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A review of data analytics in technological forecasting

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ABSTRACT

Technological forecasting (TF) has significantly benefited from data analytics over the past decades. However, little effort has been made to present an overview of data analytics in TF and discuss its key features and contributions. Consequently, there exist duplication of efforts, inconsistency in applications and a lack of understanding of the current state-of-the-art and common methodology frameworks. This study attempts to fill this research gap by conducting a review of the work on data analytics in TF published in leading journals in the field of technology and innovation management. We first develop a process-focused morphological matrix that provides a simple yet comprehensive view and enables the full spectrum of data analytics in TF to be examined. Specifically, the matrix consists of four dimensions and 12 factors: (1) awareness of TF contexts (objective, time horizon, field and level of analysis); (2) data collection and pre-processing (data source, data item and measure); (3) data analysis and validation (approach, methodology and performance evaluation); and (4) value creation (outcome and implication). A thorough presentation of the literature is then provided after the configurations of each article are identified. Accordingly, we also examine the practical implications of the process-focused morphological matrix and suggest future research directions in the field.

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Technology forecasting (TF) and technology assessment (TA) methodologies: a conceptual review

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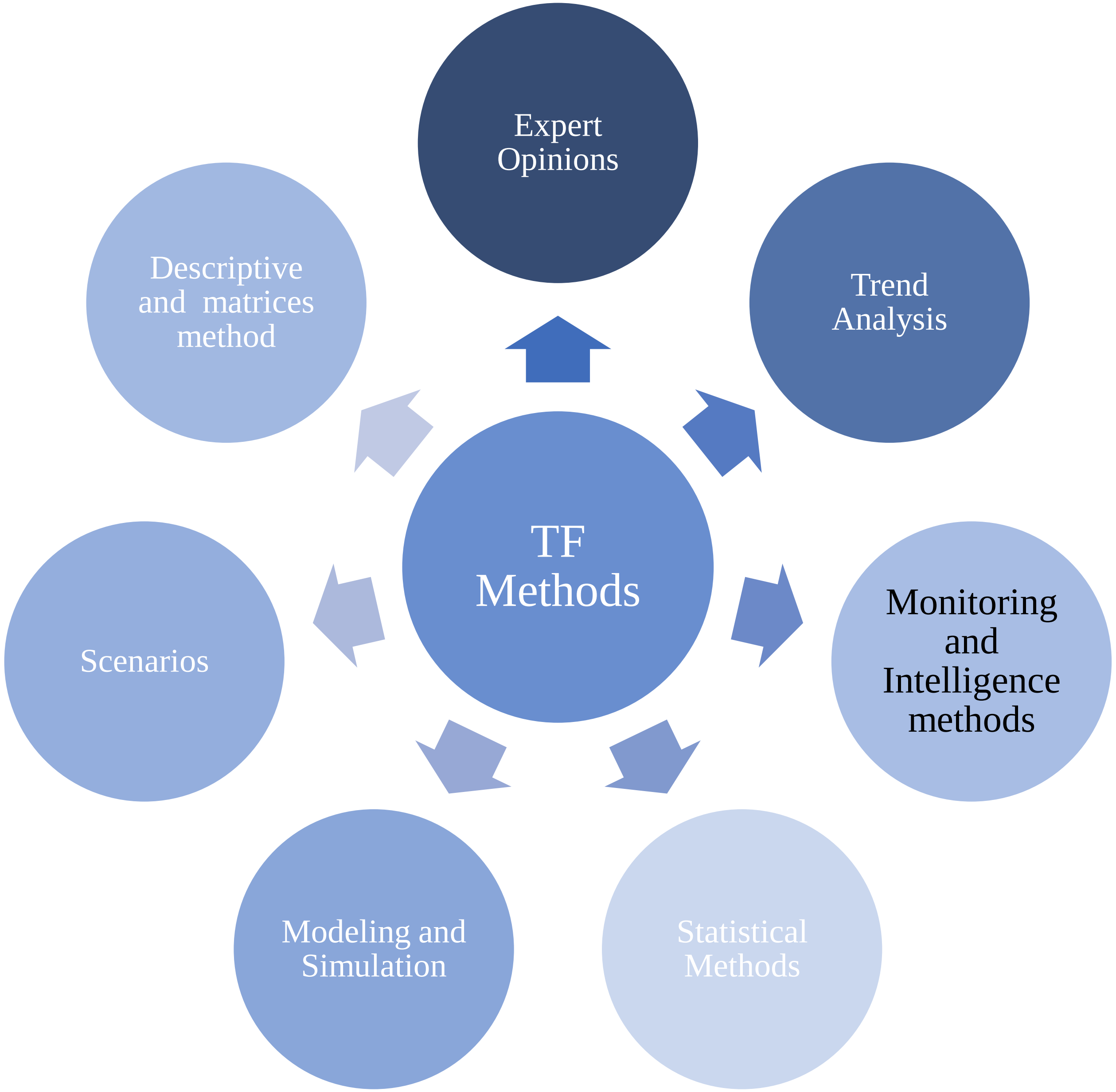
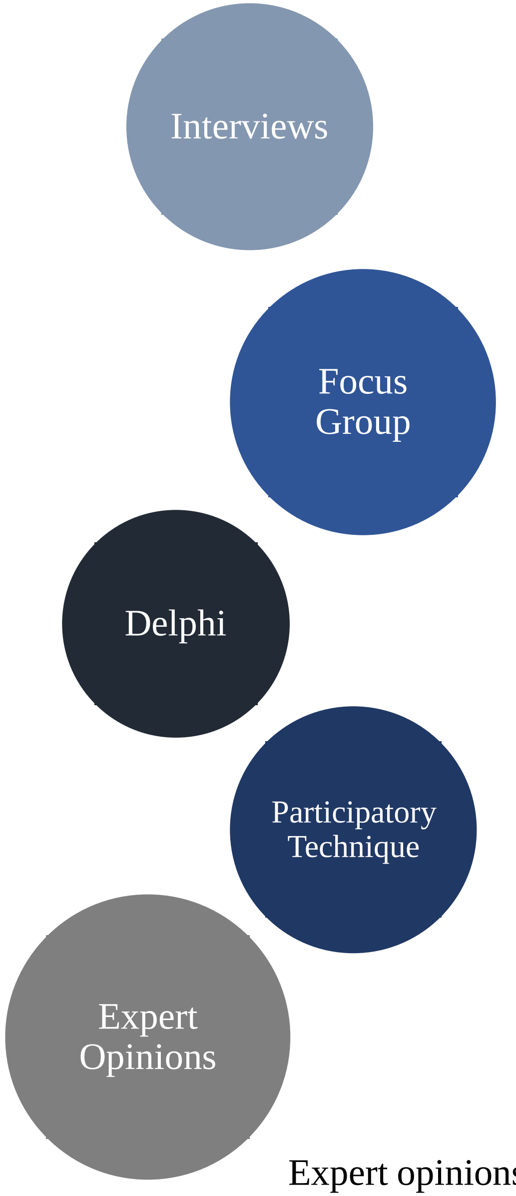

Expert Opinions
Trend Analysis
Monitoring and Intelligence methods
Statistical Methods
Modeling and Simulation
Scenarios
Descriptive and matrices method
TF Methods



Expert opinion plays a crucial role in technology forecasting, as it provides valuable insights and informed judgments about future technological developments.

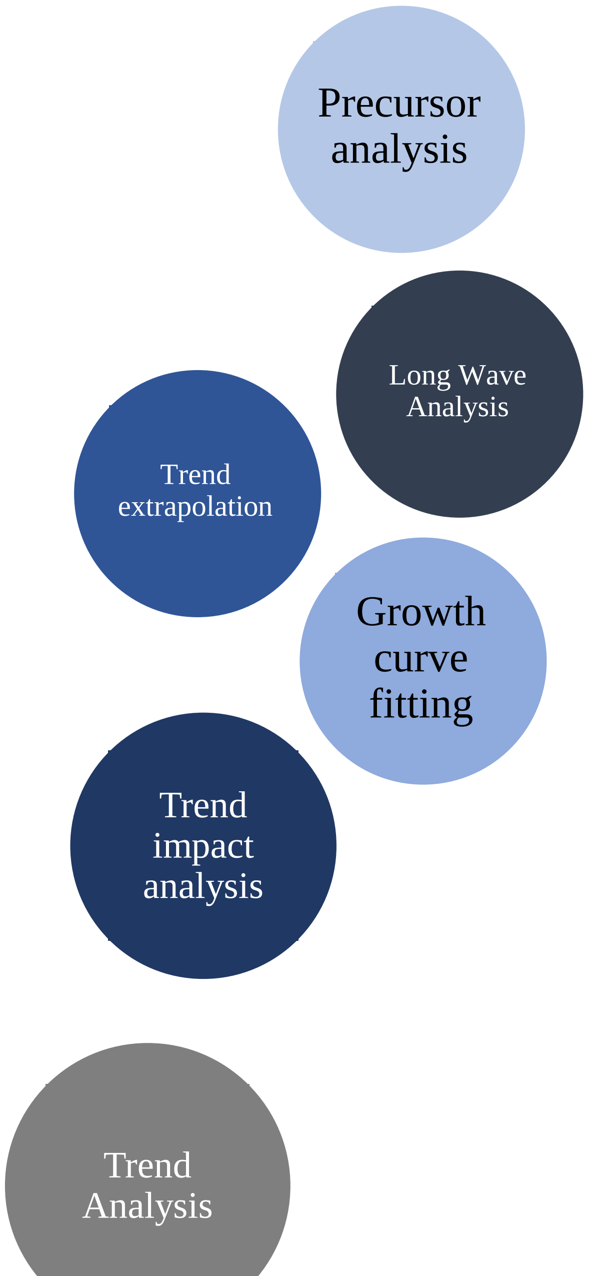
Participatory techniques involve engaging experts actively in the forecasting process. These techniques foster collaboration and knowledge exchange among participants, enabling them to collectively explore and assess technological trends.

Delphi method is a structured approach to gather and aggregate expert opinions. It involves multiple rounds of questionnaires or surveys, where experts provide their judgments anonymously. Through a controlled feedback process, the Delphi method facilitates consensus-building among experts and helps identify areas of agreement or divergence.

Focus groups bring together a small group of experts to engage in facilitated discussions on a specific topic. The participants share their insights, perspectives, and experiences related to technological advancements.

Interviews involve one-on-one interactions with experts, either face-to-face or through virtual platforms. Interviews provide an opportunity to delve deeper into an expert's knowledge, experiences, and subjective interpretations of future technology trends.

Expert opinions are generally used when there is a **little** or **no past data** available or in the condition when organizations want to maintain the secrecy of their end-product, process, services or technology before introducing time



Trend analysis plays a pivotal role in technology forecasting, enabling researchers and businesses to anticipate future developments and make informed decisions.

Trend extrapolation involves extending existing trends into the future, assuming that historical patterns will continue. By examining past data, such as sales figures, adoption rates, or technological advancements, analysts can identify and project future trajectories. Linear regression, exponential smoothing, and autoregressive integrated moving average (ARIMA) models are commonly employed for extrapolation.

