

# AI in FinTech: Metaverse, Web3, DeFi, NFT, Generative AI and Agentic AI for Financial Innovation Applications

1142AIFQA02

MBA, IM, NTPU (M5147) (Spring 2026)

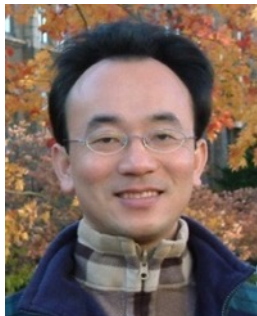
Tue 5, 6, 7 (13:10-16:00) (B3F17)



[https://meet.google.com/  
miy-fbif-max](https://meet.google.com/miy-fbif-max)

 **NVIDIA**  
University Ambassador  
Certified Instructor

 **aws** educate | Cloud  
Ambassador  
2020 Cohort



**Min-Yuh Day, Ph.D,**  
**Professor and Director**

**Institute of Information Management, National Taipei University**

<https://web.ntpu.edu.tw/~myday>



# Syllabus

Week	Date	Subject/Topics
1	2026/02/24	Introduction to Artificial Intelligence in Finance and Quantitative Analysis
2	2026/03/03	AI in FinTech: Metaverse, Web3, DeFi, NFT, Generative AI and Agentic AI for Financial Innovation Applications
3	2026/03/10	Investing Psychology and Behavioral Finance
4	2026/03/17	Event Studies in Finance
5	2026/03/24	Case Study on AI in Finance and Quantitative Analysis I
6	2026/03/31	Finance Theory and Data-Driven Finance

# Syllabus

**Week Date Subject/Topics**

7 2026/04/07 Make-up holiday for NTPU Sports Day (No Classes)

**8 2026/04/14 Midterm Project Report**

**9 2026/04/21 Financial Econometrics**

**10 2026/04/28 AI-First Finance**

**11 2026/05/05 Industry Practices of AI in Finance and  
Quantitative Analysis**

**12 2026/05/12 Case Study on AI in Finance and Quantitative Analysis II**

# Syllabus

<b>Week</b>	<b>Date</b>	<b>Subject/Topics</b>
<b>13</b>	<b>2026/05/19</b>	<b>Deep Learning in Finance; Reinforcement Learning in Finance; Generative AI and Agentic AI in Finance</b>
<b>14</b>	<b>2026/05/26</b>	<b>Algorithmic Trading; Risk Management; Trading Bot and Event-Based Backtesting</b>
<b>15</b>	<b>2026/06/02</b>	<b>Final Project Report I</b>
<b>16</b>	<b>2026/06/09</b>	<b>Final Project Report II</b>

**AI in FinTech:  
Metaverse,  
Web3, DeFi, NFT,  
Generative AI and Agentic AI  
for Financial Innovation  
Applications**

**AI**

**in**

**FinTech**

# FinTech ABCD

**A**I

**B**lock Chain

**C**loud Computing

Big **D**ata

# Decentralized Finance (DeFi)

## Block Chain Financial Technology

**Block Chain & Bitcoin  
(BTC)**

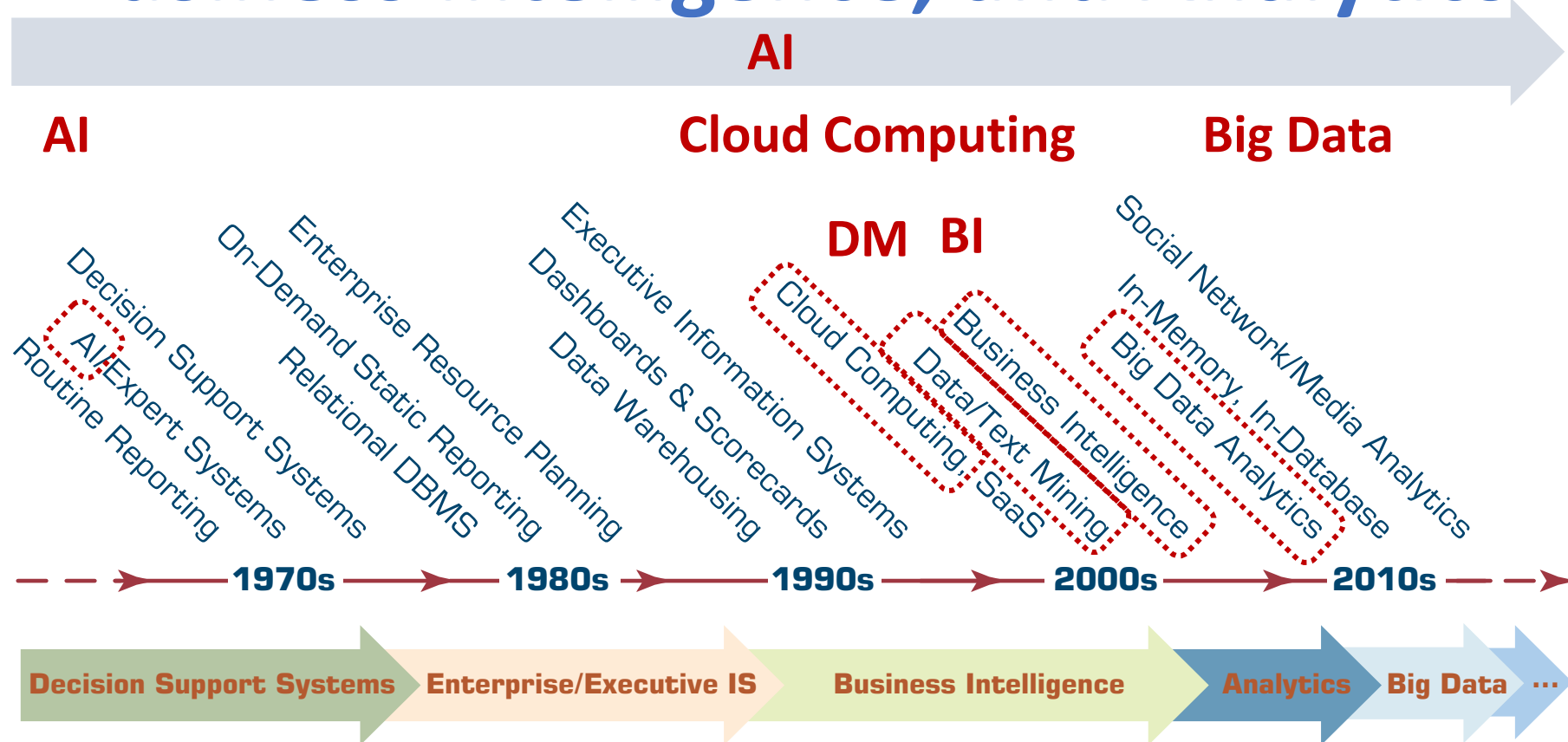
**Smart Contract & Ethereum  
(ETH)**

**Decentralized Application  
(DApp)**

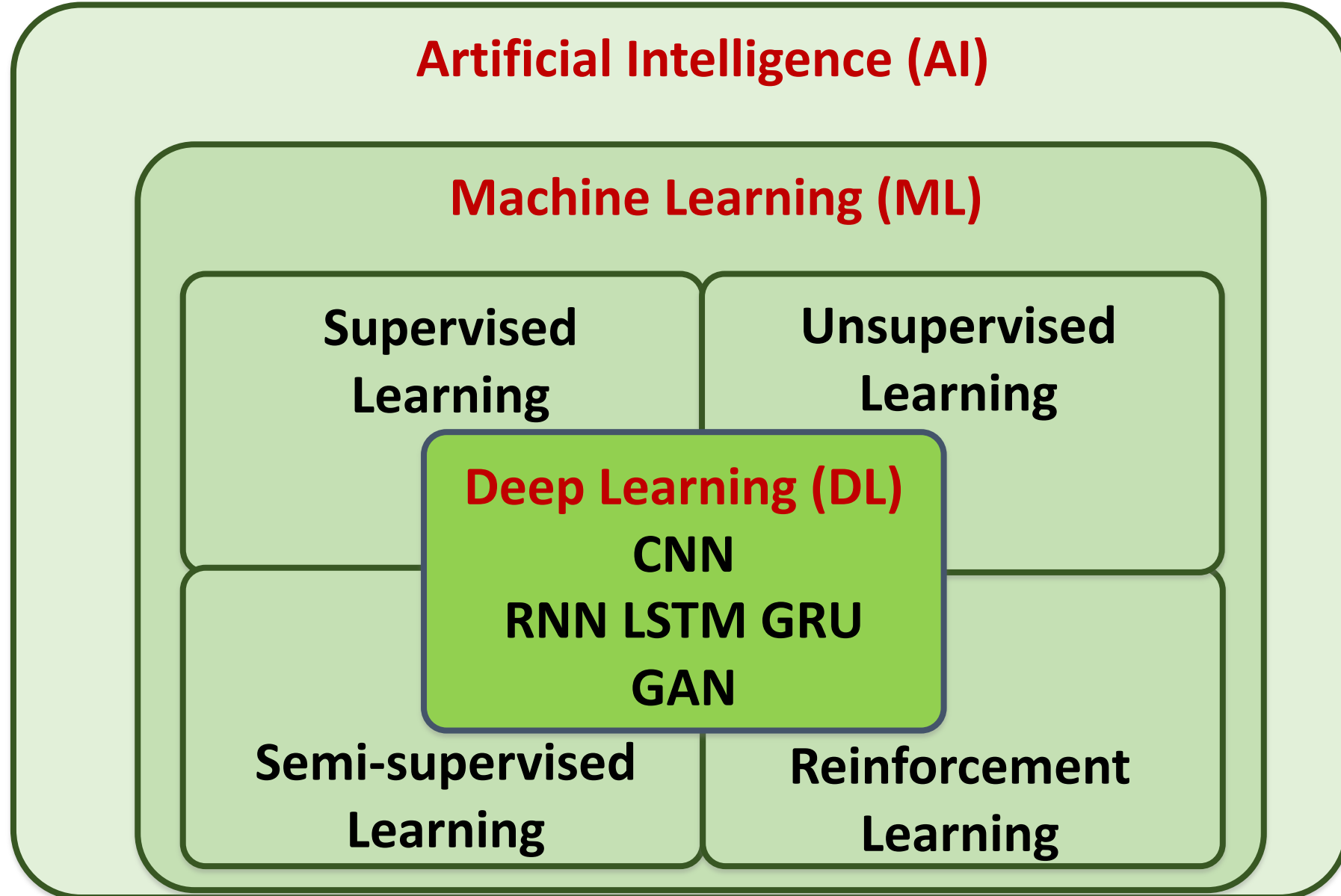
# Artificial Intelligence (AI)

