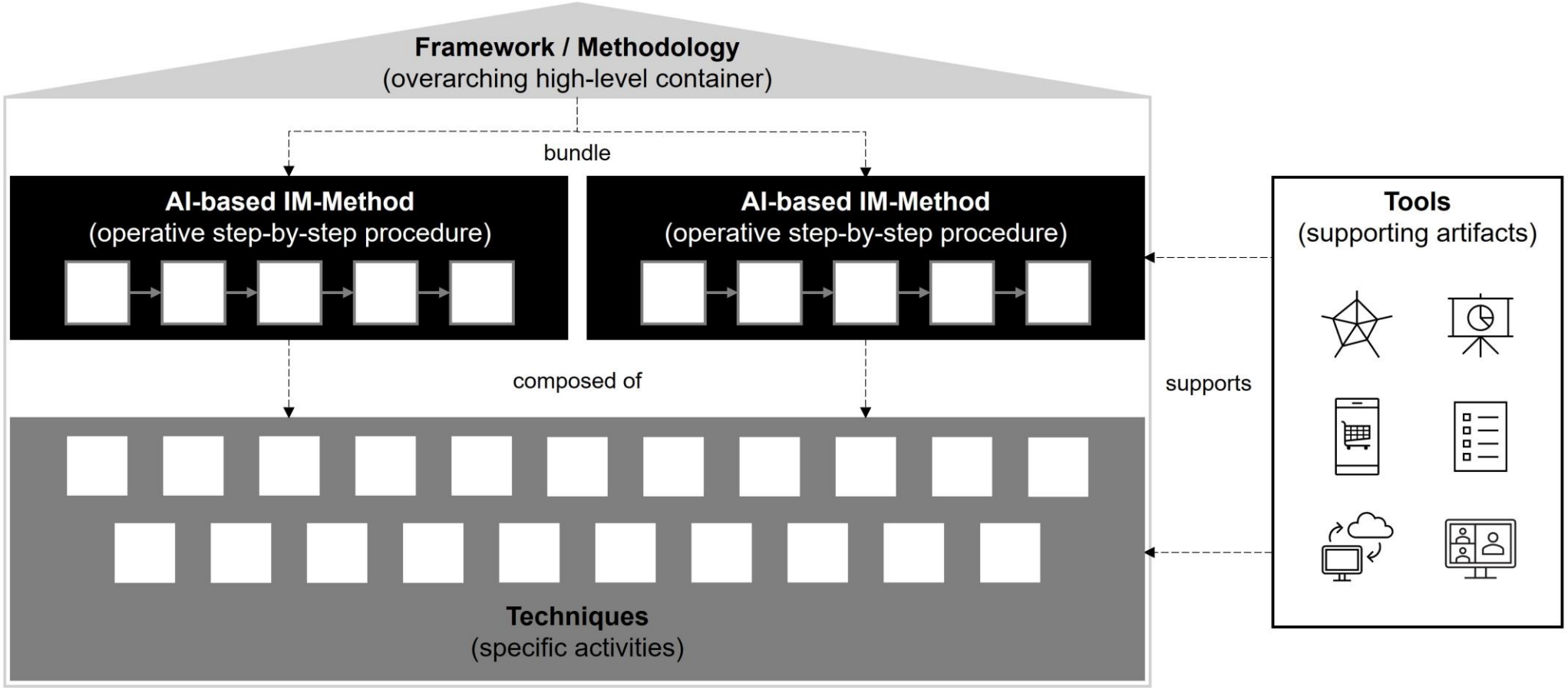


An AI-based IM-Method is a clearly delimitable, recipe-like, step-by-step procedure that a company can apply within its IM process to achieve a specific operational sub-objective of IM, and in which at least one central step inherently relies on AI (ML, NLP, GenAI).

## FOUR CUMULATIVE CRITERIA

| | |
|---|---|
| 01 | Clearly delimitable standalone procedure |
| 02 | Recipe-like sequence of steps |
| 03 | Specific operational task within IM |
| 04 | AI-based core element |

# The definition delineates AI-based IM-Methods from frameworks, tools, and techniques and makes them empirically tangible for the first time