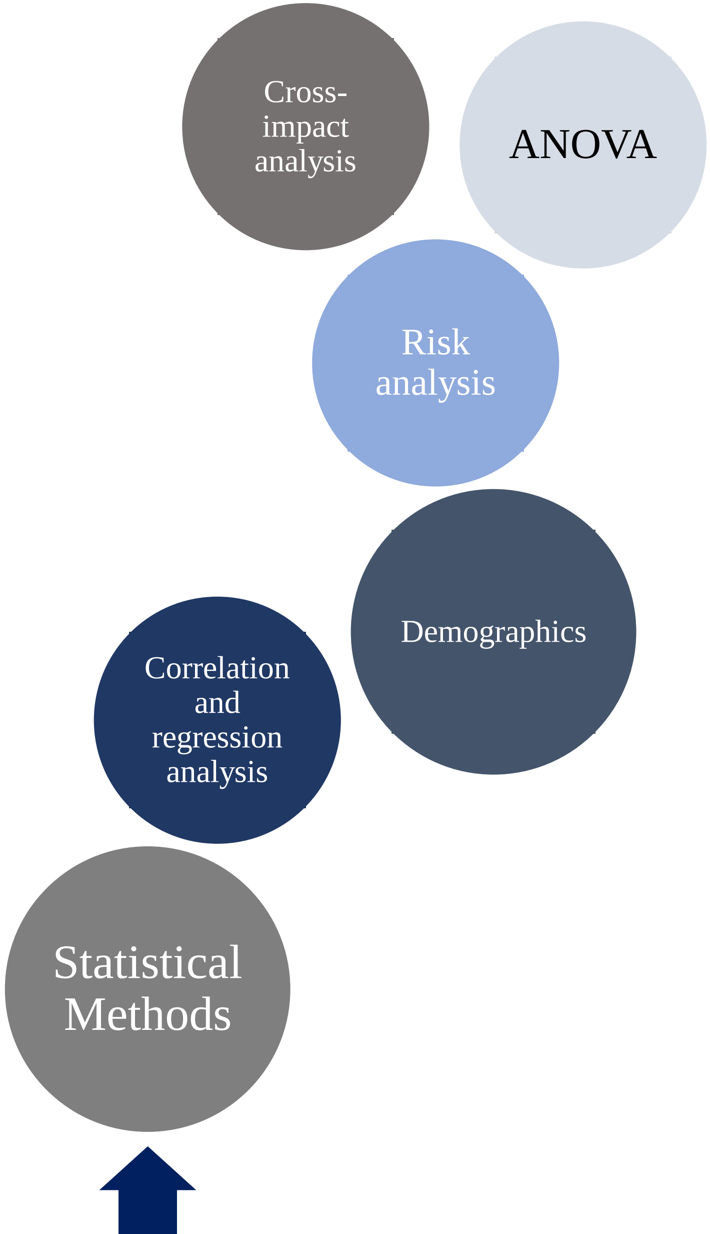
Trend impact analysis focuses on understanding the potential consequences of emerging trends on various aspects of technology and society. By evaluating the interdependencies between trends, industries, and societal factors, analysts can determine the likelihood and magnitude of their impact. This analysis involves assessing potential opportunities, risks, disruptions, and shifts in market dynamics, which enables businesses to formulate effective strategies to adapt and thrive.

Growth curve fitting involves modeling the growth patterns of technological phenomena over time. This technique allows analysts to identify the underlying dynamics and parameters that drive technological progress.

Precursor analysis entails identifying early signals or indicators that precede significant technological shifts. By examining emerging technologies, scientific breakthroughs, patent filings, or research publications, analysts can spot potential precursors that hint at future trends.

Long wave analysis, often referred to as Kondratiev waves or technological cycles, examines long-term oscillations in technological and economic development. It posits that economies undergo alternating periods of growth and decline spanning several decades.

Trend analysis methods are used to benchmark when the organization continuously produces the technologies, product and services. It is a quantitative approach which requires enough past data for analysis and is generally used by the textile, automobile and electronics industry



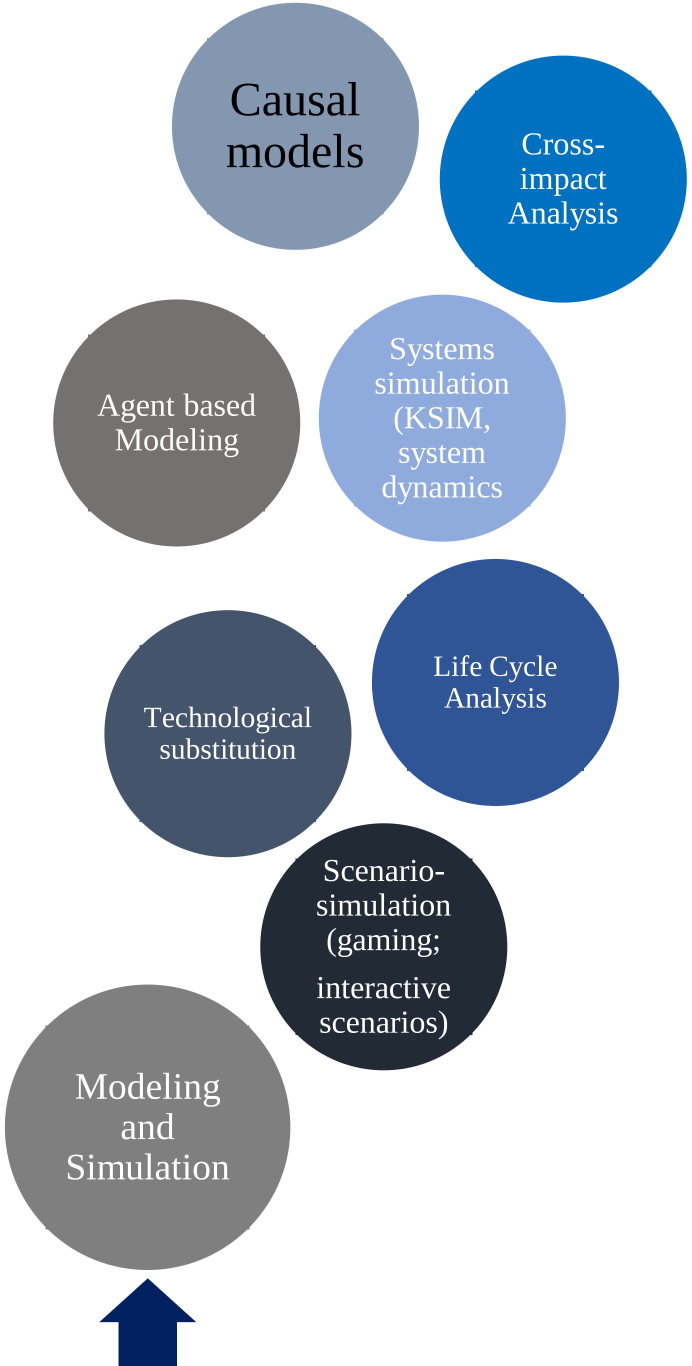
Correlation analysis investigates the relationship between variables, assessing the degree of association between them. By quantifying the strength and direction of the relationship, correlations help identify key drivers and predictors of technological change.

Demographic analysis involves examining population characteristics and trends, such as age, gender, education, income, and geographic distribution. These demographic factors can significantly impact technology adoption rates, diffusion patterns, and market demand. By incorporating demographic data into forecasting models, organizations can better understand and predict the acceptance and usage of emerging technologies within specific target populations.

Cross-impact analysis examines the interdependencies and feedback loops between different technological factors. This method assesses how changes in one technology or trend can influence the development and diffusion of others.

ANOVA is a statistical technique that compares the means of multiple groups to determine if there are statistically significant differences between them. In technology forecasting, ANOVA is useful for analyzing the effects of various factors on technology performance or market outcomes.

Risk analysis evaluates potential uncertainties and their impacts on technology development and adoption. Statistical methods, such as probabilistic modeling, Monte Carlo simulations, and sensitivity analysis, help assess the likelihood of different future scenarios and quantify associated risks.



Scenario simulation involves constructing plausible future scenarios based on different sets of assumptions and conditions. It allows stakeholders to assess the potential outcomes of technology adoption, policy interventions, market shifts, and societal changes.

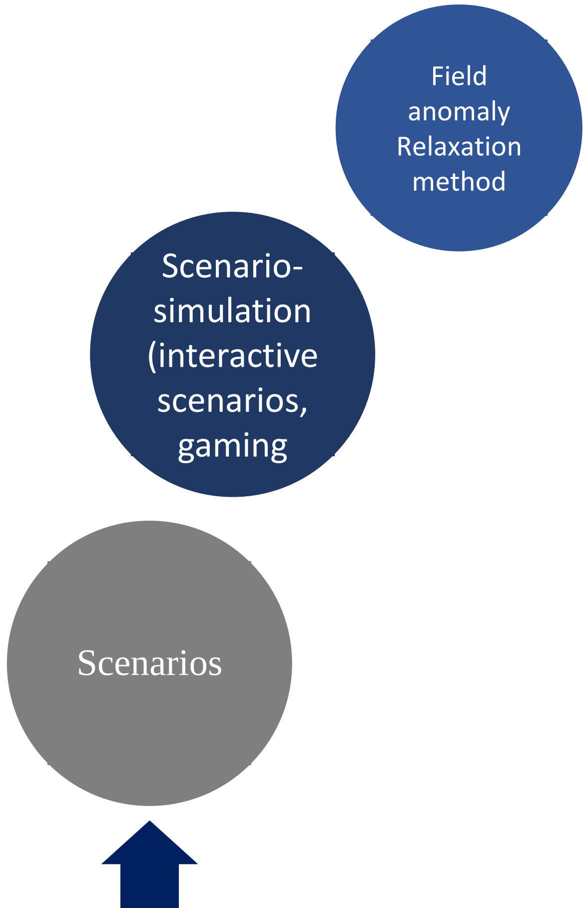
Technological substitutions occur when a new technology replaces an existing one in a specific application or industry. Modeling and simulation techniques help forecast the timing and implications of such substitutions, considering factors like cost-effectiveness, performance improvements, environmental impacts, and social acceptance.

Life cycle analysis (LCA) examines the environmental impacts of a technology throughout its entire life cycle.Modeling and simulation enable researchers to quantify and compare the environmental footprints of different technologies, supporting informed decision-making that prioritizes sustainability and identifies opportunities for improvement.

Agent-based modeling (ABM) represents complex systems as a collection of autonomous agents interacting with each other and their environment. ABM provides a bottom-up approach to technology forecasting, capturing individual behavior and emergent phenomena. By simulating interactions and decision-making processes at the micro-level, ABM offers insights into the dynamics of technology diffusion, market behavior, and innovation processes.

System simulation encompasses various methodologies, including KSIM (Knowledge-based Simulation), system dynamics, and other system-level modeling approaches. These techniques capture the interdependencies and feedback loops within technological systems, enabling researchers to explore how changes in one component impact the entire system.

Causal models aim to identify cause-and-effect relationships between variables and predict the impacts of changes in those variables. By analyzing historical data and applying statistical and computational methods, causal models assist in understanding the drivers behind technological developments and their consequences.



Scenarios in technology forecasting are hypothetical narratives that describe possible futures based on different sets of assumptions and variables. These scenarios help policymakers, businesses, and researchers gain insights into the potential outcomes of technological advancements. They often encompass various factors, such as social, economic, environmental, and technological aspects, to provide a comprehensive understanding of future possibilities.