# AI, Big Data, Cloud Computing

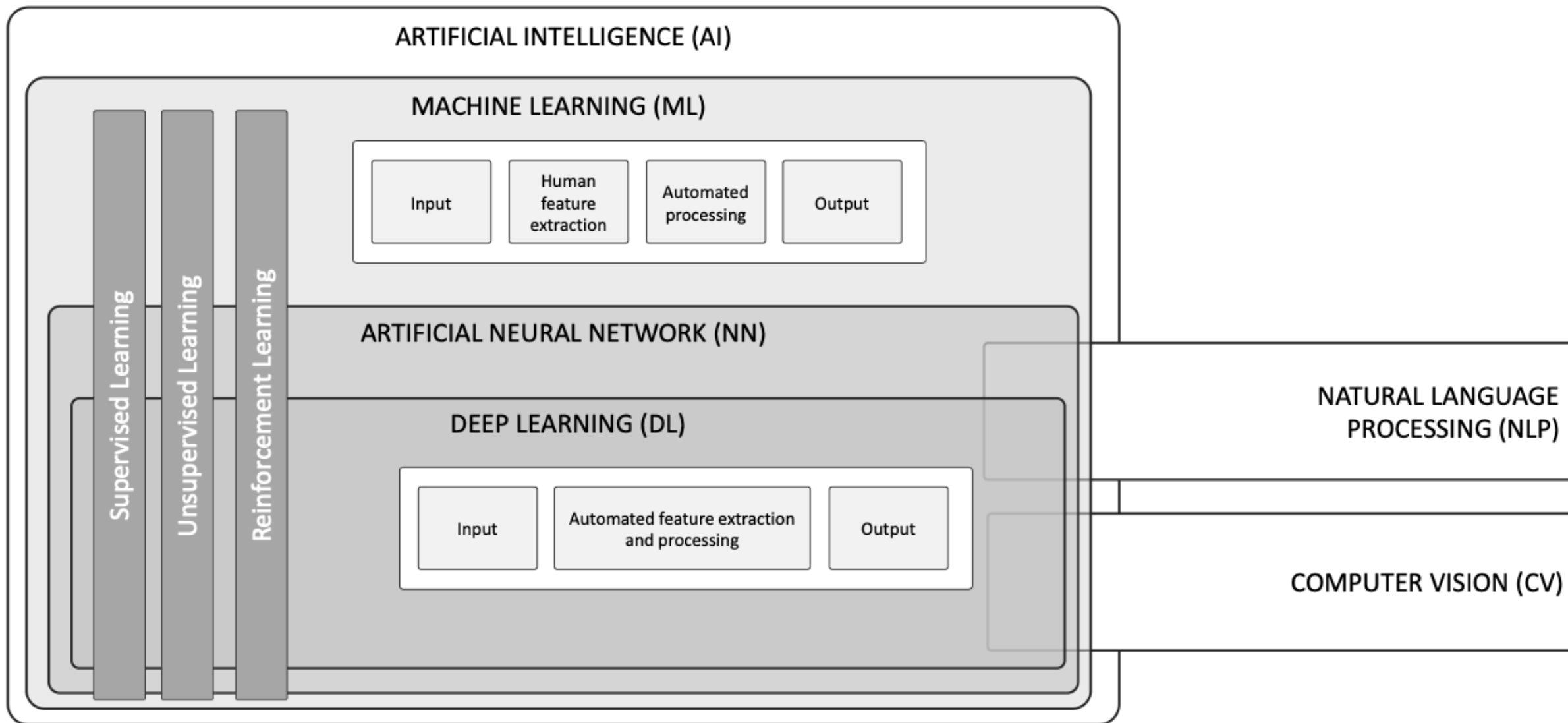
## Evolution of Decision Support, Business Intelligence, and Analytics



# AI, ML, DL

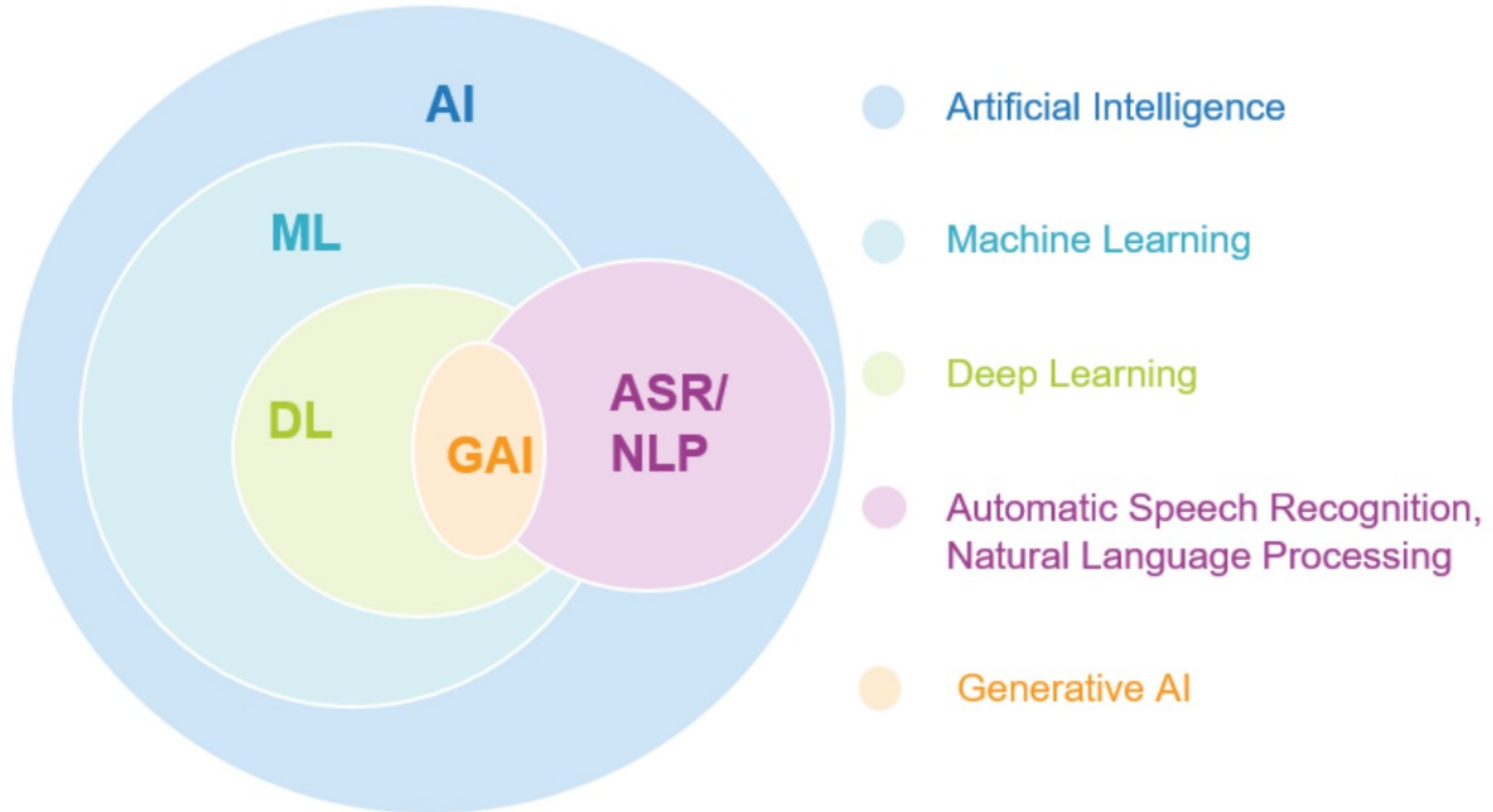


# AI, ML, NN, DL



Source: Schoormann, T., Strobel, G., Möller, F., Petrik, D., & Zschech, P. (2023).