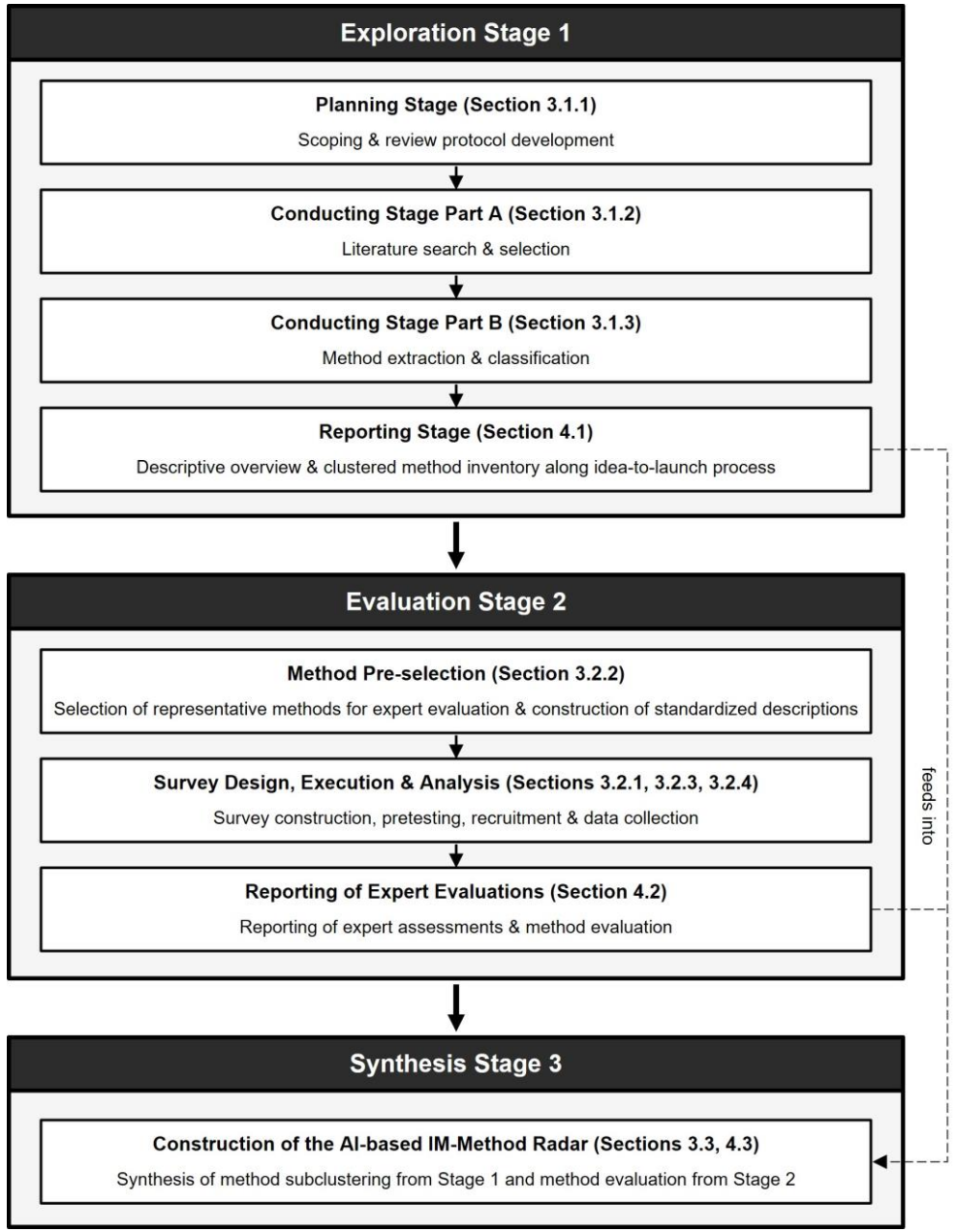
# Three research questions are addressed through a process aligned with an exploratory sequential design

## RESEARCH QUESTIONS

**RQ1 · Exploration**
Which AI-based IM-Methods are described in the current scientific literature that could potentially be suitable for application in German SMEs?

**RQ2 · Evaluation**
How do innovation experts evaluate the relevance of the identified AI-based IM-Methods for German SMEs?

**RQ3 · Synthesis**
How can the identified and evaluated AI-based IM-Methods be synthesized into a decision-support tool for innovation managers in German SMEs?



# The method identification follows the procedure of an SSLR to capture the fragmented field comprehensively

## PROCEDURAL STEPS OF STAGE 1

### Database & search strategy

Two separate search strings in Scopus capturing the method and the AI perspective.