Anomaly detection involves identifying patterns or events that deviate significantly from expected behavior. In technology forecasting, anomalies can indicate potential breakthroughs, disruptions, or changes in the trajectory of technological development. By detecting and analyzing these anomalies, researchers can gain valuable insights into emerging trends and opportunities

Field Anomaly Relaxation (FAR) method combines the principles of scenario analysis and anomaly detection. It involves identifying anomalies within a specific field of technology and exploring the potential relaxation or resolution of these anomalies.

The FAR method has found applications in diverse fields, such as energy, healthcare, transportation, and information technology. For example, in the energy sector, the FAR method can be employed to identify anomalies related to renewable energy adoption, explore relaxation scenarios, and inform policies that promote sustainable energy transitions. Similarly, in healthcare, the FAR method can help identify potential breakthroughs, analyze their societal impact, and guide the development of innovative medical technologies.

Energy Sector - Sustainable Energy Transitions

Objective: To identify anomalies related to renewable energy adoption and explore relaxation scenarios for sustainable energy transitions.

Identify potential anomalies in renewable energy adoption:

- Fluctuating renewable energy generation patterns.
- Challenges in integrating renewable energy into existing power grids.
- Limited energy storage capacities for renewable sources.
- High upfront costs and investment barriers for renewable energy infrastructure.
- Policy and regulatory constraints hindering renewable energy deployment.

Analyze relaxation scenarios:

Relaxation Scenario 1: Development of advanced energy storage technologies to address the intermittent nature of renewable energy generation.

Relaxation Scenario 2: Implementation of smart grid technologies for improved integration and management of renewable energy sources.

Relaxation Scenario 3: Policy incentives and financial mechanisms to reduce investment barriers and encourage greater adoption of renewable energy.

Relaxation Scenario 4: Collaborative research and development efforts to enhance the efficiency and cost-effectiveness of renewable energy technologies.

Assess societal impact:

Evaluate the potential societal impact of each relaxation scenario, considering factors such as environmental benefits, job creation, energy affordability, and energy security.

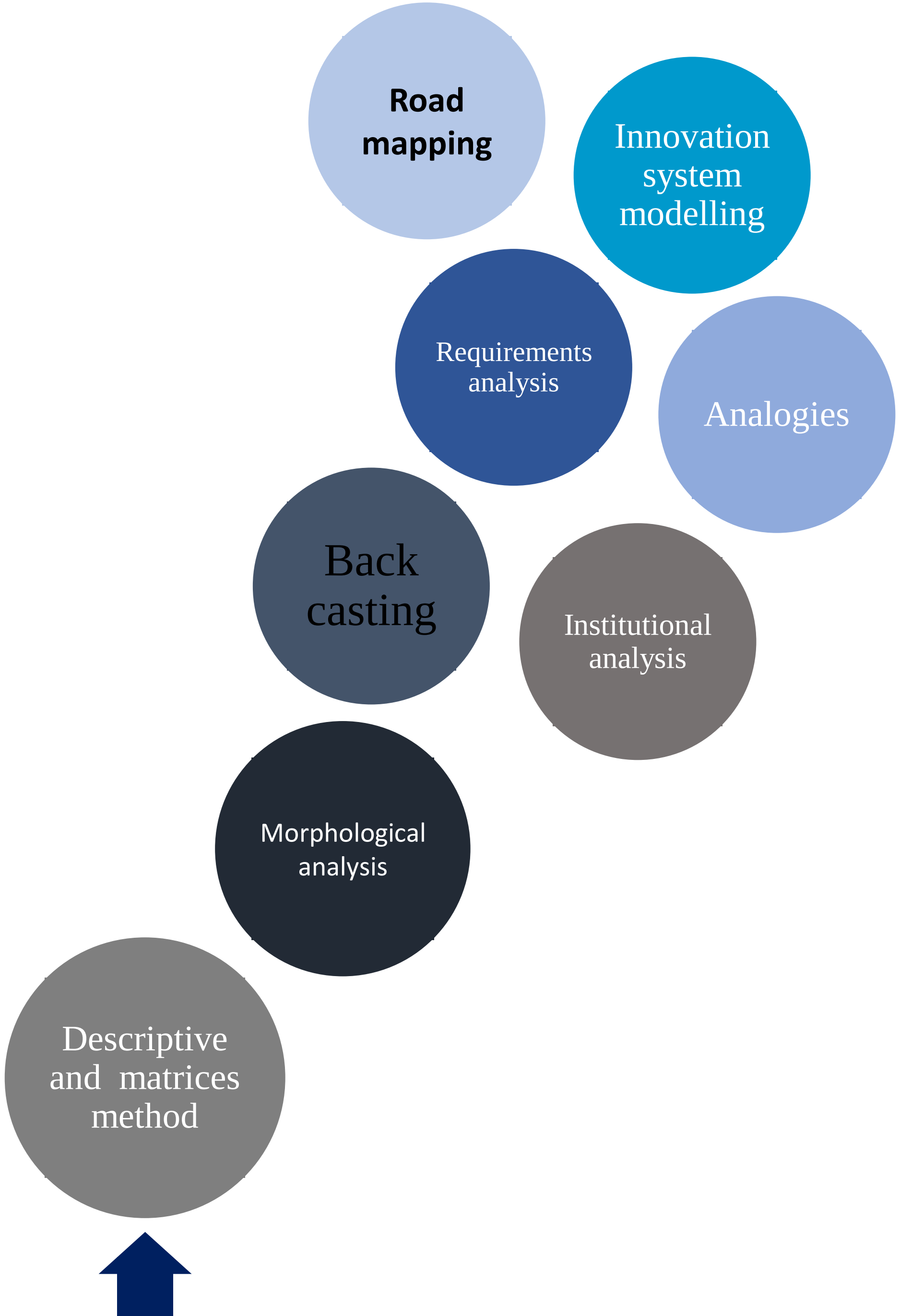
Inform policy and decision-making:

Based on the analysis, provide insights and recommendations to policymakers and stakeholders to inform the development of policies and strategies that promote sustainable energy transitions. This may include suggestions for regulatory reforms, funding allocation, and technology research and development initiatives.

Scenario 1: Quantum Leap in Computing Power
In this scenario, there is a significant breakthrough in quantum computing that enables a dramatic increase in computing power. Quantum computers with thousands, or even millions, of qubits become a reality, surpassing the capabilities of classical supercomputers. This advancement revolutionizes computational tasks, allowing for rapid optimization, complex simulations, and encryption cracking. Industries such as pharmaceuticals, finance, and logistics benefit greatly from this quantum leap, achieving previously impossible feats in drug discovery, financial modeling, and supply chain optimization.

Scenario 2: Quantum Machine Learning and Artificial Intelligence
This scenario explores the fusion of quantum computing with machine learning and artificial intelligence (AI). Quantum machine learning algorithms are developed, leveraging the inherent parallelism and computational power of quantum systems to enhance pattern recognition, data analysis, and optimization tasks. Quantum AI models outperform classical approaches, enabling breakthroughs in various domains, including image recognition, natural language processing, and autonomous systems. Quantum machine learning finds applications in medical diagnostics, autonomous vehicles, personalized marketing, and scientific research, accelerating advancements in these fields.

"Imagine a future where quantum computers with unprecedented computing power become widely accessible. How do you envision this quantum leap impacting industries and everyday life? Can you provide specific examples of how quantum computing could revolutionize existing processes or enable entirely new possibilities in areas such as healthcare, finance, or scientific research?"



Descriptive methods aim to understand and describe existing technological trends and patterns. They provide a basis for analyzing historical data and identifying patterns that can inform future projections.

Morphological analysis is a systematic and structured approach to exploring the future development of technology. It involves breaking down complex systems into their constituent parts or attributes and analyzing the different possible combinations or configurations. By considering various combinations, morphological analysis can identify potential future scenarios and assess their feasibility, desirability, and impact.

Backcasting is a methodology that starts with a desirable future scenario and works backward to determine the necessary steps to achieve it. In technology forecasting, backcasting helps envision the desired technological outcomes and subsequently identifies the required technological advancements, policy interventions, and research initiatives to realize those outcomes.

Morphological Analysis for Quantum Computing:

1.Identify key attributes:

- Sensing technology: Lidar, radar, cameras, ultrasonic sensors.
- Control systems: Artificial Intelligence, machine learning algorithms, deep neural networks.
- Navigation and mapping: GPS, high-definition maps, simultaneous localization and mapping (SLAM) algorithms.
- Communication: Vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I) communication protocols.
- Power source: Electric, hybrid, or hydrogen fuel cell.
- Safety features: Advanced driver-assistance systems (ADAS), collision avoidance systems, redundancy mechanisms.
- Passenger comfort: Interior design, entertainment systems, adaptive seating.
- Legal and regulatory considerations: Compliance with traffic regulations, liability frameworks, data privacy

2. Generate configurations:

Configuration 1: Sensing technology (Lidar, cameras), Control systems (AI, machine learning), Navigation and mapping (GPS, SLAM algorithms), Communication (V2V, V2I), Power source (Electric), Safety features (ADAS, collision avoidance systems), Passenger comfort (Interior design, adaptive seating), Legal and regulatory considerations (Compliance with traffic regulations).

Configuration 2: Sensing technology (Radar, cameras), Control systems (AI, deep neural networks), Navigation and mapping (High-definition maps, SLAM algorithms), Communication (V2V, V2I), Power source (Hybrid), Safety features (ADAS, redundancy mechanisms), Passenger comfort (Entertainment systems, adaptive seating), Legal and regulatory considerations (Data privacy regulations).

3.Evaluate feasibility, desirability, and impact:

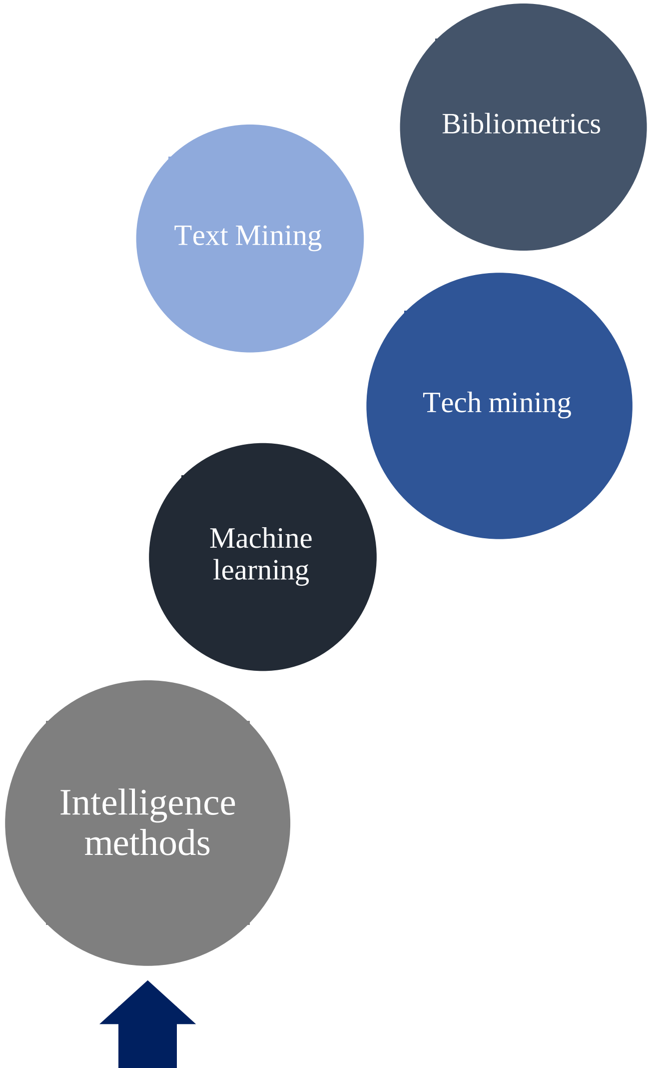
Assess each configuration based on factors such as technical feasibility, market demand, safety implications, regulatory compliance, and potential societal impact. Consider the advantages and disadvantages of each configuration and evaluate their potential to achieve the desired objectives.