# AI, ML, DL, Generative AI



# Generative AI, Agentic AI, Physical AI

## Physical AI

Self-driving cars  
General robotics

## Agentic AI

Coding assistants  
Customer service  
Patient care

## Generative AI

Digital marketing  
Content creation

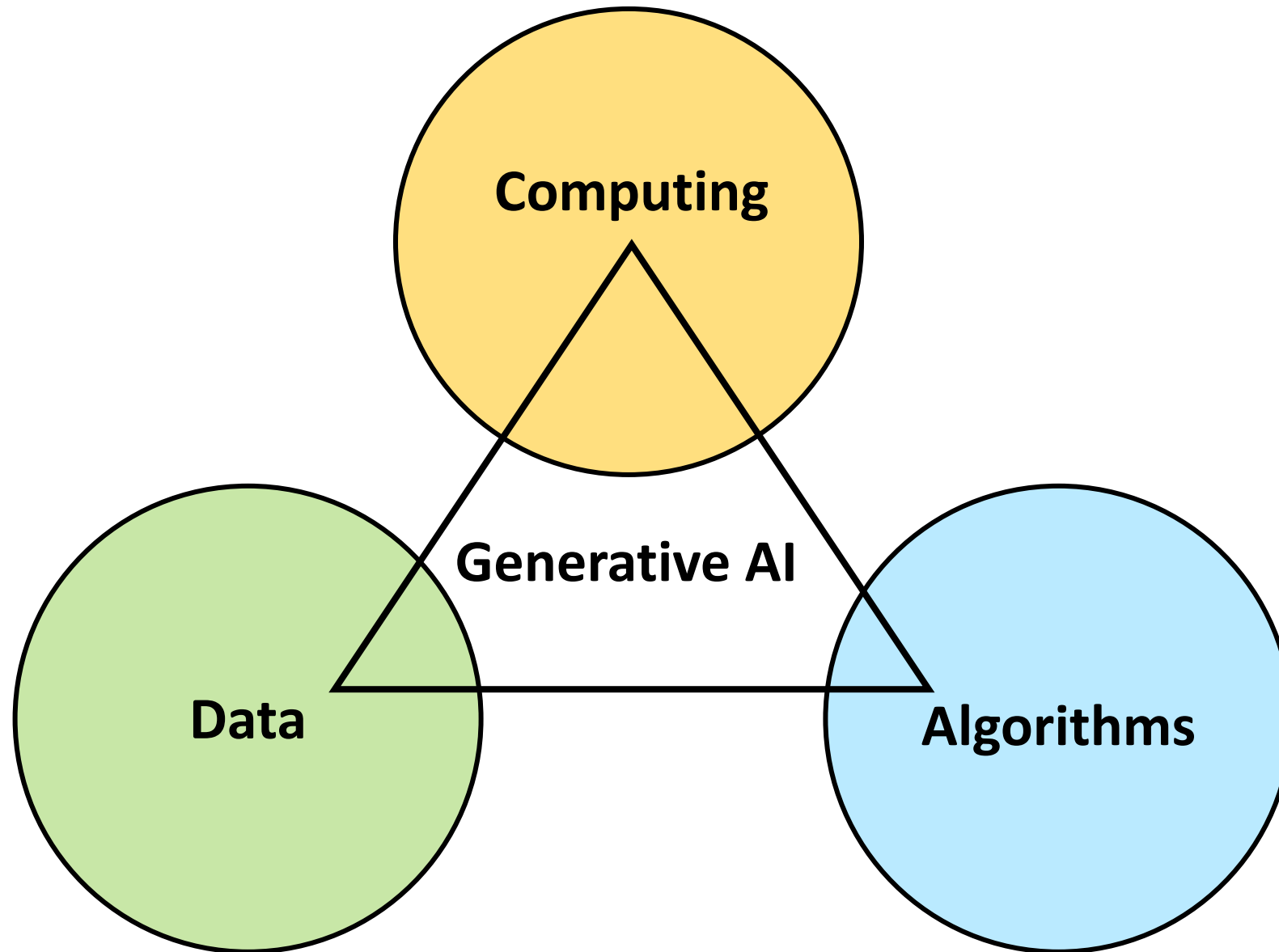
## Perception AI

Speech recognition  
Deep recommender systems  
Medical imaging

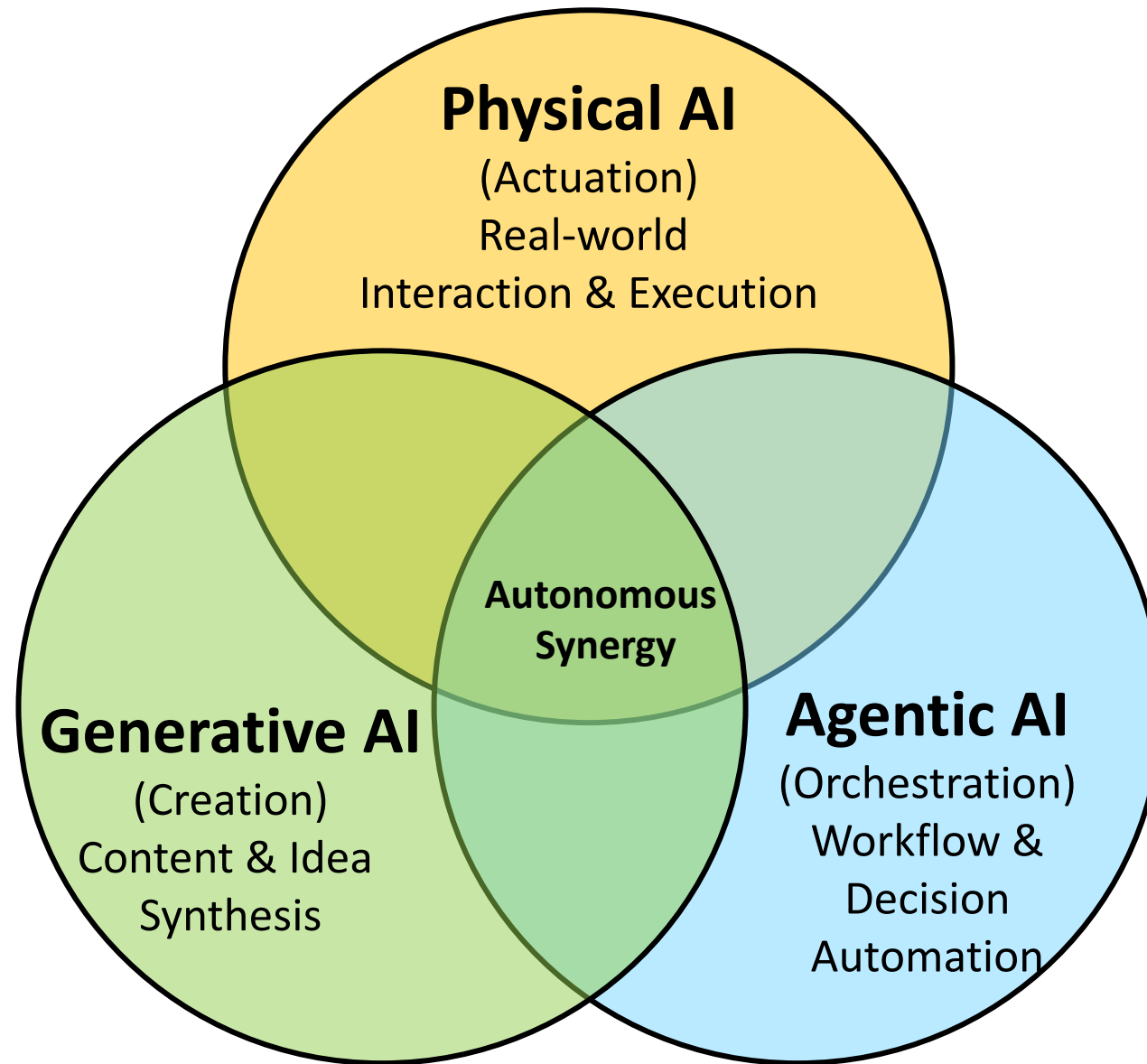
## 2012 AlexNet

Deep learning breakthrough