### Sample selection through screening and snowballing

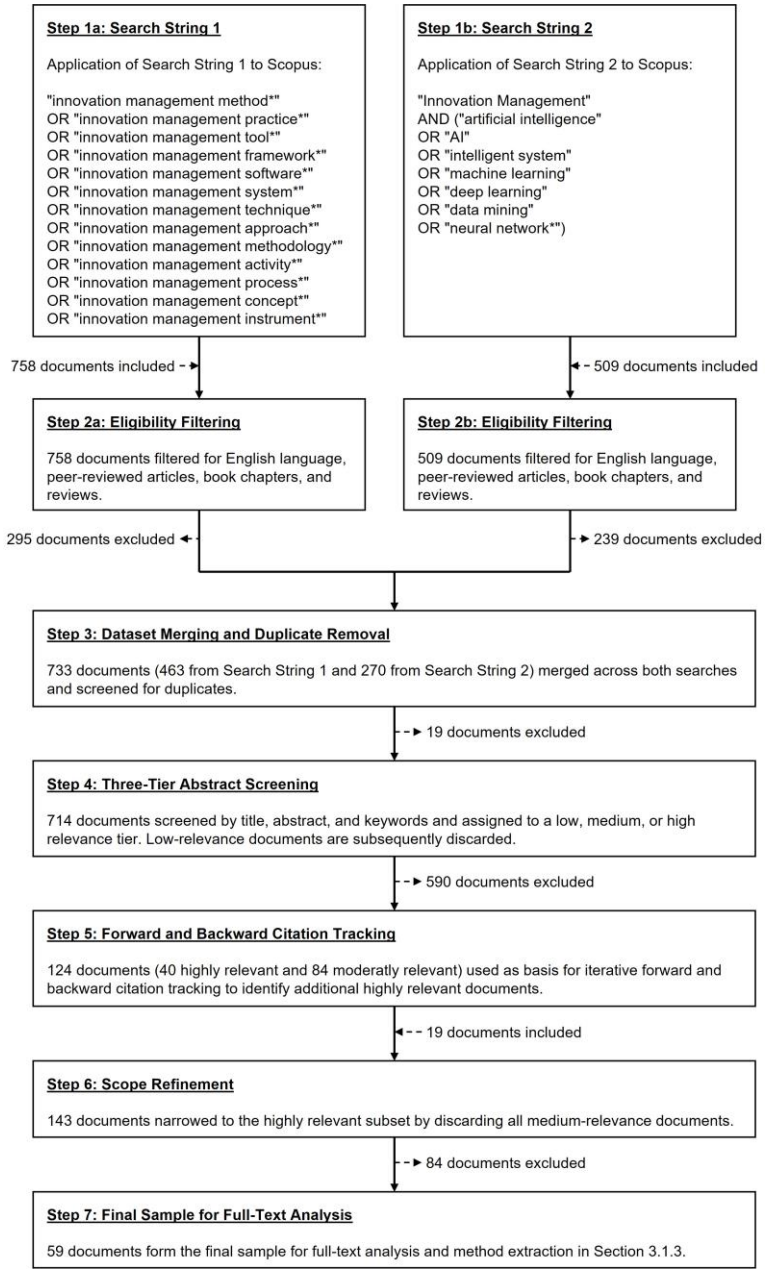
Application of exclusion criteria and screening of titles, abstracts, and keywords, followed by iterative forward and backward citation tracking.

### Eligibility filter via four definitional criteria

Each construct in the full text is tested against the four definitional criteria; only constructs passing all four are extracted.

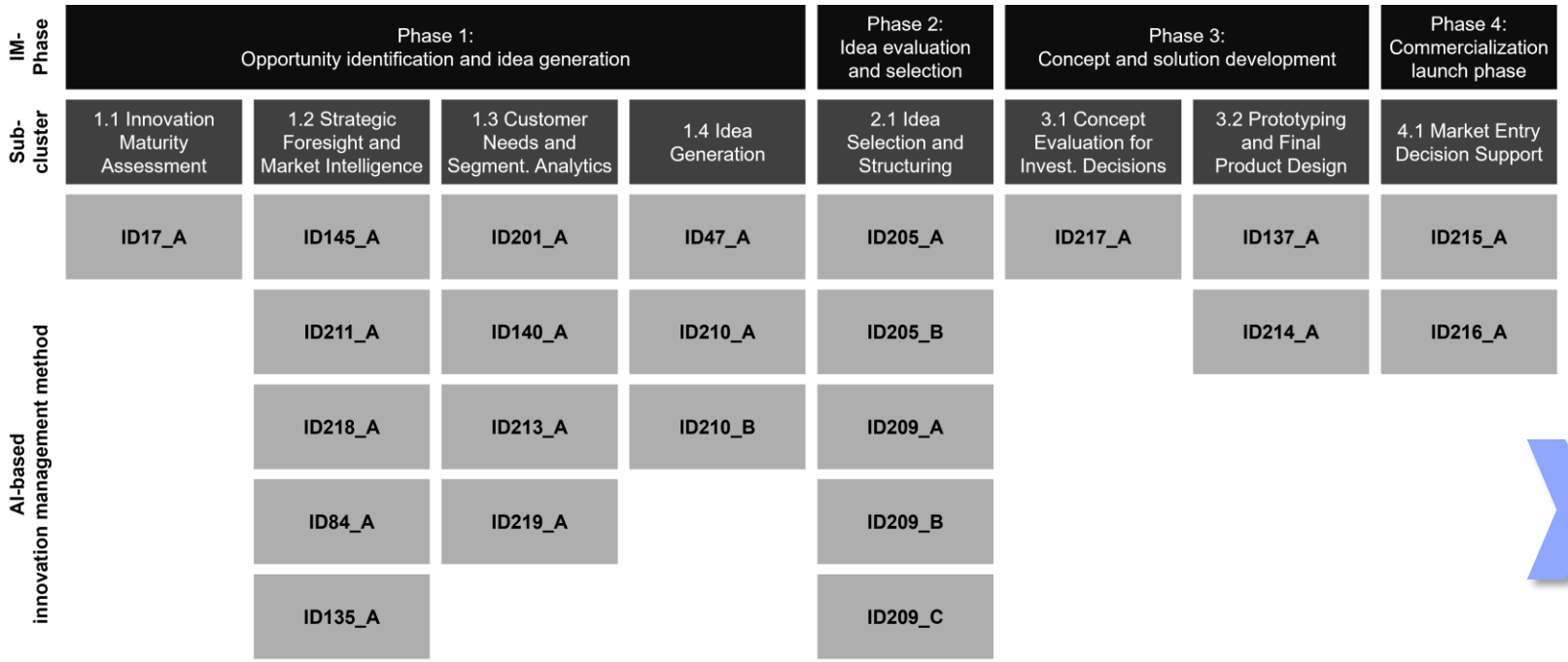
### Two-step classification of qualified methods