4.Select preferred configurations:

Based on the evaluation, select the most promising configurations that align with the desired objectives, taking into account technical feasibility, market potential, safety considerations, and regulatory requirements.

5. Refine and iterate:

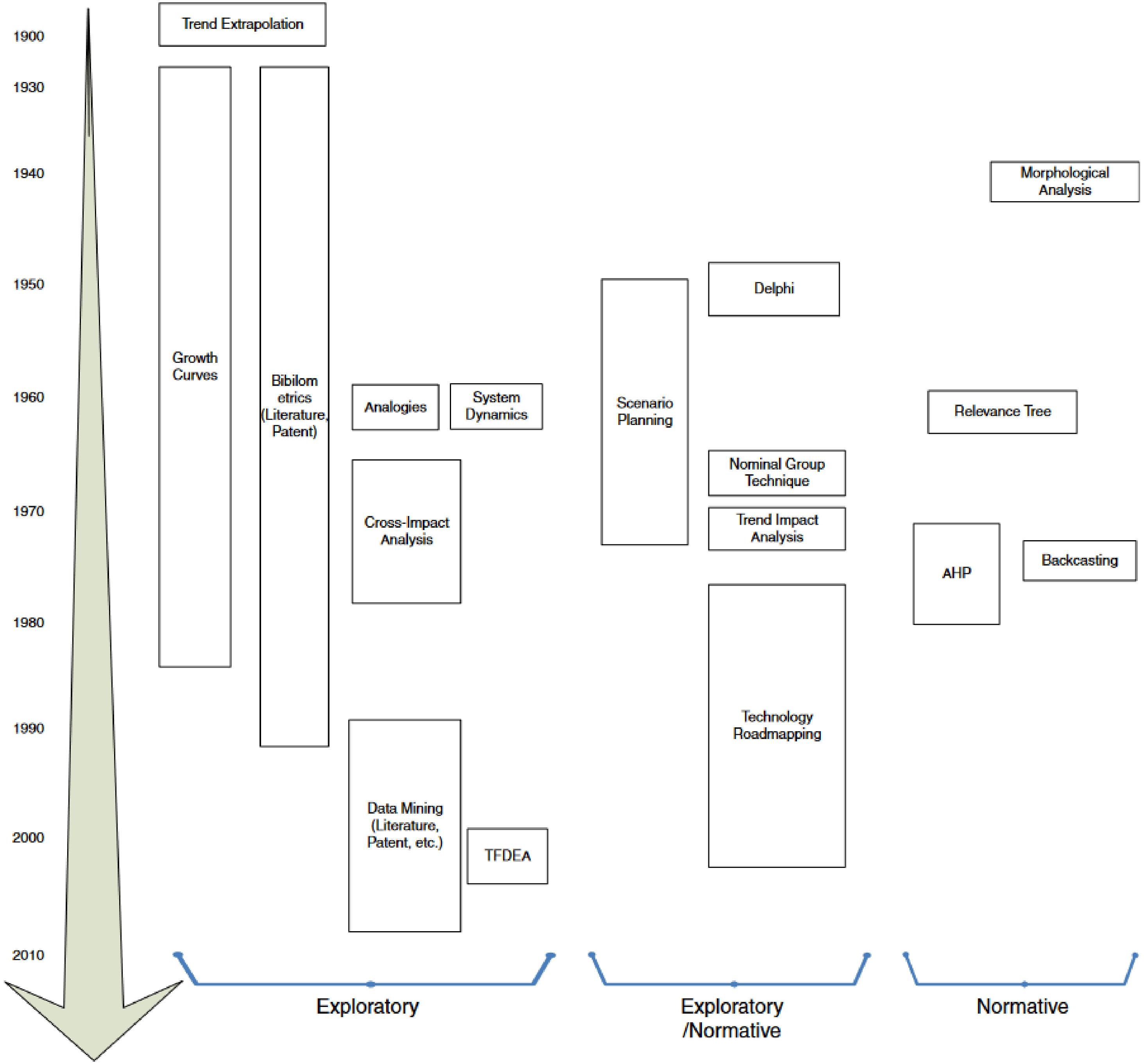
Refine the selected configurations based on additional inputs, expert opinions, and emerging technologies. Iterate the analysis to ensure comprehensive coverage of potential attributes and configurations.


Bibliometrics
Text Mining
Tech mining
Machine learning
Intelligence methods

Discontinuous		
Bibliometrics (patent analysis, text mining, research profiling)	Trend Impact Analysis	Decision analysis
	Delphi	Morphological analysis
Cross-impact analysis	Scenario planning	AHP
Input–output analysis		Relevance tree
Diffusion modelling		
Continuous		
Trend extrapolation	Road mapping	Morphological analysis
Growth curve fitting	Trend impact analysis	AHP
Precursor analysis	Delphi	Relevance tree
Long wave analysis	Scenario planning	
System dynamics		
Exploratory	Exploratory/Normative	Normative

Source: Adopted from Daim *et al.* (2006)

The heritage of TF strategies



Building a Foundation

- Deep understanding of the field.
- Creating effective search queries
- Data collection from academic publications, industry reports, and patent databases.
- data preparation and cleaning

From Data to Insight

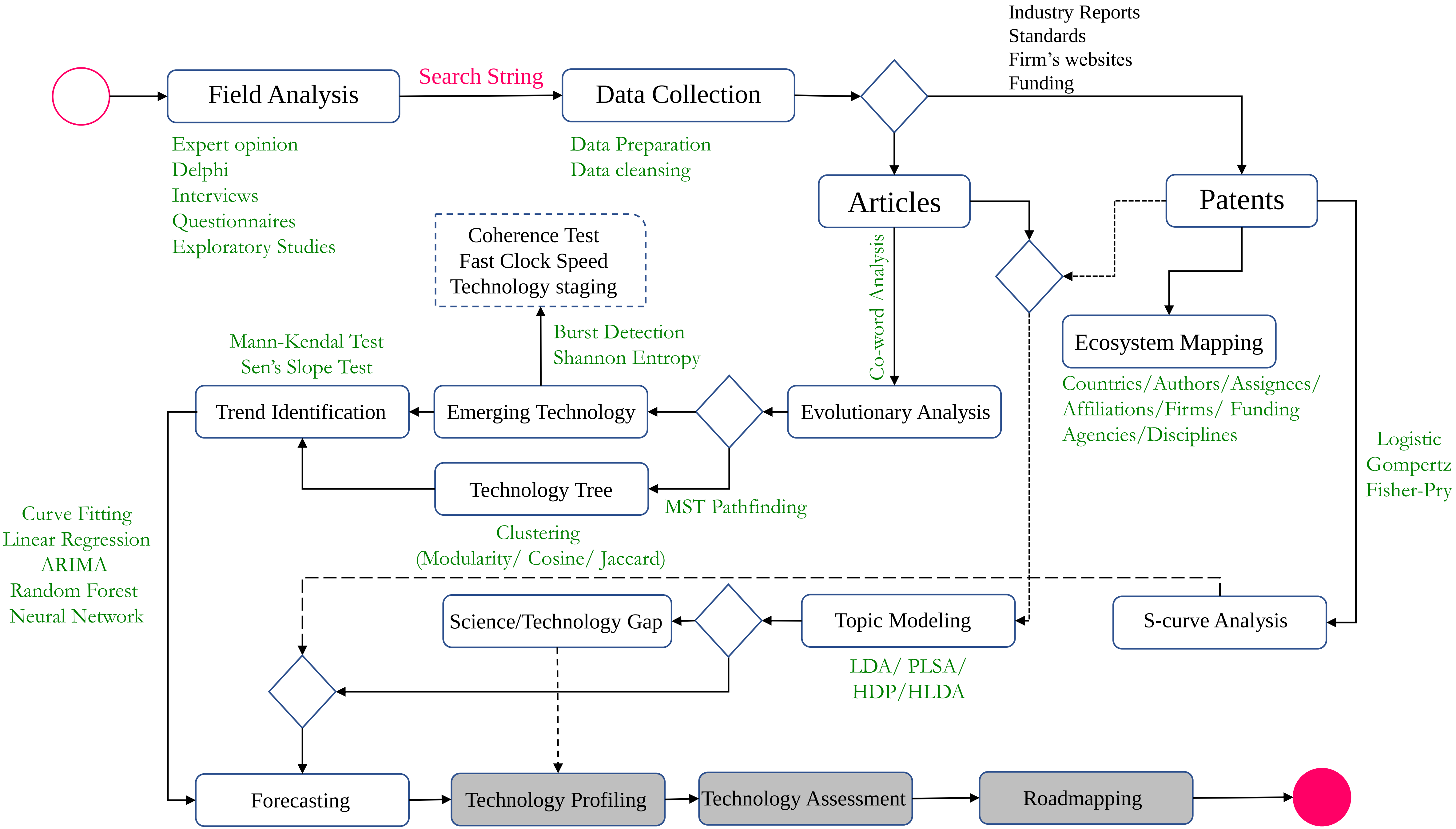
- Ecosystem Mapping
- Technology Landscape Mapping
- Evolutionary Analysis of technology
- Emerging Technology Detection
- Technological trajectory Identification
- Topic Modeling
- Science & Technology gap Analysis
- Technology Application Analysis

Seizing the Opportunity

- Technological Roadmapping
- Technology development strategy
- Technology Landscape monitoring

Beyond the Horizon

- Trend analysis
- Pattern recognition
- Technology Life-cycle Analysis
- Time series Analysis
- Weak Signal Analysis