# Generative AI



# Generative AI, Agentic AI, Physical AI

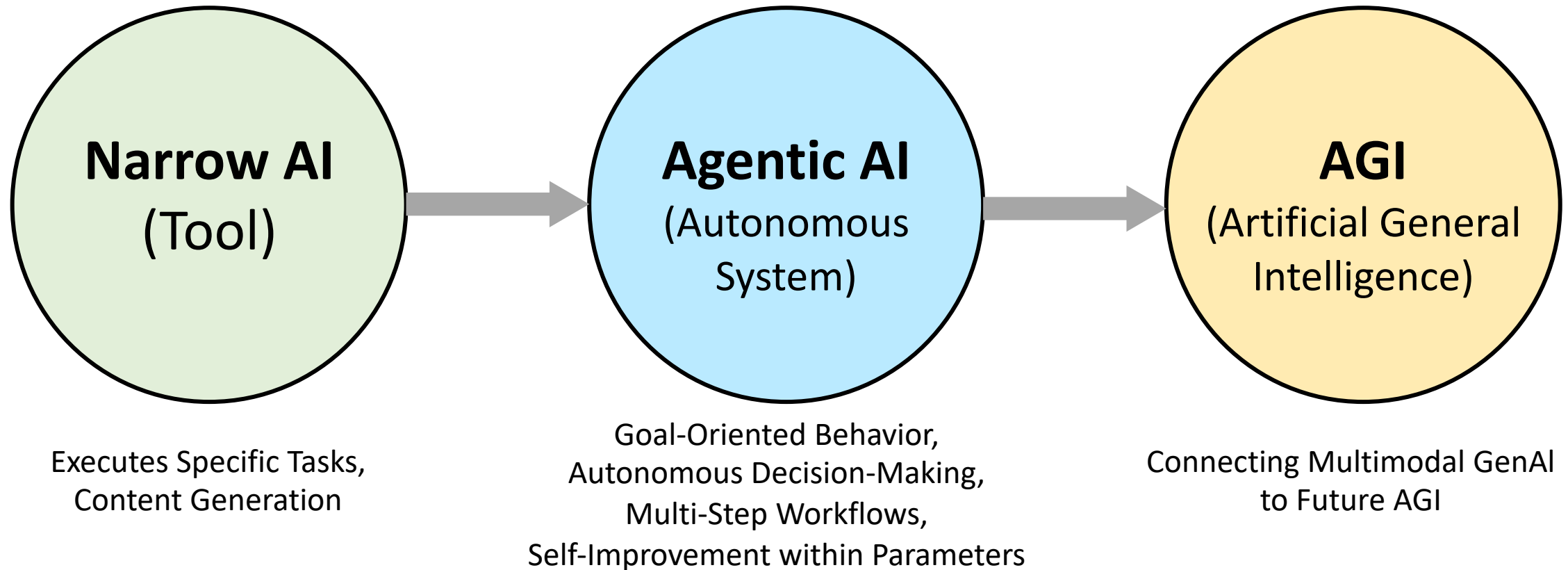


**New Economic  
Paradigm Shift:  
From Creation  
to Execution**

# The Future of AI

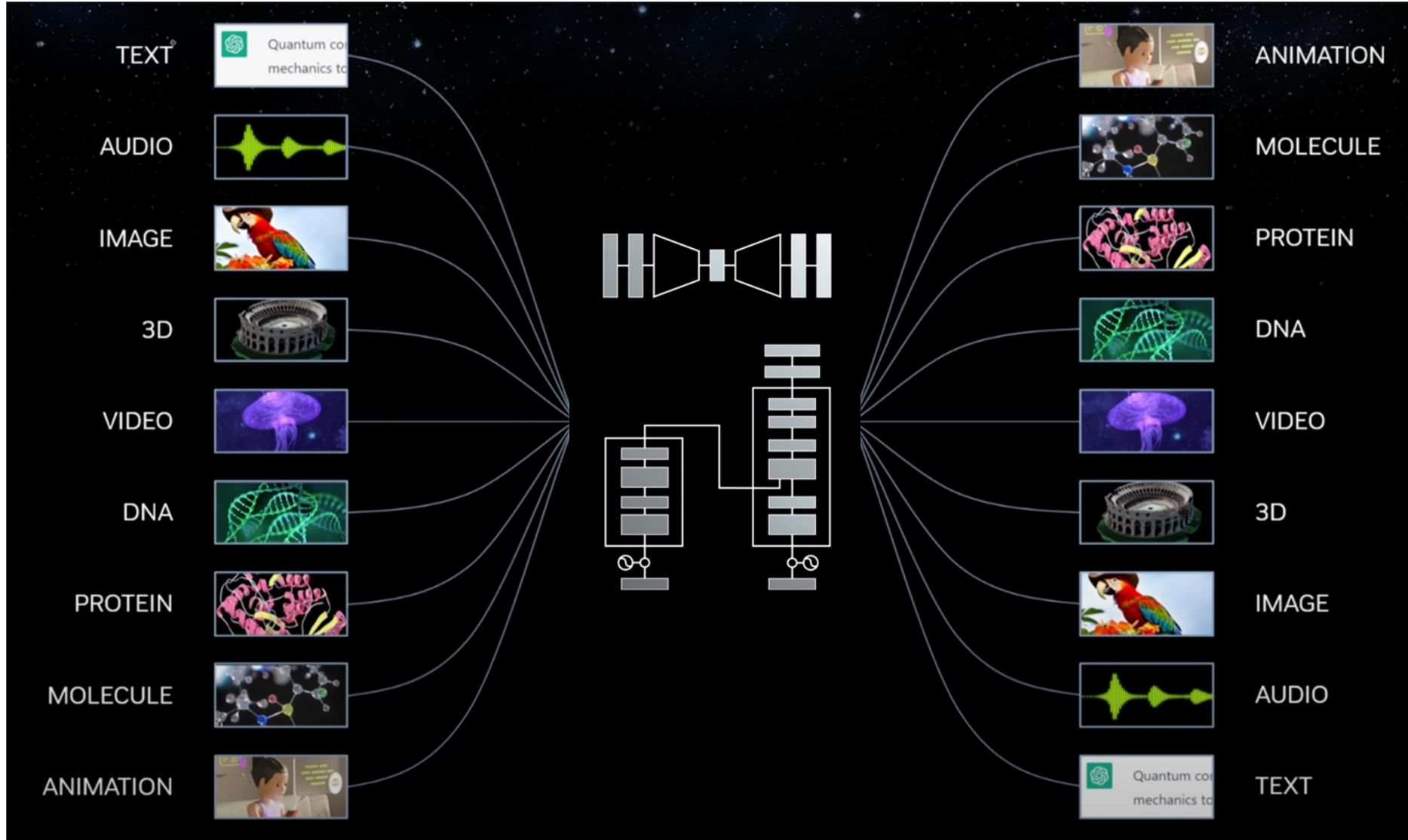
## From Tools to Agents:

### The Rise and Autonomy of Agentic AI

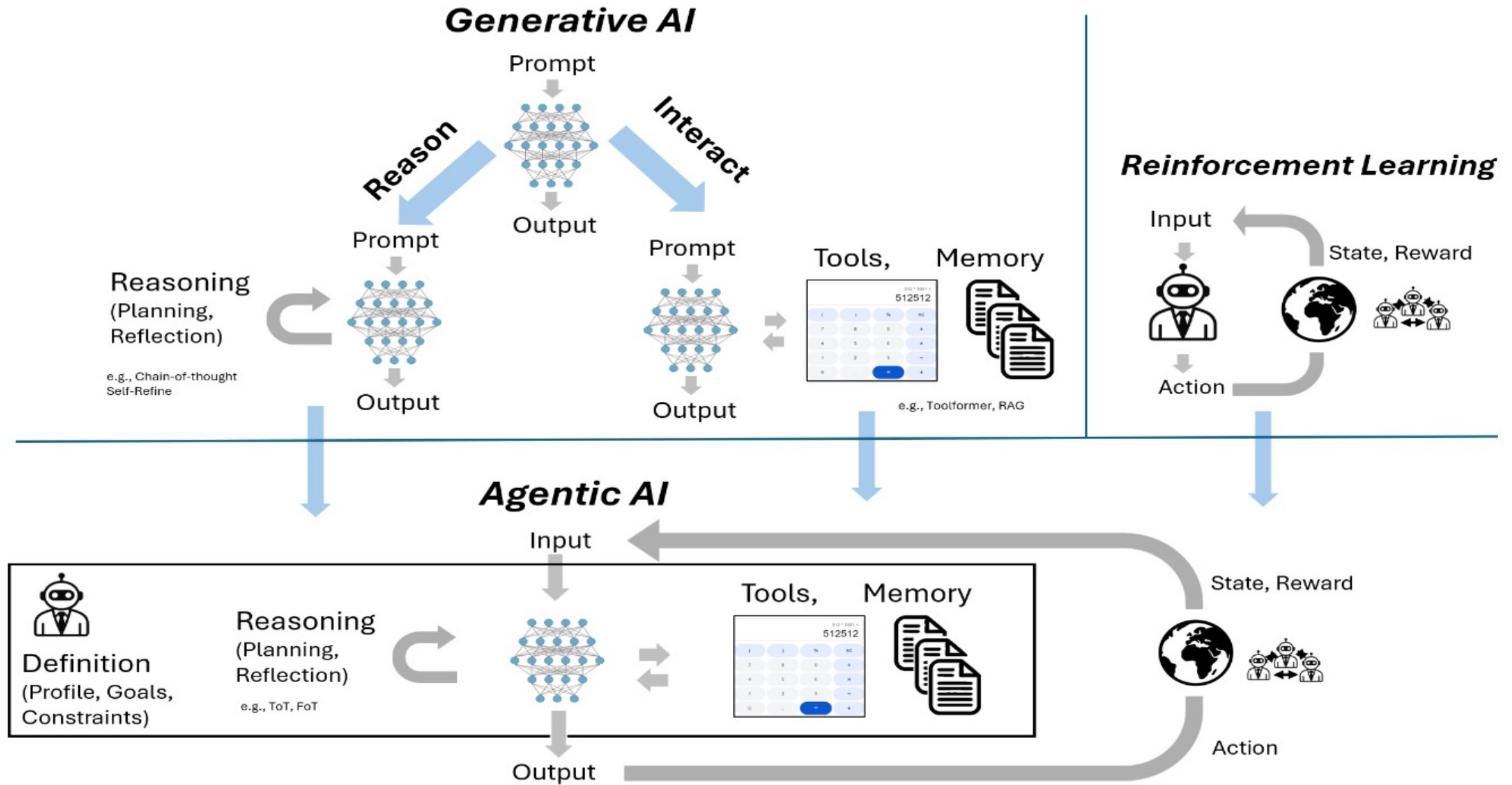


# Modular Modalities

## Where Can The Transformer Fit?



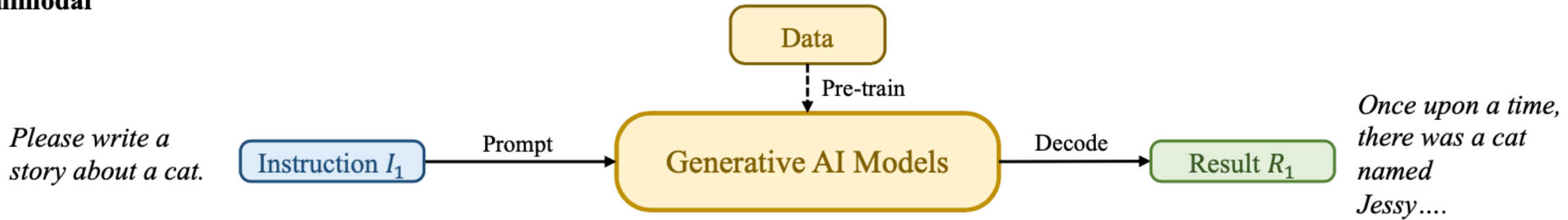
# From Generative AI to Agentic AI



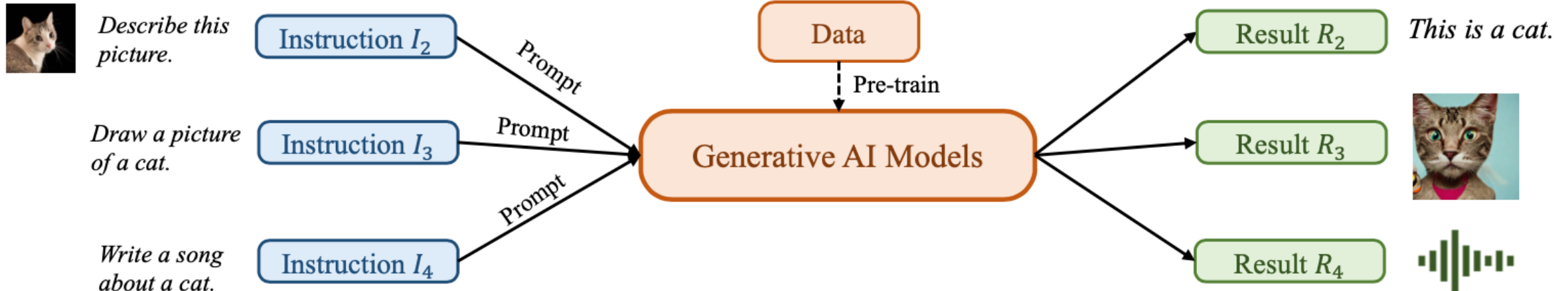
# Generative AI (Gen AI)