Deductive assignment to the four phases of the idea-to-launch process, followed by inductive grouping into subclusters.



# A total of 23 AI-based IM-Methods are identified from the literature, with a pronounced concentration in the front-end phases of the innovation process

## CLUSTERING OF AI-BASED IM-METHODS




### KEY FINDING

**Pronounced front-end concentration**

**FRONT END · Phases 1–2**

**78 % · 18 methods**

**BACK END · Phases 3–4**

**22 % · 5 methods**

*This imbalance leaves SMEs with limited methodological options for several operational back-end tasks.*

# The relevance of 13 identified methods for German SMEs is evaluated by 33 innovation experts within a standardized online survey

## FORMAT · SAMPLE · TASK

### Standardized online survey
Includes 13 methods preselected based on functional equivalence to balance survey feasibility with the exploratory ambition of the study.

### *N* = 33 innovation experts from German SMEs
Recruited primarily from firms recognized by the TOP 100 innovation award. Predominantly Heads of IM/R&D with at least 6 years of professional experience.

### Method evaluation along three categories
Experts assessed the 13 methods based on standardized method descriptions and assigned each to one of three recommended actions for SMEs.



## Hybrides Brainstorming

**Zweck der Methode:**

Die Methode dient dazu, eine große Vielfalt an Ideen zu erzeugen und daraus einen kompakten, nutzbaren Ideenpool für nachgelagerte Innovationsentscheidungen vorzubereiten. Dabei wird der Effekt vieler unabhängiger Ideengeber mithilfe generativer KI nachgebildet und die Varianz zwischen unabhängigen Ideationsläufen gezielt genutzt.

**Operativer Ablauf:**

Innovationsverantwortliche definieren zunächst die Innovationsaufgabe mit klaren Anforderungen. Anschließend werden mehrere voneinander unabhängige KI-Sessions durchgeführt, in denen jeweils neue Ideen generiert werden. Die entstandenen Ideen werden thematisch gruppiert. Für jede Gruppe wird anschließend eine weitere KI-Session gestartet, wobei das KI-Modell hier die Rolle eines Bewertungsteams simuliert. Dieses wählt aus der jeweiligen Gruppe die vielversprechendsten Ideen aus, formuliert sie mutiger, entwickelt sie weiter und kombiniert bei Bedarf mehrere Ideen zu neuen hybriden Vorschlägen. Innovationsverantwortliche nutzen den so verdichteten Ideenpool als Ausgangspunkt für weitere Innovationsentscheidungen.

**Ergebnis:**

Ein kompakter Ideenpool mit ausgewählten, weiterentwickelten und teilweise kombinierten Ideen als Grundlage für nachgelagerte Screening-, Bewertungs- oder Entscheidungsprozesse.

*Welche Implementierungsempfehlung sprechen Sie auf Basis der Methodenbeschreibung für deutsche KMU aus?*

- ◯ Kategorie 1: Act (Universelle Implementierungsempfehlung)
- ◯ Kategorie 2: Prepare (Bedingte Implementierungsempfehlung)
- ◯ Kategorie 3: Watch (Keine sofortige Implementierungsempfehlung)

# The evaluation categories Act, Prepare, and Watch translate the expert judgments into clear recommended actions for German SMEs

| | |
|---|---|
| **ACT**<br>*Universal implementation recommendation* | The method offers clear functional added value and is broadly implementable across German SMEs without major preconditions, justifying immediate prioritization. |
| **PREPARE**<br>*Conditional implementation recommendation* | The method offers clear functional added value, but its implementation depends on specific preconditions that not all German SMEs can meet immediately. |
| **WATCH**<br>*Withholding of short-term recommendation* | The method offers insufficient functional added value in its current form. Further technological developments should be observed before committing resources. |

STAGE 2 · RESULT

# Eight methods are classified as Act and form a directly actionable entry pool broadly recommendable for German SMEs

## ACT

**8**

**Methods recommended for broad implementation**

Clear functional value, broadly applicable across German SMEs without major preconditions.

## PREPARE

**3**

**Methods requiring specific preconditions**

Clear functional value, but adoption requires specific data, infrastructure, or competence foundations within the SME.