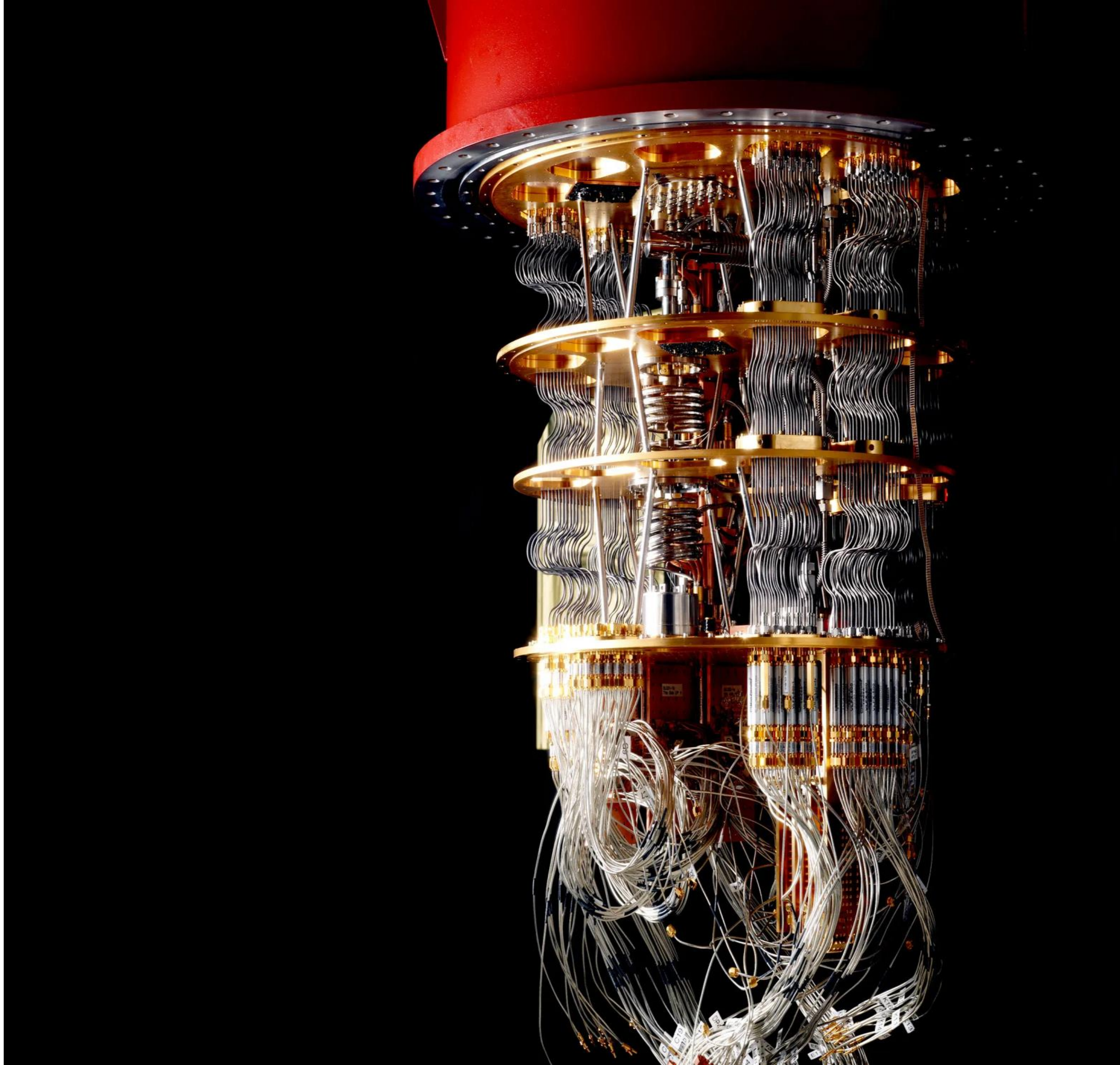
Industry Reports
Standards
Firm's websites
Funding
Field Analysis
Search String
Data Collection
Expert opinion
Delphi
Interviews
Questionnaires
Exploratory Studies
Data Preparation
Data cleansing
Articles
Patents
Coherence Test
Fast Clock Speed
Technology staging
Co-word Analysis
Burst Detection
Shannon Entropy
Mann-Kendal Test
Sen's Slope Test
Ecosystem Mapping
Countries/Authors/Assignees/
Affiliations/Firms/ Funding
Agencies/Disciplines
Trend Identification
Emerging Technology
Evolutionary Analysis
Technology Tree
MST Pathfinding
Logistic
Gompertz
Fisher-Pry
Curve Fitting
Linear Regression
ARIMA
Random Forest
Neural Network
Clustering
(Modularity/ Cosine/ Jaccard)
Science/Technology Gap
Topic Modeling
S-curve Analysis
LDA/ PLSA/
HDP/HLDA
Forecasting
Technology Profiling
Technology Assessment
Roadmapping

How to use results of TF for technology Development?

Step 1. Technology Description:

Provide a concise and clear description of the critical technology, including its purpose, function, and underlying principles.

Explain the unique features or advancements that differentiate it from existing technologies in the market.



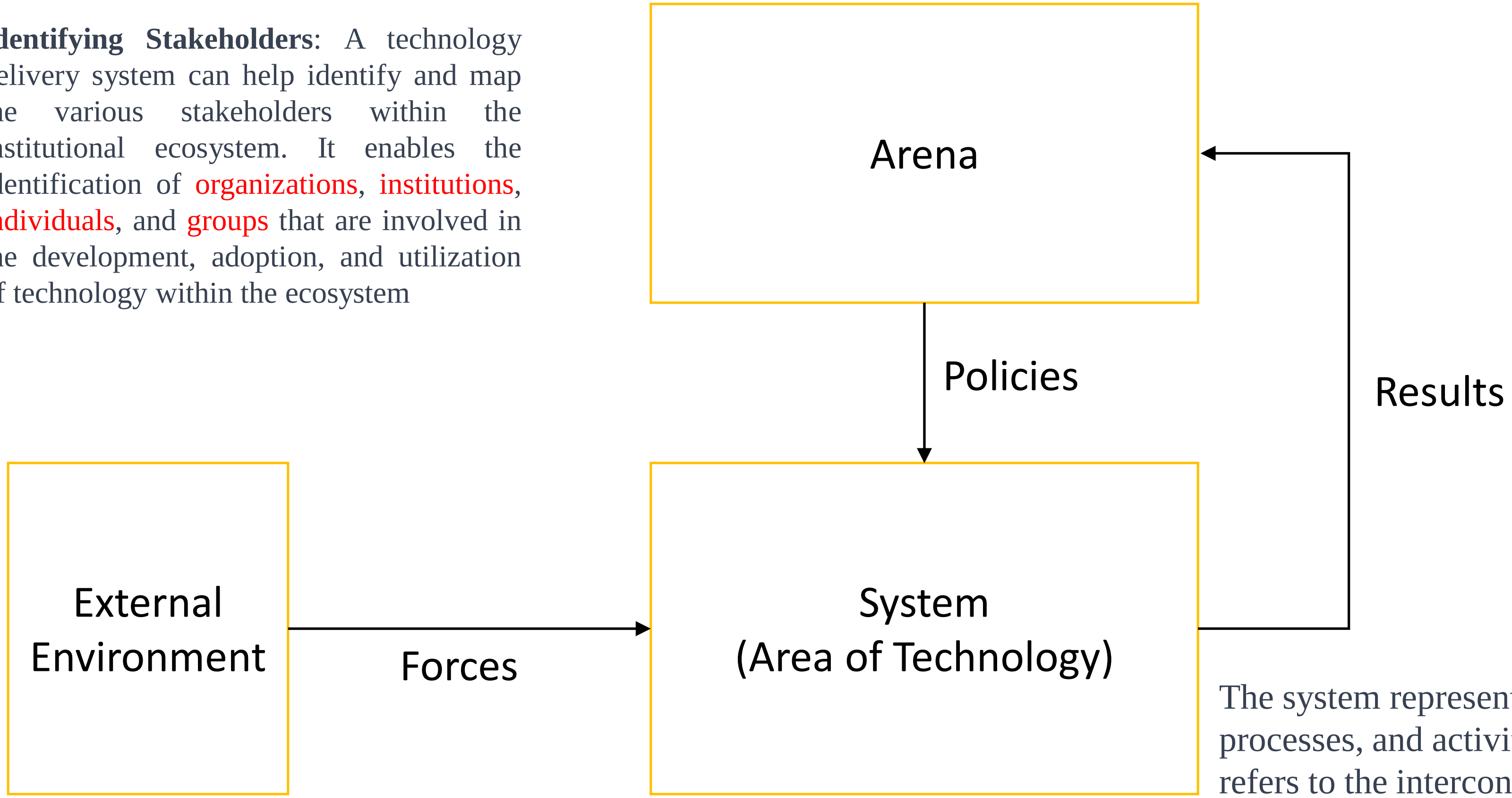
Step 2. Technology Ecosystem Mapping

Mapping ecosystem of Authors, Affiliations, Funds, Owners and countries can help you to find most crucial entities and potential agents for collaboration.

Step 3. Technology Delivery System:

A technology delivery system can play a significant role in mapping the institutional ecosystem of technology by facilitating the identification, analysis, and integration of key components within the ecosystem.

Identifying Stakeholders: A technology delivery system can help identify and map the various stakeholders within the institutional ecosystem. It enables the identification of organizations, institutions, individuals, and groups that are involved in the development, adoption, and utilization of technology within the ecosystem



The system represents the core components, processes, and activities that constitute the TDS. It refers to the interconnected elements and functions involved in delivering technology solutions.
Critical Technologies

The external environment refers to the broader context in which the TDS operates. It encompasses the external factors, forces, and influences that impact the functioning and outcomes of the TDS. The external environment includes factors such as market conditions, industry trends, regulatory frameworks, policy landscapes, socio-economic factors, technological advancements, and cultural considerations.

Case of quantum computing

Arena: could encompass organizations, entities, and stakeholders involved in the development, research, and application of quantum computing technology. This may include technology companies specializing in quantum computing, research institutions, universities, government agencies funding quantum research, regulatory bodies, industry associations, and even end-users or potential beneficiaries of quantum computing solutions.