## AI Generated Content (AIGC)

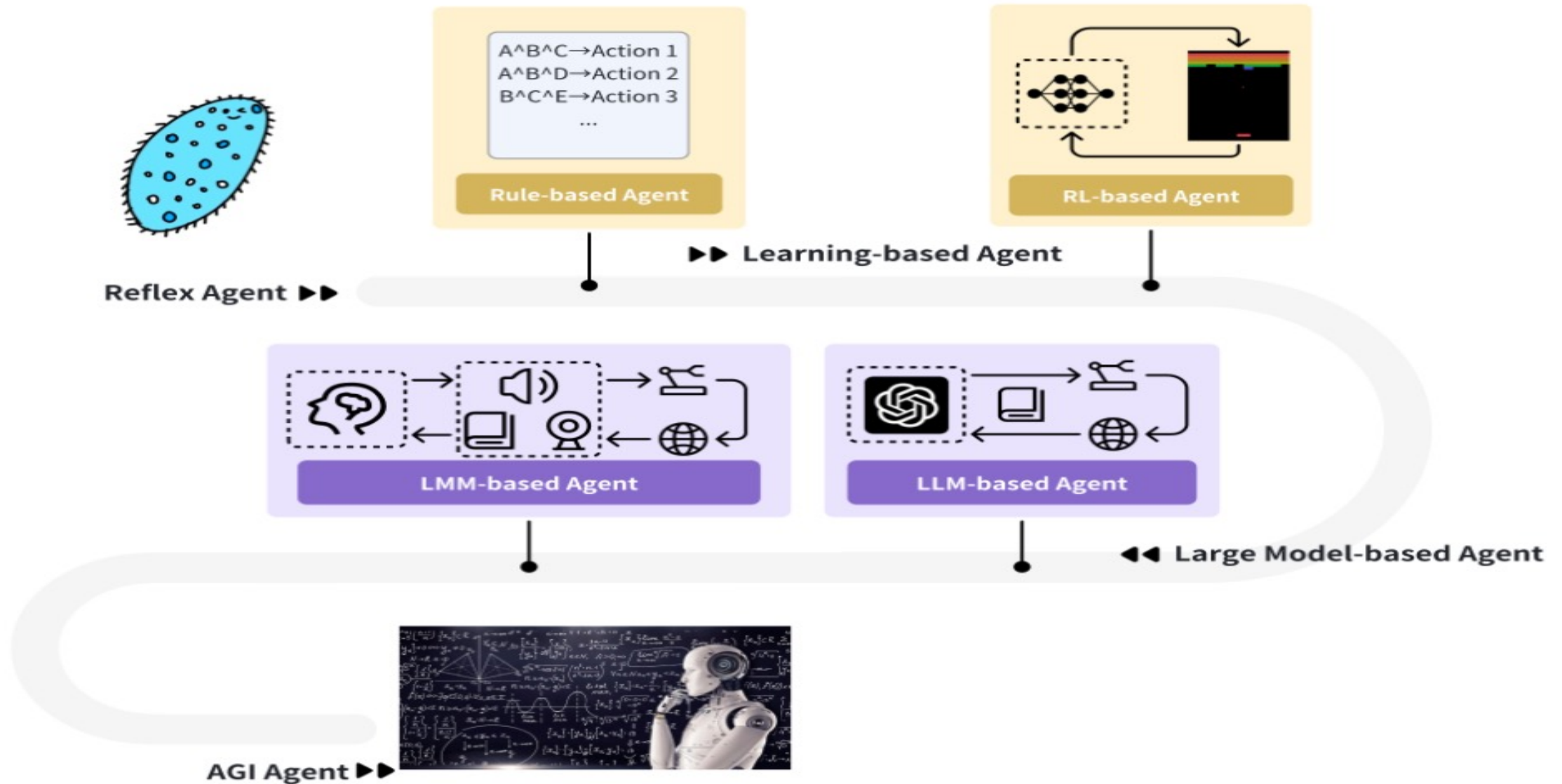
### Unimodal



### Multimodal



# Intelligent Agents Roadmap



# AI Agents

- **Traditional AI Agents**

- **Simple reflex agents**
- **Model-based reflex agents**
- **Goal-based agents**
- **Utility-based agents**
- **Learning agents**

- **Evolution of AI Agents**

- **LLM-based Agents**
- **Multi-modal agents**
- **Embodied AI agents in virtual environments**
- **Collaborative AI agents**

# **Definition of Artificial Intelligence (A.I.)**

# Artificial Intelligence

**“... the science and  
engineering  
of  
making  
intelligent machines”**

**(John McCarthy, 1955)**

# Artificial Intelligence

**“... technology that  
thinks and acts  
like humans”**

# Artificial Intelligence

**“... intelligence  
exhibited by machines  
or software”**

# 4 Approaches of AI

<b>Thinking Humanly</b>	<b>Thinking Rationally</b>
<b>Acting Humanly</b>	<b>Acting Rationally</b>

# 4 Approaches of AI

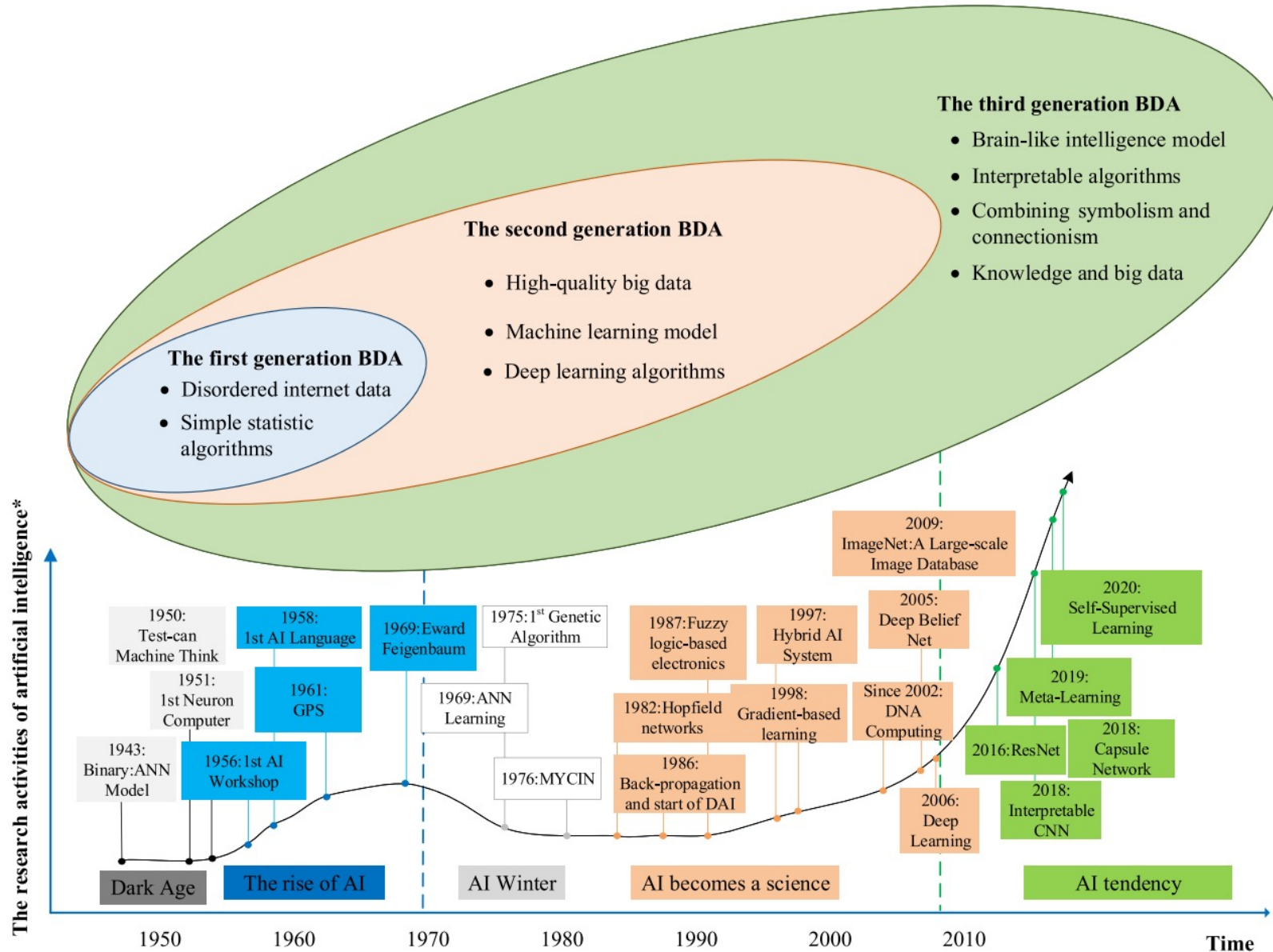
<p><b>2.</b> <b>Thinking Humanly: The Cognitive Modeling Approach</b></p>	<p><b>3.</b> <b>Thinking Rationally: The “Laws of Thought” Approach</b></p>
<p><b>1.</b> <b>Acting Humanly: The Turing Test Approach</b> (1950)</p>	<p><b>4.</b> <b>Acting Rationally: The Rational Agent Approach</b></p>

# AI Acting Humanly: The Turing Test Approach

(Alan Turing, 1950)

- Knowledge Representation
- Automated Reasoning
- Machine Learning (ML)
  - Deep Learning (DL)
- Computer Vision (Image, Video)
- Natural Language Processing (NLP)
- Robotics