## WATCH

**2**

**Methods to be observed further**

Insufficient added value in current form. Technological developments should be monitored.

STAGE 3 · SYNTHESIS

# The method radar consolidates literature- and expert-based findings into a decision-support tool for innovation managers

## READING THE RADAR

### Sectors

Eight subclusters along the four innovation phases allow filtering by operational sub-objective.

### Rings

Act in the inner core, Prepare in the middle, Watch in the outer ring, making the recommended action directly readable.

### Color intensity

Indicates the level of expert agreement: dark blue ≥ 70 % (high), medium blue > 50 % and < 70 % (moderate), light blue ≤ 50 % (low).

## KEY PATTERN

The front-end phases are dominated by Act methods, while the back-end phases are dominated by Prepare methods, indicating different implementation readiness across the innovation process.



IMPLICATIONS FOR PRACTICE

# German SMEs should use the radar as their primary reference for identifying suitable methods and invest in personnel AI competence to unlock AI's potential for their IM

## 01

### Use the radar as the first reference

Innovation managers should use the radar as the first reference point when searching for methods aligned with their operational objective.

***Apply the five-step recipe:***

- Define the innovation problem or task
- Filter relevant methods by subcluster
- Prioritize based on expert evaluations
- Study descriptions and source references
- Assess fit against firm-specific conditions

## 02

### Differentiate method selection by maturity

Front-end Act methods like Hybrid Brainstorming are broadly recommendable entry points, while back-end methods require additional readiness.

***Tailor method choice to maturity:***

- SMEs should start with suitable Act methods
- AI-mature SMEs can unlock back-end methods
- Each method should be matched against the firm's specific characteristics before adoption

## 03

### Prioritize AI competence over infrastructure

Personnel competence is the dominant adoption barrier, rated high or very high by 75.8 % of the expert panel.

***Implement concrete measures:***

- Nominate a dedicated AI-responsible role
- Anchor competence-building via workshops
- Prioritize competence-building over infrastructure investments

IMPLICATIONS FOR RESEARCH

# Researchers should build on the proprietary definition and extend the radar through the targeted development of methods for back-end phases

## 01

### Develop methods for back-end phases

The pronounced front-end concentration of existing methods stands in contrast to the high AI potential the expert panel attributes to the back end.

***Apply 3 design criteria when developing methods:***

- Design clear recipes for non-technical users
- Prefer GenAI and LLM mechanisms
- Ensure generic applicability across SME contexts

## 02

### Establish the definition as shared vocabulary

The proprietary definition with its four cumulative criteria addresses the terminological fragmentation in the TIM literature.

***Anchor the definition in future research:***

- Adopt the definition across studies
- Apply the four criteria as a classification filter
- Anchor a common conceptual foundation

## 03

### Extend the radar as research infrastructure

The radar is deliberately designed as an extendable infrastructure, allowing new methods to be integrated without structural disruption.

***Develop the radar further:***

- Update expert evaluations continuously
- Add newly developed methods
- Build sector-specific radar variants

# A multi-round Delphi study is the logical next step to validate and extend the exploratory findings of this thesis

## CENTRAL LIMITATIONS

### Single-coder approach

Literature screening and construct qualification conducted by one reviewer.
A multi-reviewer consensus would represent the methodological ideal.

### Sample size *N* = 33

Above the threshold for exploratory studies but limited statistical generalizability of the aggregated results.

### Aggregated method descriptions

The standardized three-paragraph format reduces methodological complexity.
Potential evaluation shifts cannot be fully ruled out.

## OUTLOOK

### Multi-round Delphi study as the validation pathway

#### Broader expert panel

Recruit experts with sufficient time for dedicated participation across multiple rounds.

#### Full coverage of all 23 methods

Evaluate all 23 methods on substantially more detailed descriptions, removing the complexity reduction of the three-paragraph format.

#### Multiple rating dimensions

Assess each method on separate metric scales such as functional value, technical preconditions, and organizational fit, supported by formal consensus measures.

# Thank you for your attention.

BACKUP · METHOD PROFILE

# Hybrid Brainstorming (210_B) – representative front-end method

| PHASE | SUBCLUSTER | MODAL | AGREEMENT |
| --- | --- | --- | --- |
| 1 · Opportunity identification & idea generation | 1.4 · Idea Generation | Act | high (78.8 %) |

## PURPOSE

Generates a broad variety of ideas and condenses them into a compact, usable idea pool for downstream innovation decisions. The method replicates the effect of many independent ideators through generative AI and deliberately exploits the variance between independent ideation runs.

## PROCEDURE

Innovation managers first define the innovation task with clear requirements. Several independent AI sessions are then run, each generating new ideas. The resulting ideas are grouped thematically. For each group, a further AI session is launched in which the AI model simulates an evaluation team that selects the most promising ideas, formulates them more boldly, develops them further, and where useful combines several ideas into new hybrid proposals. The condensed idea pool serves as a starting point for further innovation decisions.