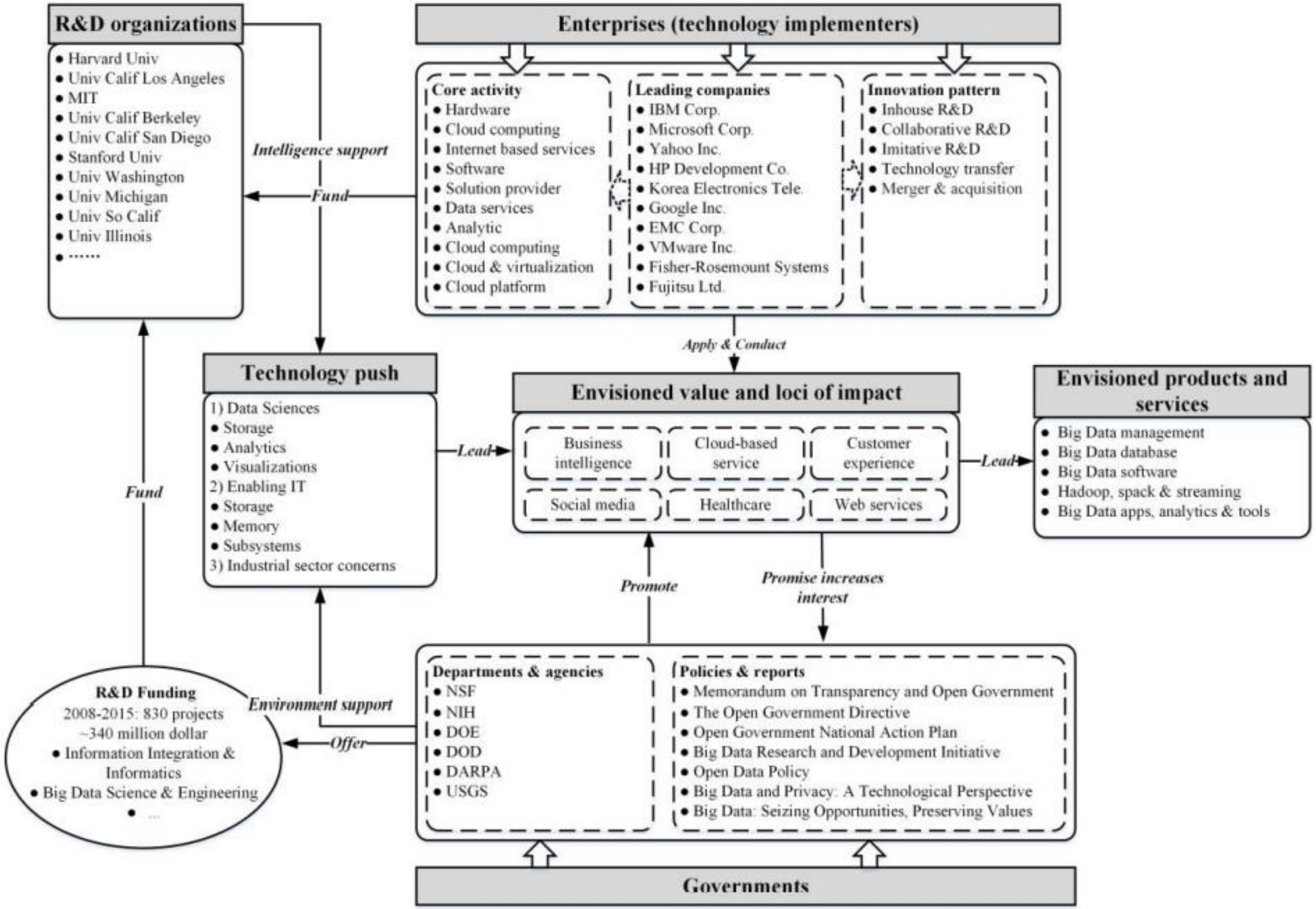
System: The system within the TDS for quantum computing would involve the core components, processes, and activities that facilitate the delivery of quantum computing technology. This includes the identification and analysis of **critical technologies** in the field of quantum computing, **forecasting the future trends** and advancements, research and development efforts to enhance quantum computing capabilities, **designing algorithms** and **programming languages** for quantum computing, building quantum computing **hardware** and **infrastructure**, testing and validation of quantum computing systems, and ultimately, the deployment and utilization of quantum computing solutions in various applications.

External Environment: The external environment for quantum computing within the TDS includes various exogenous forces that can impact the system. These may include factors such as **advancements in quantum physics** and related sciences, **availability of funding for quantum research** and development, **regulatory frameworks and policies governing quantum technology**, **intellectual property rights and patents**, market demand for quantum computing solutions, societal acceptance and ethical considerations, international collaborations and standards, and even public perception and awareness of quantum computing.

(Forces): The external environment for quantum computing can be influenced by various forces that impact the system. These forces may include:
Technological Advancements: Breakthroughs in quantum physics, materials science, and related fields
Market Demand: Increasing demand for advanced computing capabilities in sectors such as cryptography, optimization, drug discovery, and simulation that motivate the exploration and adoption of quantum computing solutions.
Regulatory Landscape: The establishment of policies, guidelines, and regulations related to quantum computing, including intellectual property rights, data security, and ethical considerations.
Funding Availability: The availability of public and private funding for research, development, and commercialization of quantum computing technologies.

(Policies): The arena, which comprises various entities and organizations involved in quantum computing, can impact the system through the formulation and implementation of policies. These policies may include:
Government Funding Initiatives: Governments allocating funds for research grants, academic programs, and industry partnerships to support the development and adoption of quantum computing technologies.
Regulatory Frameworks: Governments and regulatory bodies establishing policies and regulations to address ethical, legal, privacy, and security concerns associated with quantum computing.
Standards Development: Industry associations and international bodies working on the establishment of standards for interoperability, compatibility, and performance evaluation of quantum computing systems.

(Results): The system, which encompasses the activities and components of quantum computing, can impact the arena through its results. These results may include:
Technological Advancements: Breakthroughs in quantum computing hardware, algorithms, error correction methods, and optimization techniques that enhance the capabilities and performance of quantum computing systems.
Commercialization and Applications: Successful deployment and utilization of quantum computing in practical applications, such as optimizing supply chains, solving complex optimization problems, simulating molecular systems, or advancing cryptography.
Collaboration and Partnerships: Collaborative efforts between academia, research institutions, and industry players that foster knowledge sharing, talent development, and innovation in the field of quantum computing.



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A technology delivery system for characterizing the supply side of technology emergence: Illustrated for Big Data & Analytics

Ying Huang [a], Alan L. Porter [b c], Scott W. Cunningham [d], Douglas K.R. Robinson [e], Jianhua Liu [f], Donghua Zhu [a]

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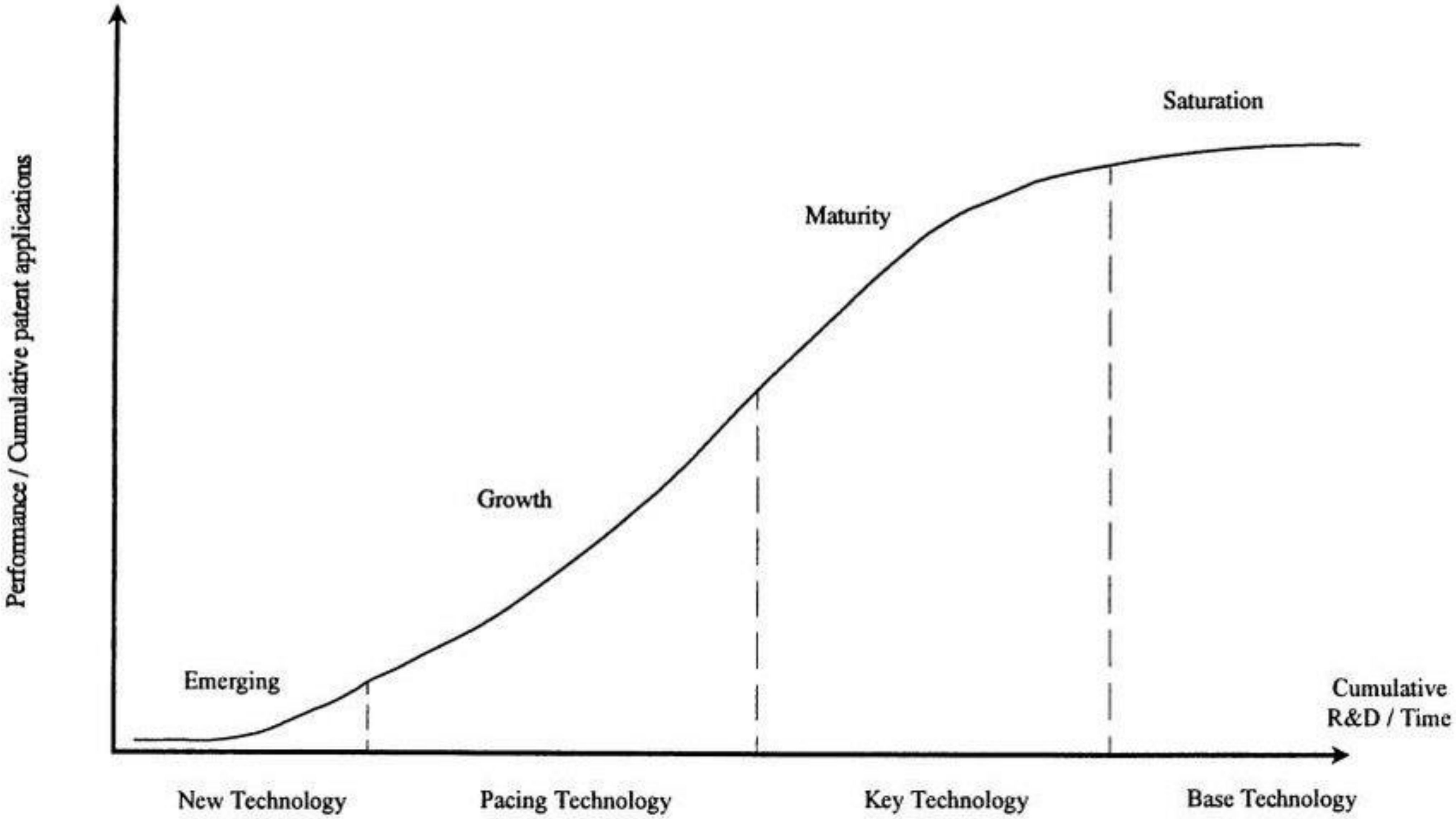
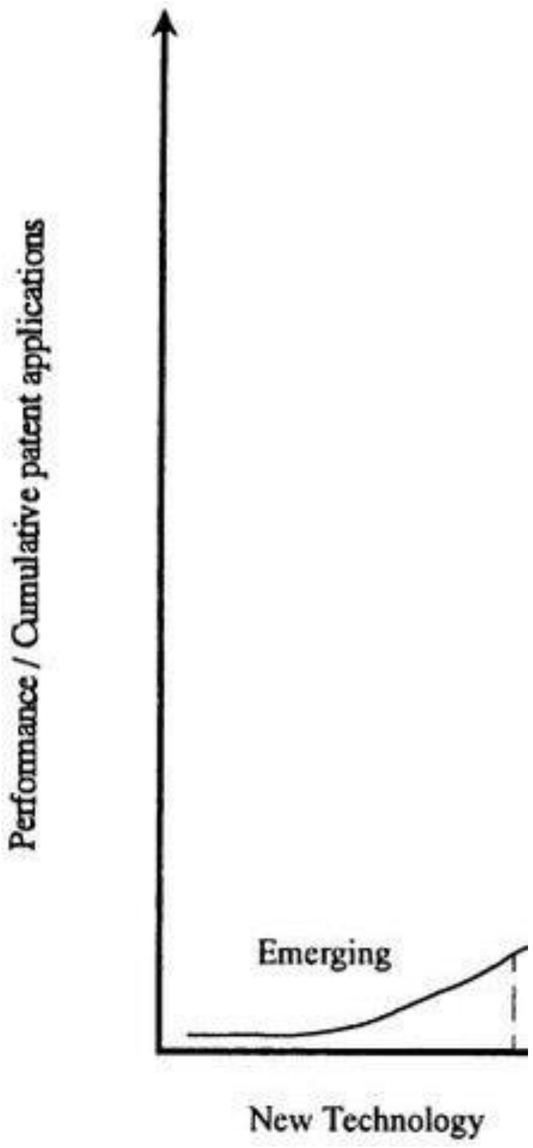
Step 4: Current Stage of Development:
Assess and specify the current stage of development for the technology, such as early research, proof of concept, prototype, pilot, or commercial deployment. Also consider the stage of TLC. Consider the level of maturity, scalability, and readiness for adoption.