# AI and Big Data Analytics (BDA)



# FinTech

# Financial Technology

## FinTech

**“providing  
financial services  
by making use of  
software and  
modern technology”**

# Financial Technology

# Financial Services

# FinTech: Financial Services Innovation



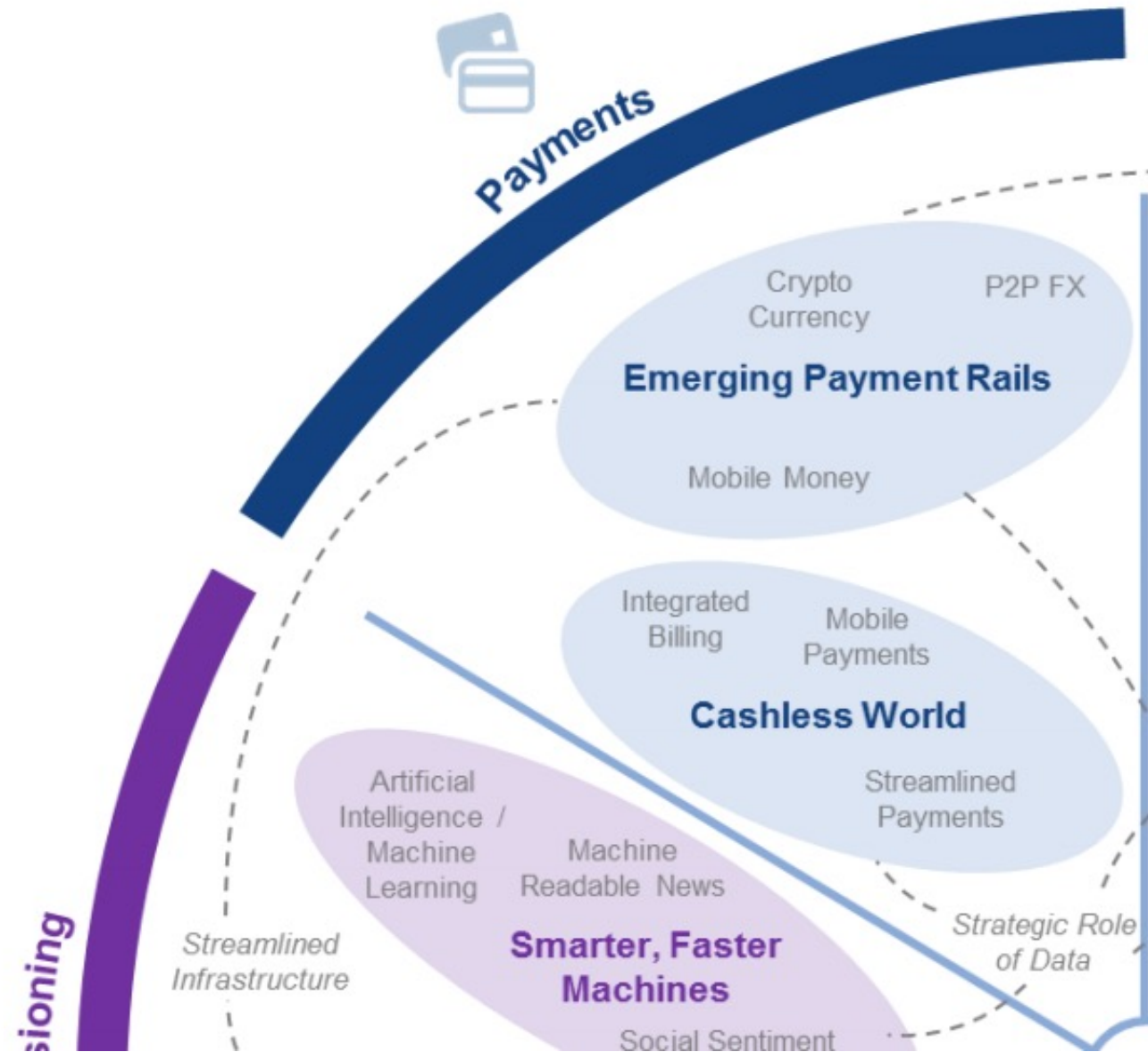
# **FinTech:**

## **Financial Services Innovation**

- 1. Payments**
- 2. Insurance**
- 3. Deposits & Lending**
- 4. Capital Raising**
- 5. Investment Management**
- 6. Market Provisioning**