## RESULT

A compact idea pool of selected, further developed, and partially combined ideas as a basis for downstream screening, evaluation, and decision processes.

## BEST SUITED FOR

### SMEs starting with AI-based IM

- ✓ Very low entry barriers – only a standard LLM required
- ✓ Idea generation as a near-universal innovation task
- ✓ Low-risk environment to build internal AI familiarity
- ✓ Foundation for moving on to more demanding methods

BACKUP · METHOD PROFILE

# Virtual Product Development with Human-AI Teaming (214_A) – representative back-end method

| PHASE | SUBCLUSTER | MODAL | AGREEMENT |
| --- | --- | --- | --- |
| 3 · Concept & solution development | 3.2 · Prototyping & Final Product Design | Prepare | moderate (66.7 %) |

## PURPOSE

Develops, tests, and optimizes technical (industrial) products virtually before physical prototypes are built. This reduces development risks, costs, and iteration effort early on and substantiates design decisions with data.

## PROCEDURE

Innovation managers first create a digital product model ("Digital Master") that captures key design parameters, requirements, and insights from previous product generations. On this basis, virtual tests and simulations are conducted. The AI model analyzes the simulation results and identifies performance deviations, potential design issues, and optimization potential. Explainable AI (XAI) makes these results transparent and interpretable for human innovation managers. Based on the insights, innovation managers adjust design parameters and launch further simulations. This human-AI iteration process is repeated until a virtually validated product design is achieved.

## RESULT

A virtually tested and optimized product design that serves as a robust foundation for building physical prototypes or for subsequent series production.

## BEST SUITED FOR

### Industrial SMEs with advanced AI maturity

- ✓ Frequent and resource-intensive product development cycles
- ✓ Existing simulation and digital infrastructure
- ✓ In-house AI competence and data science capacity
- ✓ Strong incentive to reduce physical prototyping cost

# All 23 AI-based IM-Methods – Phase 1: Opportunity identification & idea generation

| ID | Method name | Short description |
|---|---|---|
| 17_A | Business Innovation Self-Assessment with AI Support | Innovation managers answer a structured question set; an AI-supported system evaluates responses across innovation dimensions to generate a diagnostic profile of strengths and improvement areas. |
| 47_A | Crowdsourcing Data-Driven Approach for Innovation | A hashtag-based call on social media collects crowd submissions; NLP and data mining build a crowd knowledge database as input for ideation. |
| 84_A | Strategic Intelligence Management (SIM) using GenAI | Iterative GenAI dialogue gathers and structures market, technology, and environmental information with source links – producing a traceable strategic intelligence summary. |
| 135_A | Innovation Signals Triple Diamond Model | Continuous AI-based scanning of external text data identifies and classifies innovation signals by relevance and novelty in a two-by-two matrix. |
| 145_A | AI-Based Data Mining Model for Spotting Emerging Topics | Self-adaptive system mines publications and patents to identify emerging topics; quadrant-based topic matrix supports strategic interpretation. |
| 201_A | ML Hybrid Method to Identify Customer Needs | AI-supported filtering and deduplication of user-generated text surfaces diverse content; output is consolidated into a structured overview of customer needs. |
| 213_A | ABSA-Community Detection Framework for Segmentation | Aspect-based sentiment analysis combined with clustering on social media posts produces dynamic customer segments and personas. |
| 218_A | Scenario-Based Technology Roadmap (Big Data) | AI analyzes technology text data to identify drivers, model relationships, and simulate alternative scenarios – informing long-term roadmap decisions. |
| 219_A | Customer Segmentation via Online Product Reviews | AI mines reviews to assess feature relevance and satisfaction; outputs segments highlighting high-importance, low-satisfaction features as concept starting points. |
| 210_A | Chain-of-Thought (CoT) Prompting | Stepwise GenAI prompting first generates and then revises ideas to increase differentiation – producing a structured idea pool with diverse, distinguishable ideas. |
| 210_B | Hybrid Brainstorming | Multiple independent GenAI sessions create a broad idea set; a further AI session groups, refines, and combines them into a compact pool for screening. |
| 211_A | Scenario Analysis Guidance Tool | Predefined prompt sequence guides a GenAI to develop multiple future scenarios; iterative refinement produces a fit-for-purpose scenario set for strategic discussion. |

*Own illustration. Method numbering corresponds to the document IDs of the qualified source articles.*

# All 23 AI-based IM-Methods – Phase 2: Idea evaluation & selection

| ID | Method name | Short description |
|---|---|---|
| 205_A | Single-Model Idea Screening with ISE-Curve | Automated single-model pre-sorting visualizes the trade-off between reduction and risk in an ISE curve; threshold setting leaves a focused pool for human evaluation. |
| 205_B | Idea Screening Two-Step Approach | Heuristic reduction first, then theory-based AI screening approximating expert judgments – producing a smaller pre-sorted pool while preserving high-potential ideas. |
| 209_A | Direct Search | Semantic AI-based search matches a need or problem description against a large idea pool to identify relevant ideas beyond exact wording. |
| 209_B | Cluster Exploration | AI-supported clustering groups large idea pools into semantically similar clusters; interpretation reveals dominant themes, needs, and niche areas. |
| 209_C | Pattern Discovery | AI decomposes the idea pool into recurring thematic components and maps their co-occurrence – revealing dominant patterns, overlooked combinations, and structural gaps. |