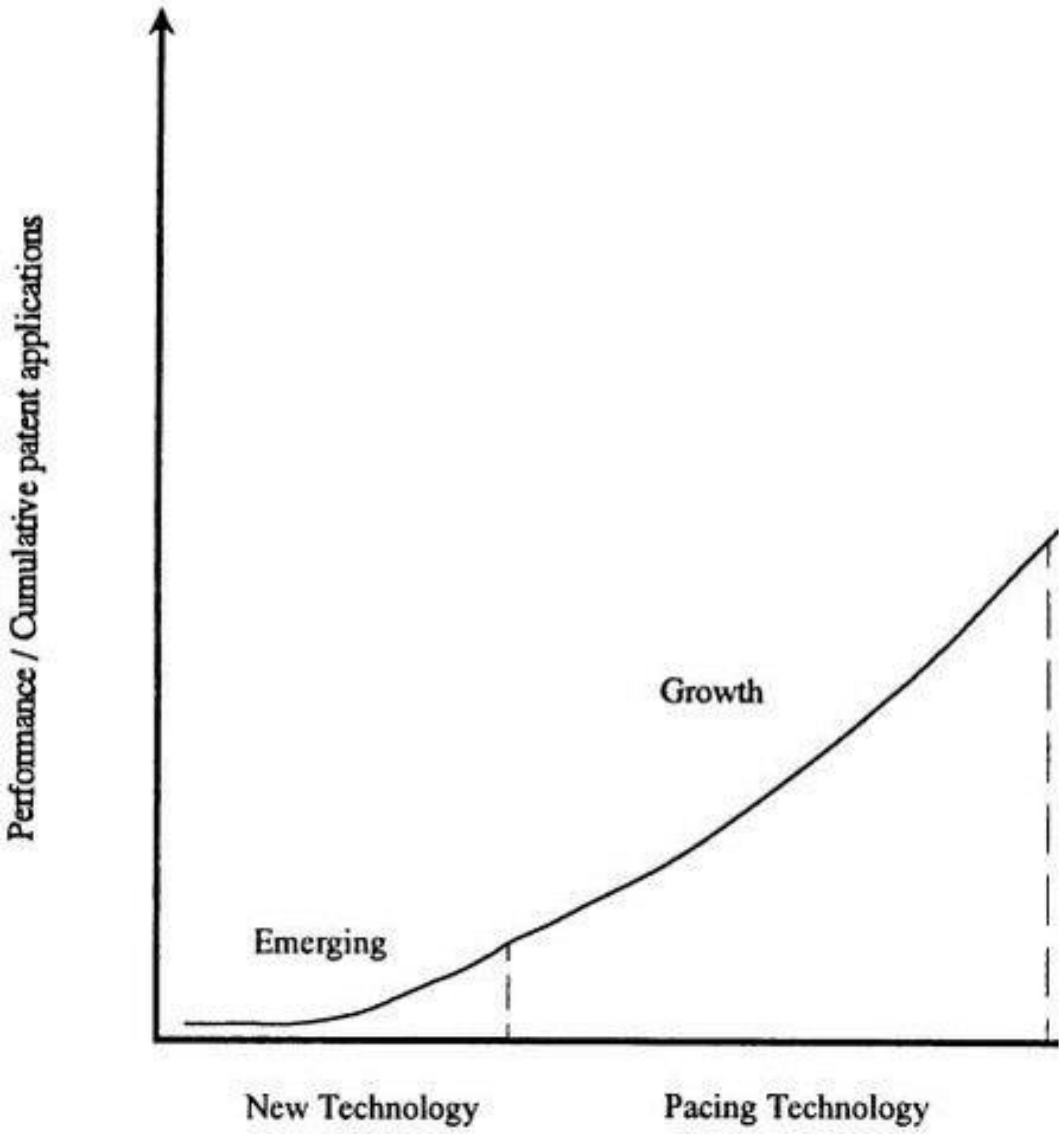




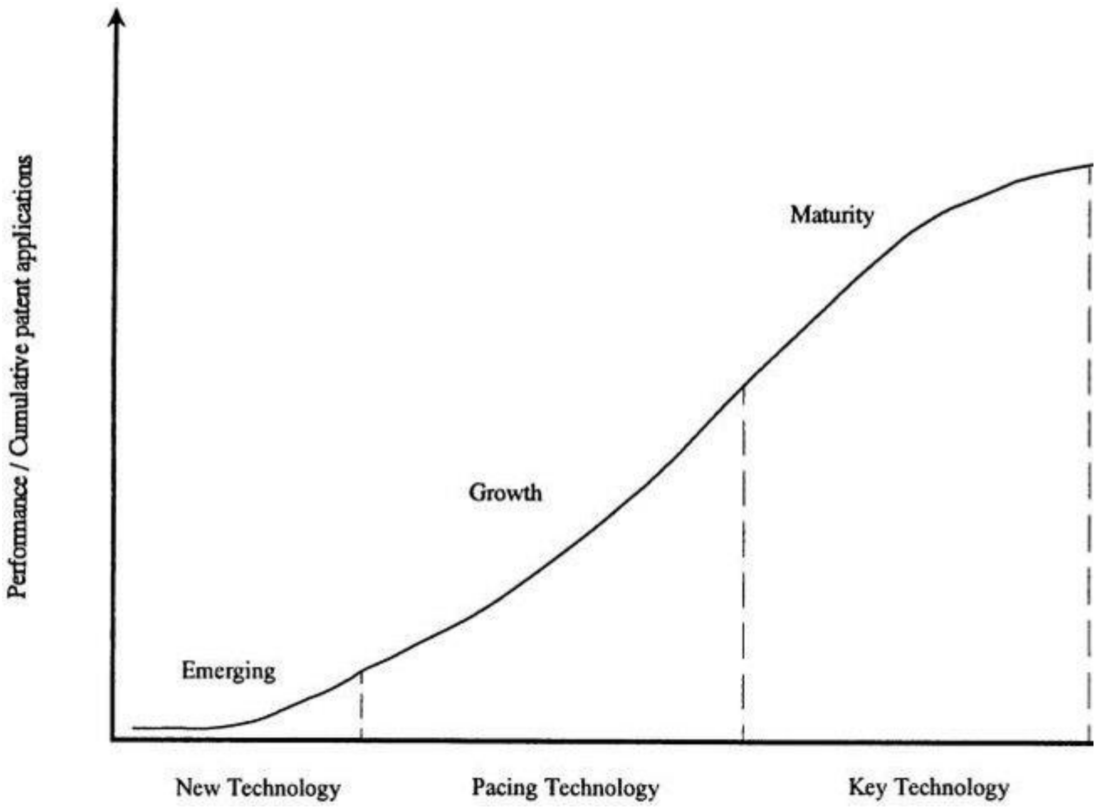
Research Partnerships: Form alliances with research institutions, universities, and other organizations to collaborate on fundamental research, explore new concepts, and share knowledge and resources.

Industry Consortia: Join or establish industry consortia or alliances that bring together multiple stakeholders, including technology developers, suppliers, and end-users, to collaborate on standardization efforts, technology roadmaps, and joint research initiatives.

Open Innovation: Embrace open innovation principles by actively seeking external collaborations, encouraging knowledge sharing, and engaging with external experts and innovators to enhance the development of the technology.



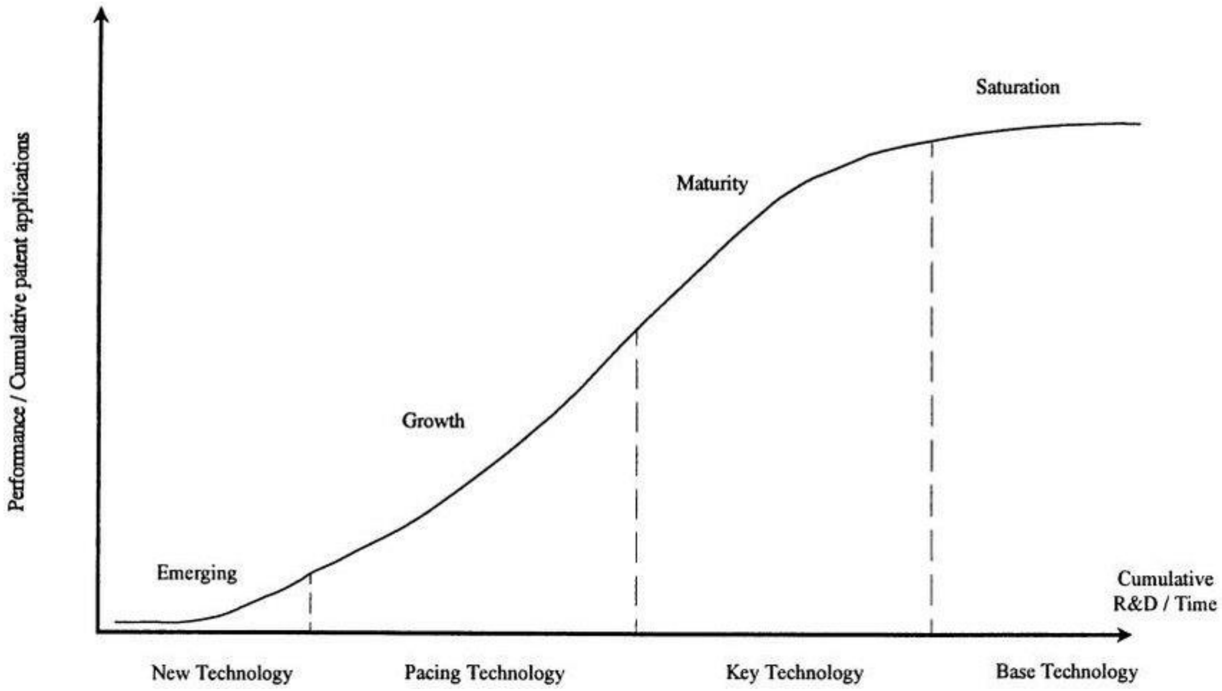
Strategic Partnerships: Forge strategic partnerships with complementary technology providers, suppliers, or distribution channels to leverage synergies, expand market reach, and create integrated solutions that meet customer needs more effectively.
Ecosystem Development: Collaborate with other stakeholders in the industry to build a robust ecosystem around the technology. This includes engaging with software developers, service providers, consultants, and industry associations to collectively drive adoption, develop supporting infrastructure, and create value-added offerings.
Customer Collaboration: Establish partnerships with early adopter customers and engage them in co-development or pilot projects. This collaboration can provide valuable insights, validate technology applications, and enhance the value proposition of the technology.



Strategic Alliances: Form alliances with competitors or other players in the industry to consolidate market presence, share resources, and collectively address common challenges. This could involve joint marketing efforts, cross-licensing agreements, or cooperative R&D initiatives.

Industry Standards: Engage in collaborative efforts to define and establish industry standards that ensure interoperability, compatibility, and seamless integration of the technology within the broader ecosystem. Active participation in standardization bodies or industry consortia can help shape the technology landscape and maintain a competitive advantage.

Customer-Centric Collaboration: Deepen collaboration with customers by involving them in product development, co-creation of solutions, and gathering feedback to continuously improve the technology and align it with evolving market needs.



Diversification Alliances: Seek collaborations with organizations in different industries or sectors to explore new applications or markets for the technology. This can involve joint ventures, strategic partnerships, or mergers and acquisitions to access new customer segments or expand product offerings.

Continuous Innovation: Foster a culture of innovation and collaboration within the organization and across the industry. Actively engage in cross-sector collaborations, open innovation initiatives, or **startup partnerships** to **explore new technologies**, **business models**, or **disruptive approaches** that can rejuvenate the technology's relevance in the market.

Market Consolidation: Assess market dynamics and consider strategic alliances or acquisitions to consolidate market share, streamline operations, and eliminate competition. This strategy aims to strengthen the position of the technology in the face of market saturation and intensifying competition.