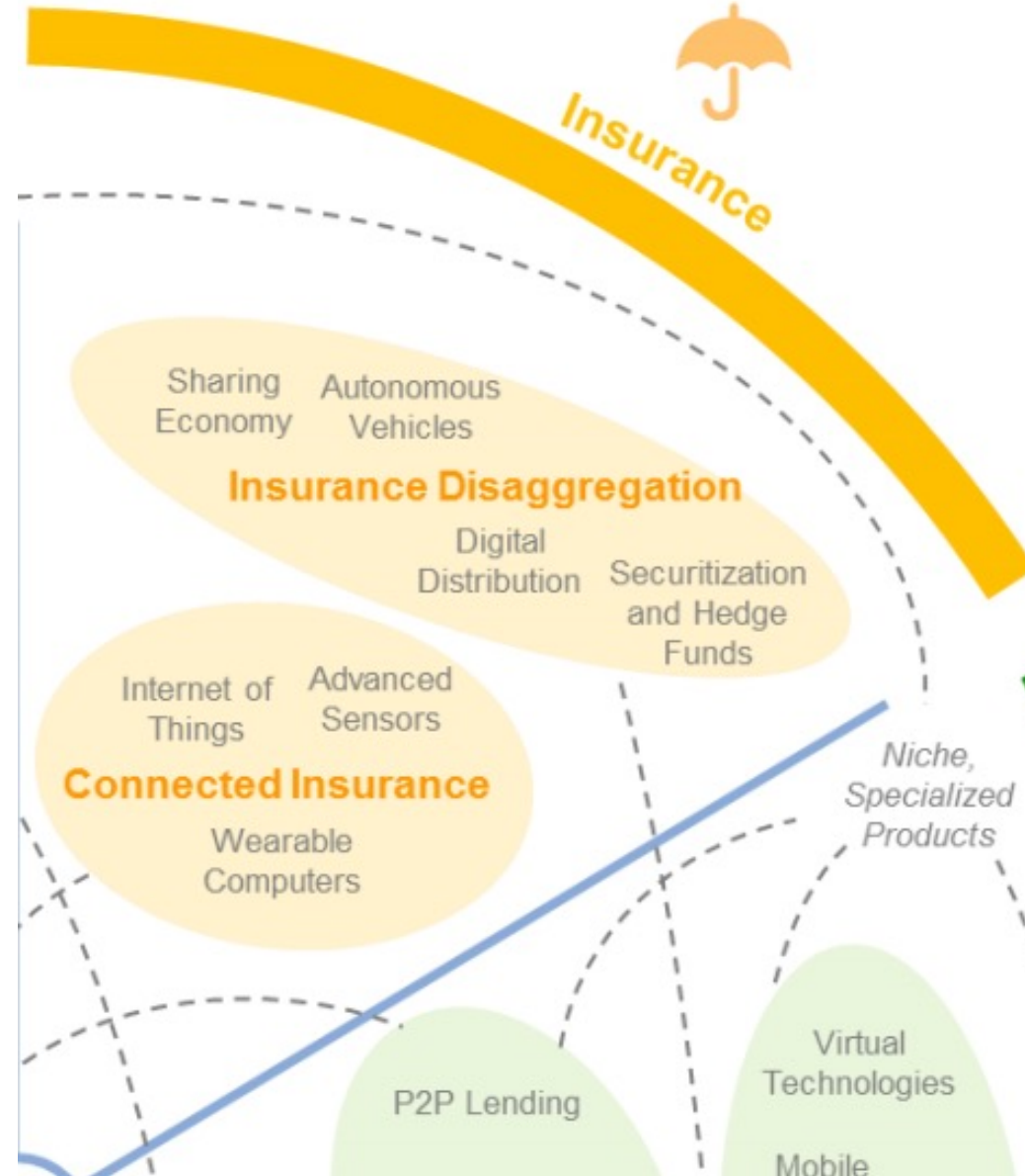
# 1

# FinTech: Payment



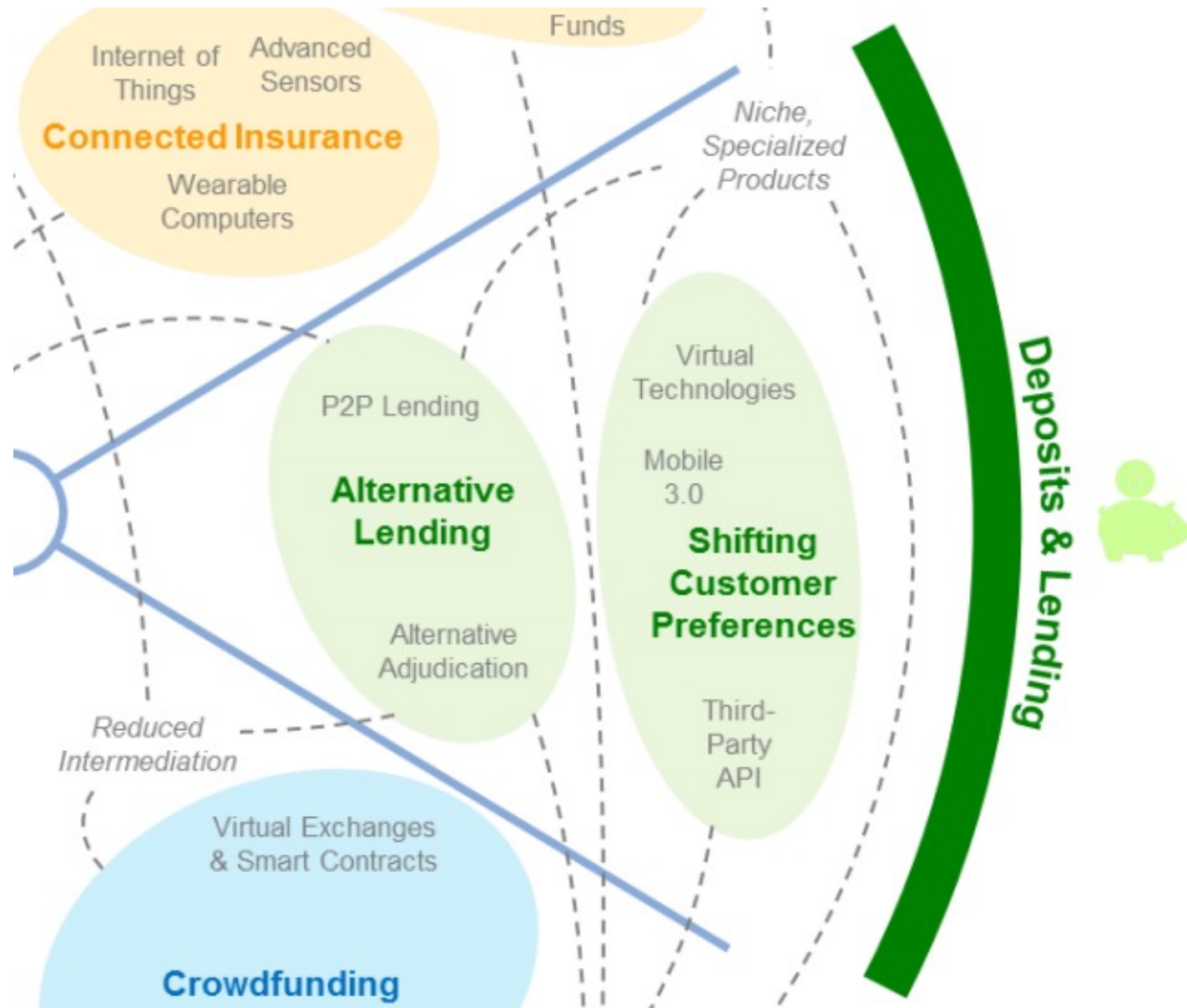
# 2

# FinTech: Insurance



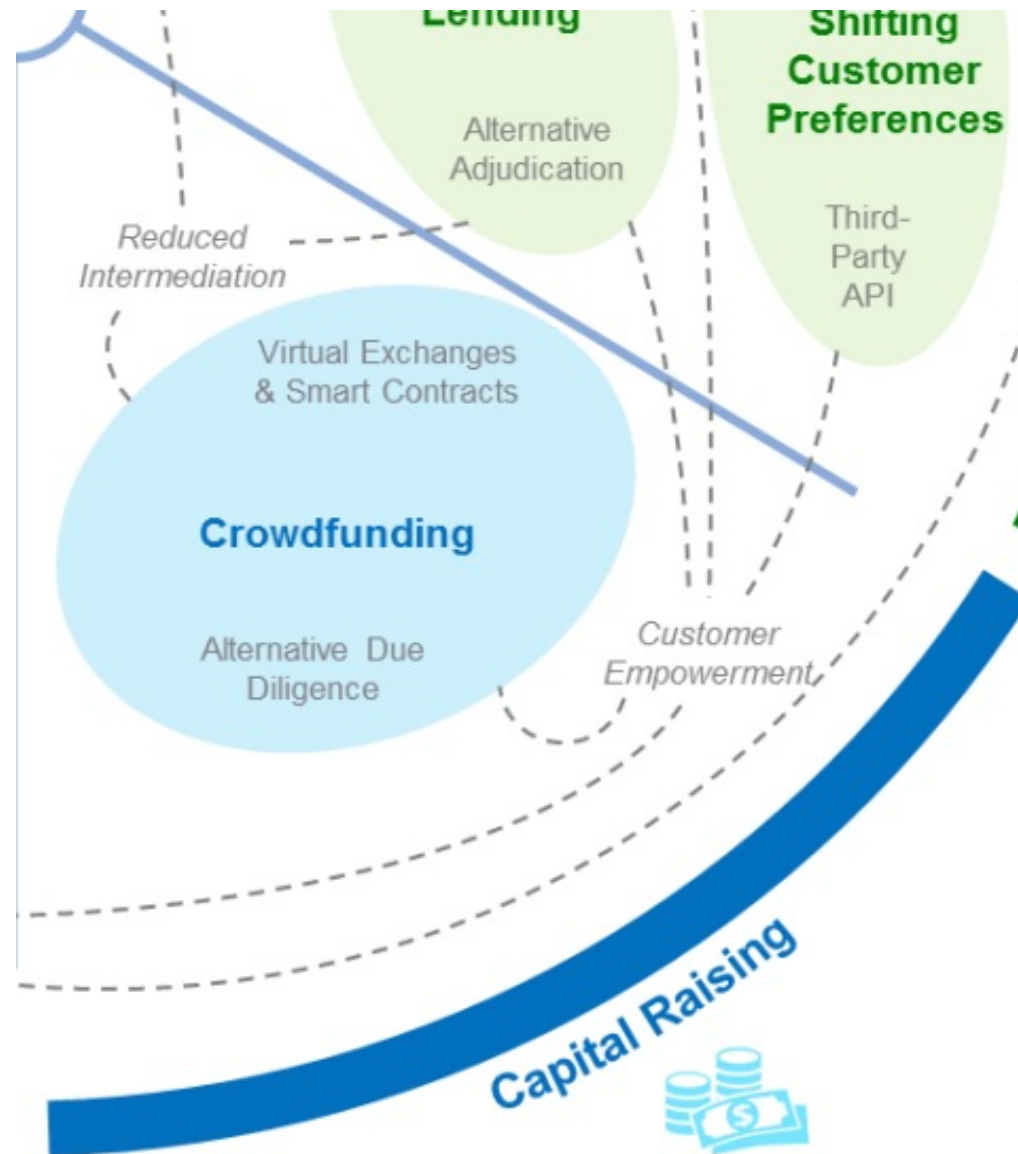
# 3

## FinTech: Deposits & Lending

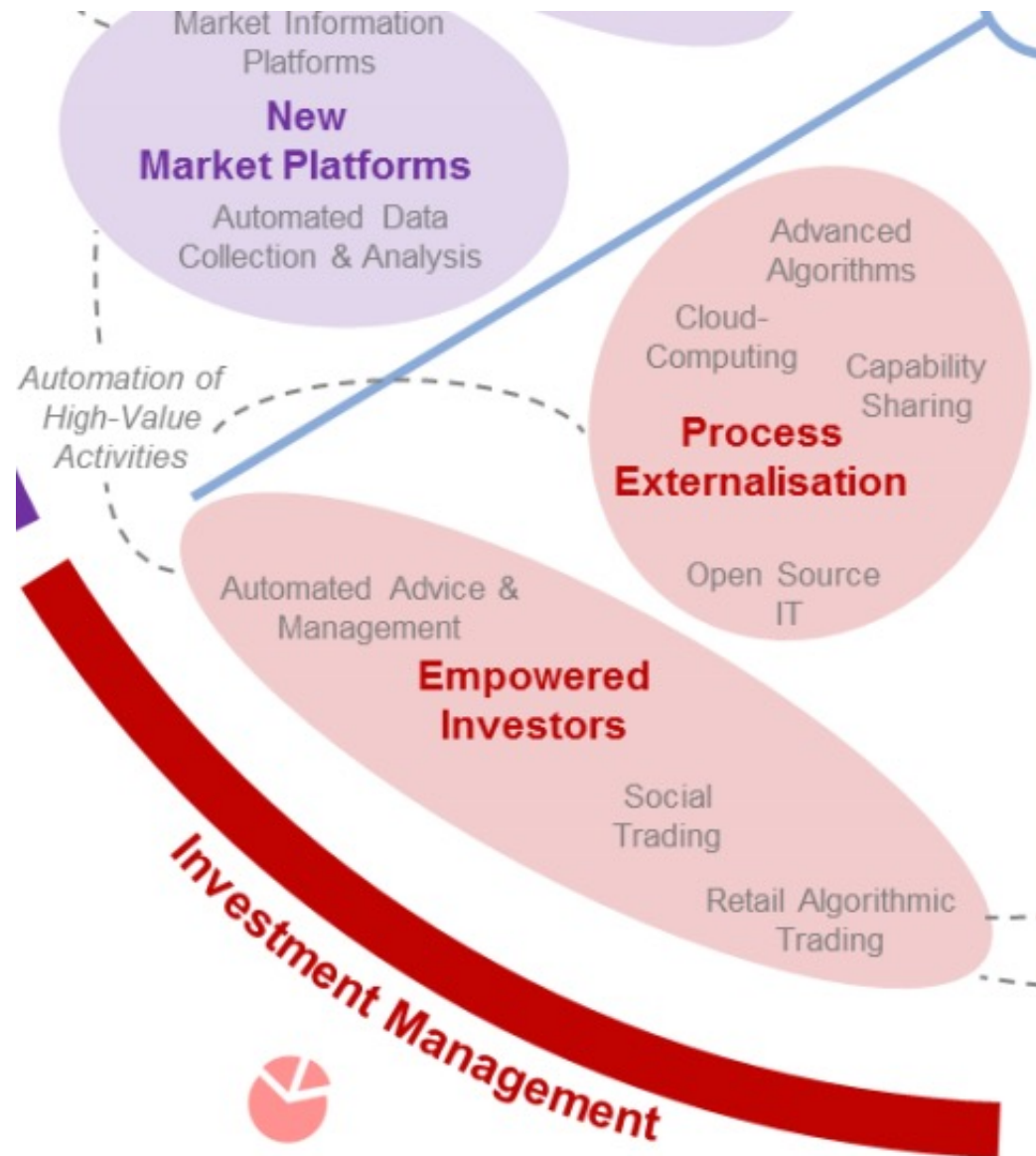