*Own illustration. Method numbering corresponds to the document IDs of the qualified source articles.*

# All 23 AI-based IM-Methods – Phase 3: Concept & solution development

| ID | Method name | Short description |
|---|---|---|
| 137_A | AI-Augmented Digital Prototyping | Natural-language prompts iteratively guide a GenAI to build and refine a functional digital prototype – ready for user-based concept validation. |
| 140_A | LDA-LightGBM and QFD Specification Recommendation | Customer review data is processed via topic modeling and ML and linked to specifications through QFD – producing ranked specification recommendations for R&D prioritization. |
| 214_A | Virtual Product Development (Human-AI Teaming) | Digital product model is tested in virtual simulations; AI and XAI identify performance issues and optimization potential – iterated until a validated digital design is ready. |
| 217_A | Objective Scoring of R&D Proposals using ML | Structured proposal information is processed by an ML scoring system that estimates success probabilities and computes a weighted score – enabling transparent portfolio prioritization. |

*Own illustration. Method numbering corresponds to the document IDs of the qualified source articles.*

# All 23 AI-based IM-Methods – Phase 4: Commercialization launch

| ID | Method name | Short description |
|---|---|---|
| 215_A | ML Framework for Forecasting Short-Life-Cycle Sales | Historical trajectories of comparable products plus early sales weeks are used to forecast remaining demand – informing launch, capacity, and inventory decisions. |
| 216_A | Dynamic Dual-Phase Forecasting Framework (DDPFF) | Pre-launch demand forecast continuously updated post-launch with incoming sales data – producing an adaptive forecast across the launch transition. |

*Own illustration. Method numbering corresponds to the document IDs of the qualified source articles.*

# Complete evaluation results for the 13 selected AI-based IM-Methods

| ID | Method | Act % | Prep % | Watch % | Modal | Agreement |
|---|---|---|---|---|---|---|
| 210_B | Hybrid Brainstorming | 78.8 | 18.2 | 3.0 | Act | high |
| 201_A | ML Hybrid Method to Identify Customer Needs | 75.8 | 24.2 | 0.0 | Act | high |
| 17_A | Business Innovation Self-Assessment | 66.7 | 12.1 | 21.2 | Act | moderate |
| 84_A | Strategic Intelligence Management (SIM) | 63.6 | 24.2 | 12.1 | Act | moderate |
| 219_A | Customer Segmentation via Online Reviews | 57.6 | 36.4 | 6.0 | Act | moderate |
| 205_B | Idea Screening Two-Step Approach | 54.6 | 33.3 | 12.1 | Act | moderate |
| 209_A | Direct Search | 42.4 | 36.4 | 21.2 | Act | low |
| 217_A | Objective Scoring of R&D Proposals | 39.4 | 36.4 | 24.2 | Act | low |
| 214_A | Virtual Product Development (Human-AI Teaming) | 21.2 | 66.7 | 12.1 | Prepare | moderate |
| 137_A | AI-Augmented Digital Prototyping | 33.3 | 63.6 | 3.0 | Prepare | moderate |
| 216_A | Dynamic Dual-Phase Forecasting (DDPFF) | 21.2 | 54.6 | 24.2 | Prepare | moderate |
| 47_A | Crowdsourcing Data-Driven Approach | 6.0 | 42.4 | 51.5 | Watch | moderate |
| 211_A | Scenario Analysis Guidance Tool | 36.4 | 18.2 | 45.4 | Watch | low |

*Own illustration based on survey data (N = 33). Agreement thresholds: high ≥ 70 %, moderate > 50 % and < 70 %, low ≤ 50 %.*

BACKUP

# Characteristics of the expert panel (N = 33)

| Category | Response option | n | % |
|---|---|---|---|
| Professional experience in IM | < 2 years | 1 | 3.0 |
| | 2 – 5 years | 9 | 27.3 |
| | 6 – 10 years | 10 | 30.3 |
| | > 10 years | 13 | 39.4 |
| Primary function | C-level / Managing Director / Owner | 4 | 12.1 |
| | Head of IM / R&D | 12 | 36.4 |
| | Innovation Manager / Project Lead | 13 | 39.4 |
| | Other | 4 | 12.1 |
| Self-assessed AI knowledge | Very low | 0 | 0 |
| | Rather low | 1 | 3.0 |
| | Medium | 21 | 63.6 |
| | Rather high | 9 | 27.3 |
| | Very high | 2 | 6.0 |
| Organization size (employees) | 1 – 9 | 2 | 6.0 |
| | 10 – 49 | 6 | 18.2 |
| | 50 – 249 | 12 | 36.4 |
| | 250 – 2,999 | 12 | 36.4 |
| | ≥ 3,000 | 1 | 3.0 |