Step 5. Market Potential

Analyze the market potential and demand for the technology.

Evaluate the target market size, growth rate, and the specific needs or challenges the technology addresses.

Identify potential industry applications and sectors that can benefit from the technology.

Step 6. Competitive Landscape

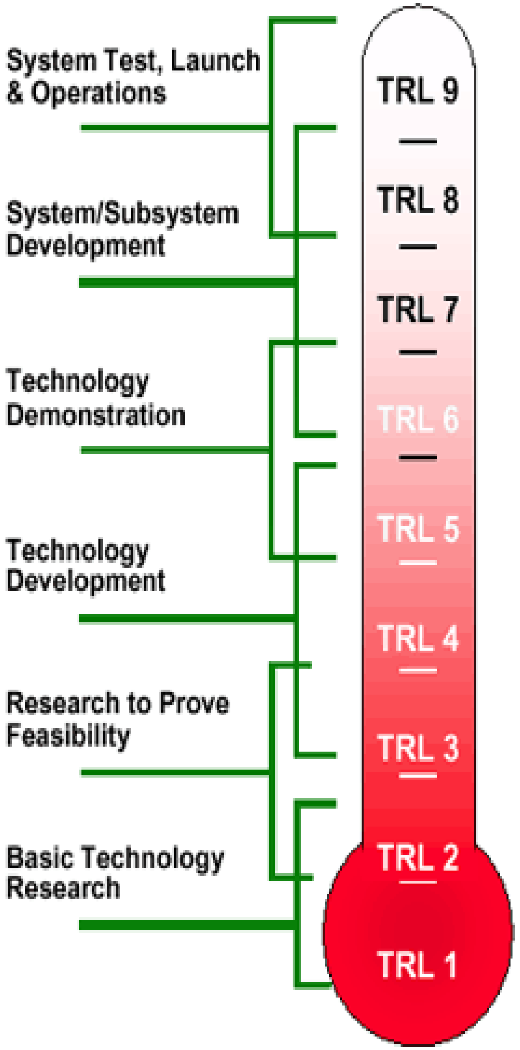
Identify key competitors or alternative solutions in the market.

Evaluate the strengths, weaknesses, and differentiation factors of the critical technology compared to competitors.

Assess any intellectual property protections or barriers to entry.

Step 7. Technical Feasibility

Assess the technical feasibility of the critical technology.
Consider factors such as technological complexity, scalability, reliability, interoperability, and potential constraints or challenges.
Evaluate the level of existing infrastructure or ecosystem required to support the technology.



The technology has been successfully deployed and proven in its operational environment.

The technology has been fully developed, qualified, and is ready for operational deployment.

A prototype has been successfully demonstrated and tested in an operational environment, closely representing real-world conditions.

A system-level prototype of the technology has been tested and evaluated in a relevant environment, showing its integration and functionality within a broader system context.

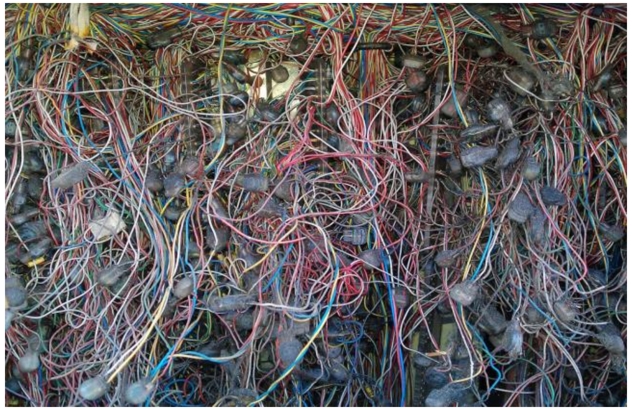
A prototype of the technology has been tested in a relevant or simulated environment to evaluate its performance under realistic conditions.

A laboratory prototype has been tested in a controlled environment, demonstrating the technology's performance and functionality.

A proof-of-concept prototype has been developed to demonstrate the basic functionality of the technology under controlled laboratory conditions.

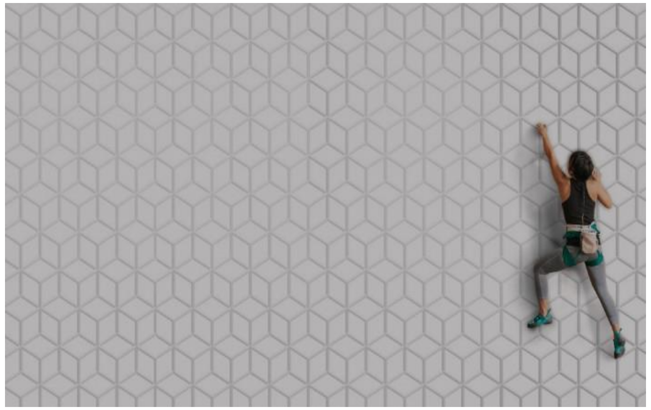
The technology concept has been formulated, and initial experiments or simulations have been conducted to validate its feasibility.

The technology is in the conceptual or theoretical stage, where basic scientific principles are being explored. Technical feasibility has not been demonstrated yet.



Technological Complexity

A complex technology could be a deep learning neural network for image recognition

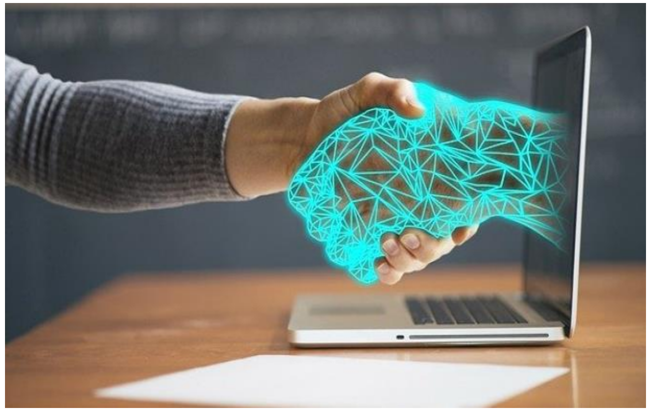


Technological Scalability

A scalable technology could be a cloud computing platform for hosting web applications

Technological Reliability

Reliability can be assessed for a self-driving car's sensor system



Technological Interoperability

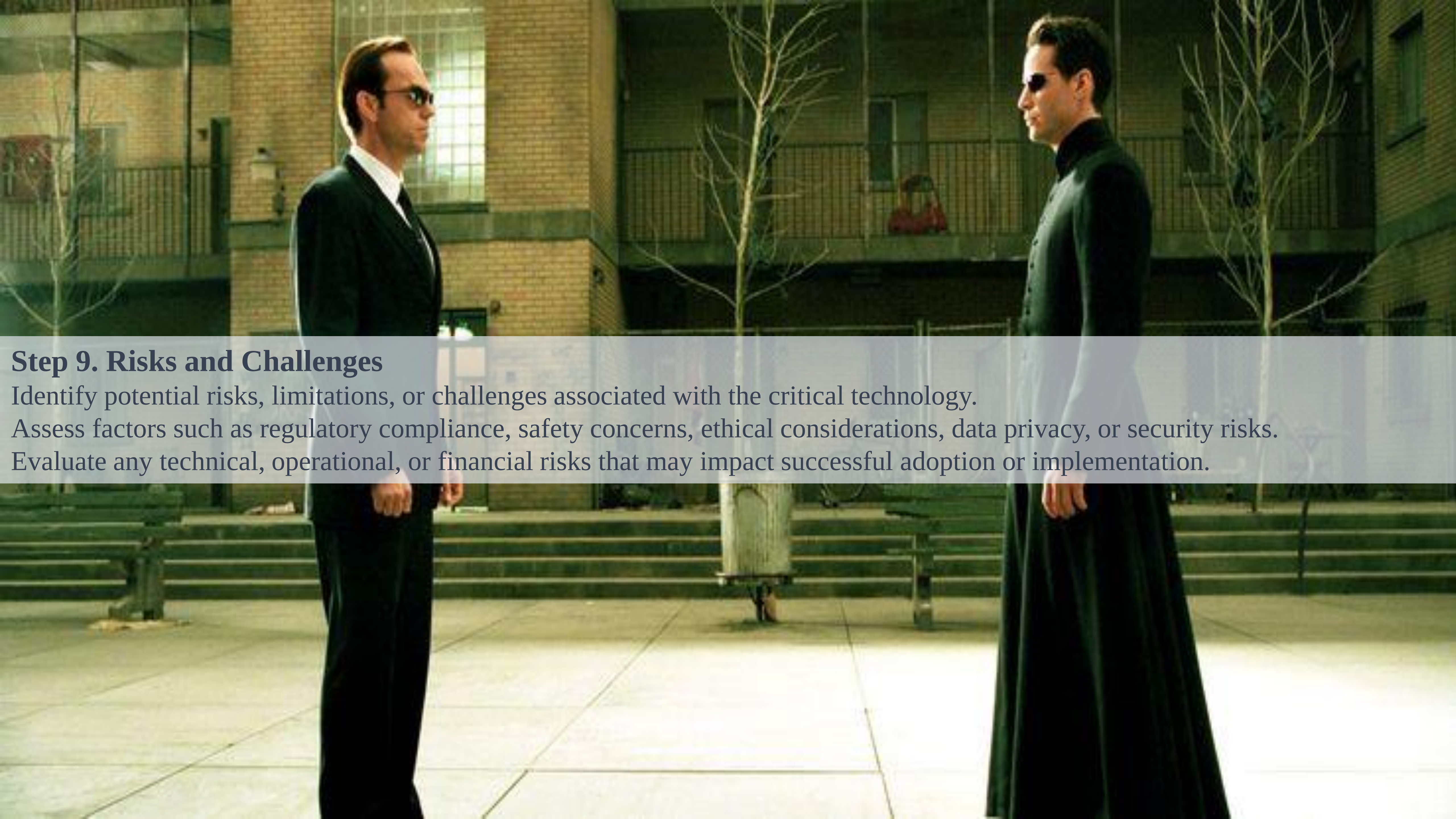
Interoperability can be evaluated for a smart home ecosystem where multiple devices from different manufacturers need to seamlessly communicate with each other.

Step 8. Potential Benefits and Impact

Identify and quantify the potential benefits and impacts of the technology.

Assess how the technology can improve efficiency, effectiveness, productivity, sustainability, or user experience.

Consider the potential economic, social, and environmental implications.



Step 9. Risks and Challenges

Identify potential risks, limitations, or challenges associated with the critical technology.
Assess factors such as regulatory compliance, safety concerns, ethical considerations, data privacy, or security risks.
Evaluate any technical, operational, or financial risks that may impact successful adoption or implementation.

Step 10. Strategic Alignment

Determine the strategic fit and alignment of the critical technology with the organization's goals, vision, and core competencies.
Assess how the technology supports and enhances the organization's competitive advantage or addresses specific strategic priorities.
Consider the potential synergies with existing technologies or capabilities.

Step 11. Implementation Plan:

•Develop an implementation plan that outlines the steps, timeline, and resources required to integrate the critical technology into the organization.

•Consider factors such as research and development, partnerships, funding, talent acquisition, and change management.

•Identify key milestones and performance indicators to track progress and success.