BACKUP

# The eight inductively derived IM subclusters along the four phases.

1.1 · Phase 1

**Innovation Maturity Assessment**

1.2 · Phase 1

**Strategic Foresight & Market Intelligence**

1.3 · Phase 1

**Customer Needs & Segmentation Analytics**

1.4 · Phase 1

**Idea Generation**

2.1 · Phase 2

**Idea Selection and Structuring**

3.1 · Phase 3

**Concept Evaluation for Investment Decisions**

3.2 · Phase 3

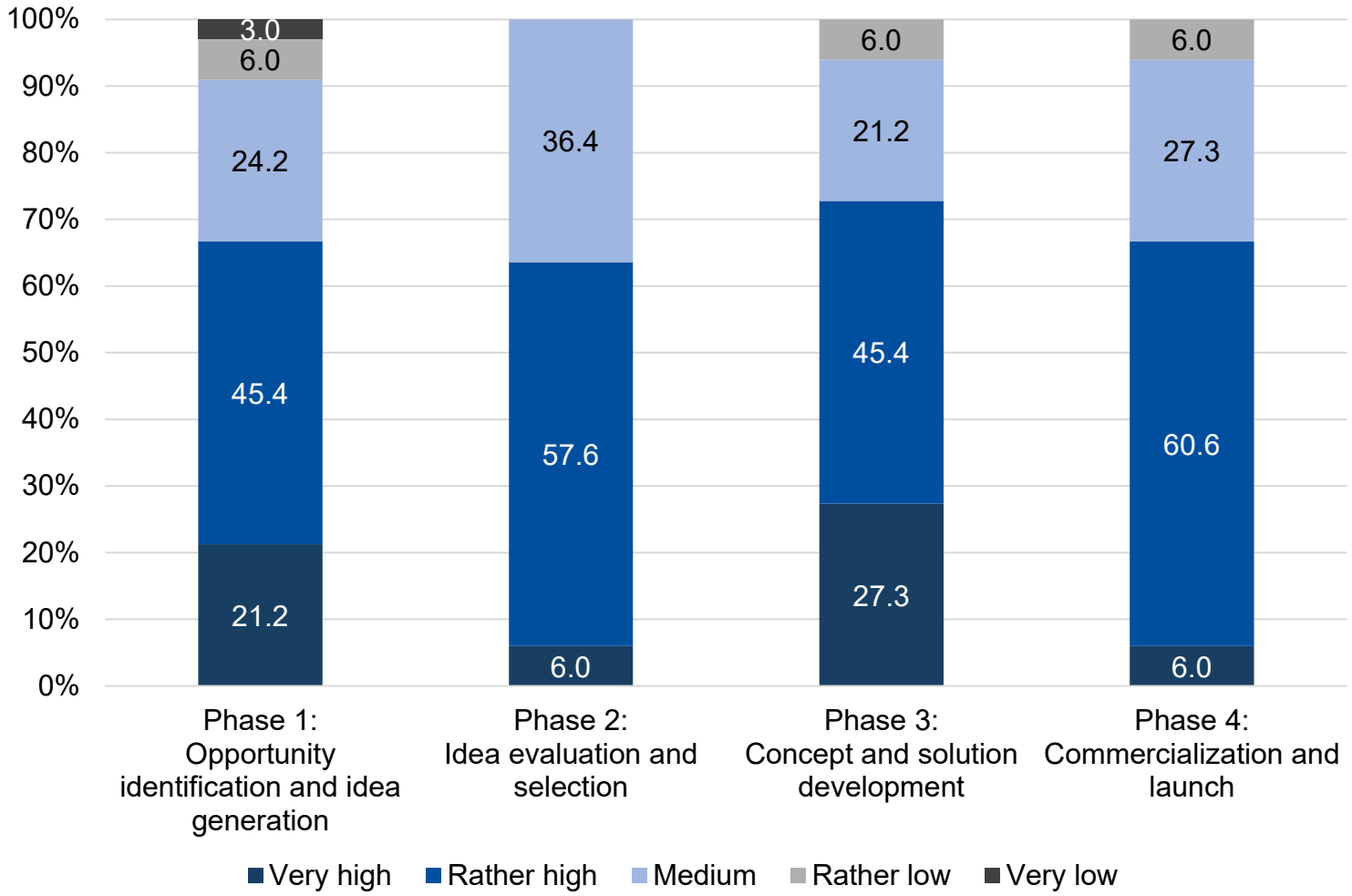
**Prototyping and Final Product Design**

4.1 · Phase 4

**Market Entry Decision Support**

BACKUP

# Expert assessment of AI potential per innovation process phase



BACKUP

# Expert assessment of adoption barriers to AI-based IM in German SMEs