# 4

# FinTech: Capital Raising

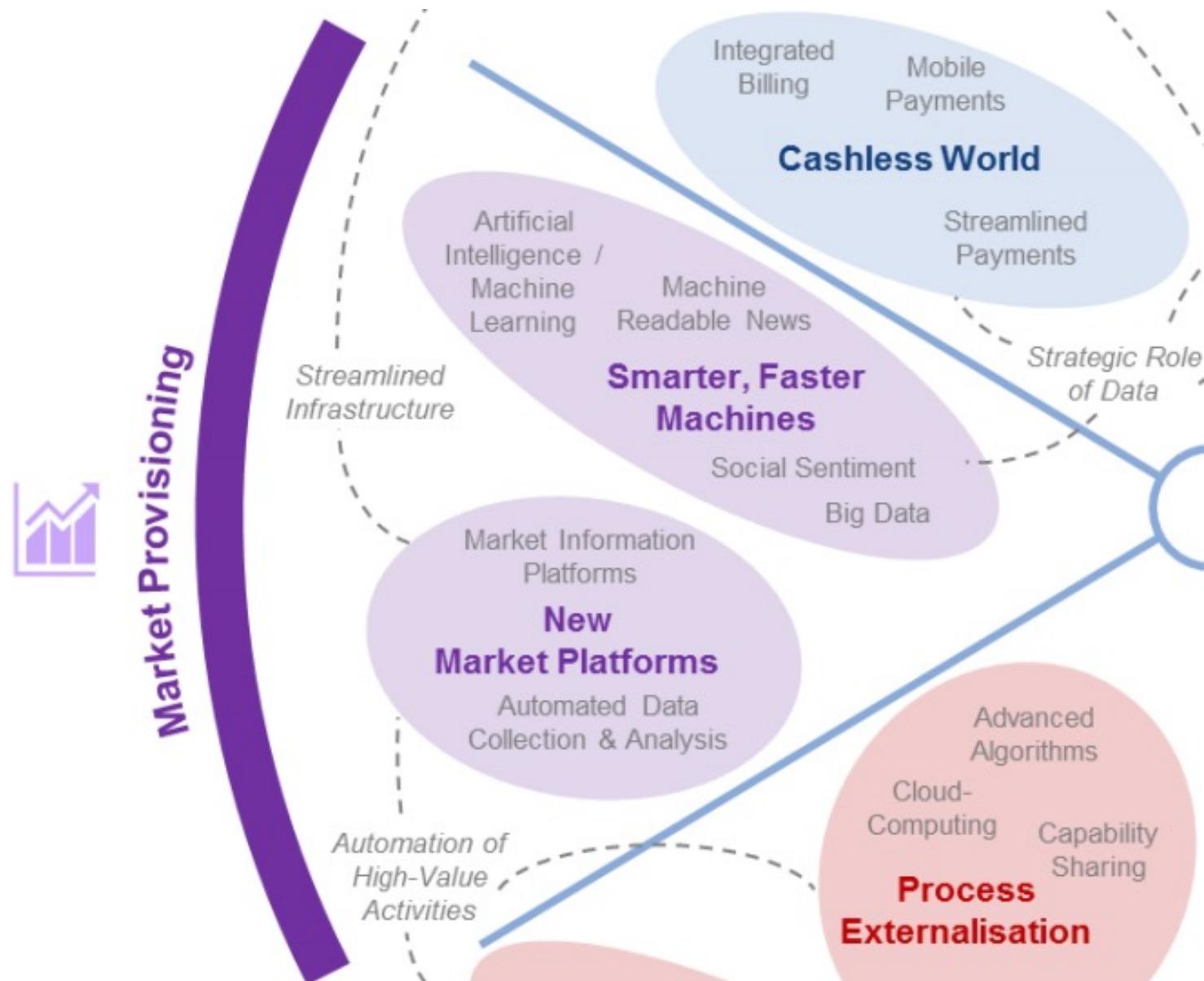


# 5 FinTech: Investment Management

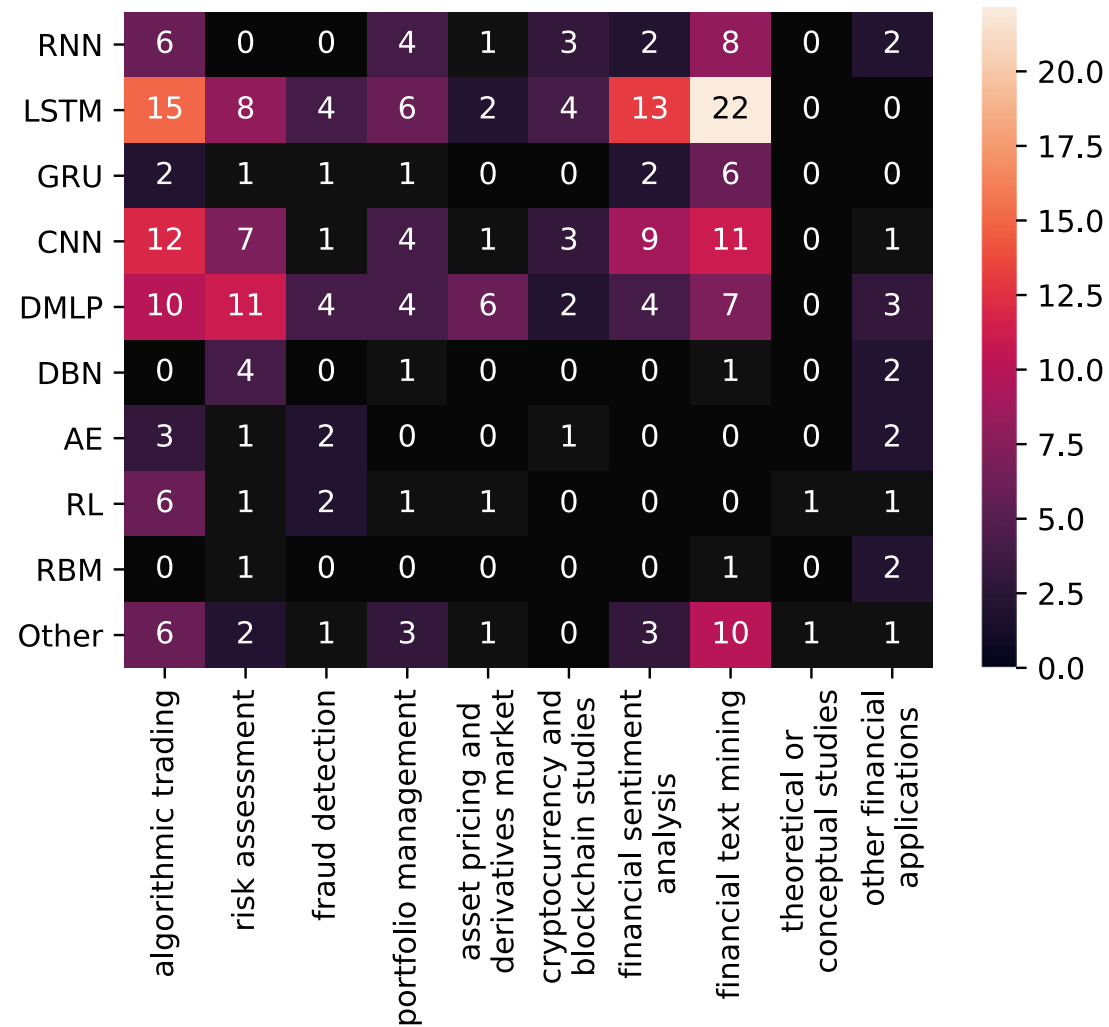


# 6

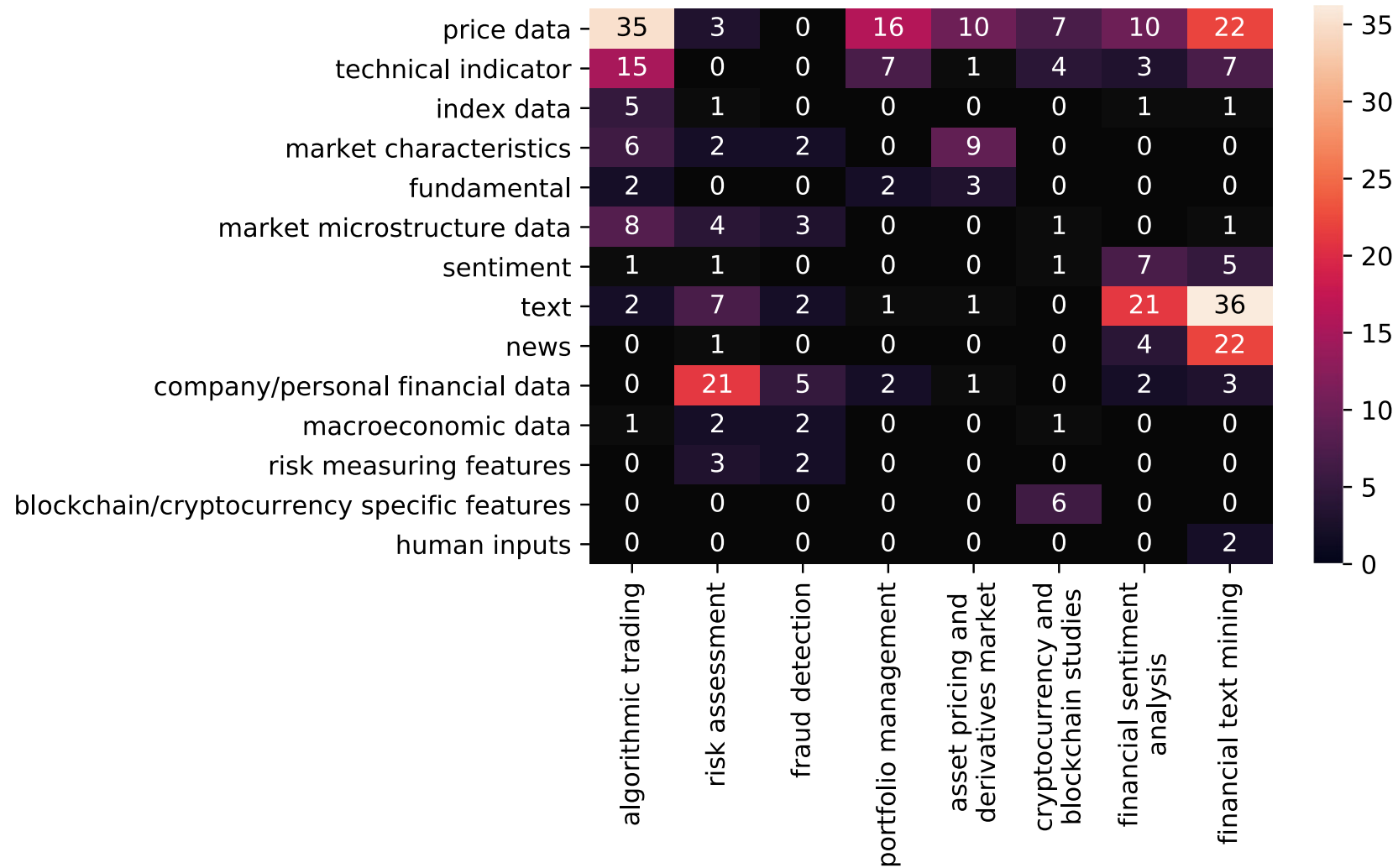
# FinTech: Market Provisioning



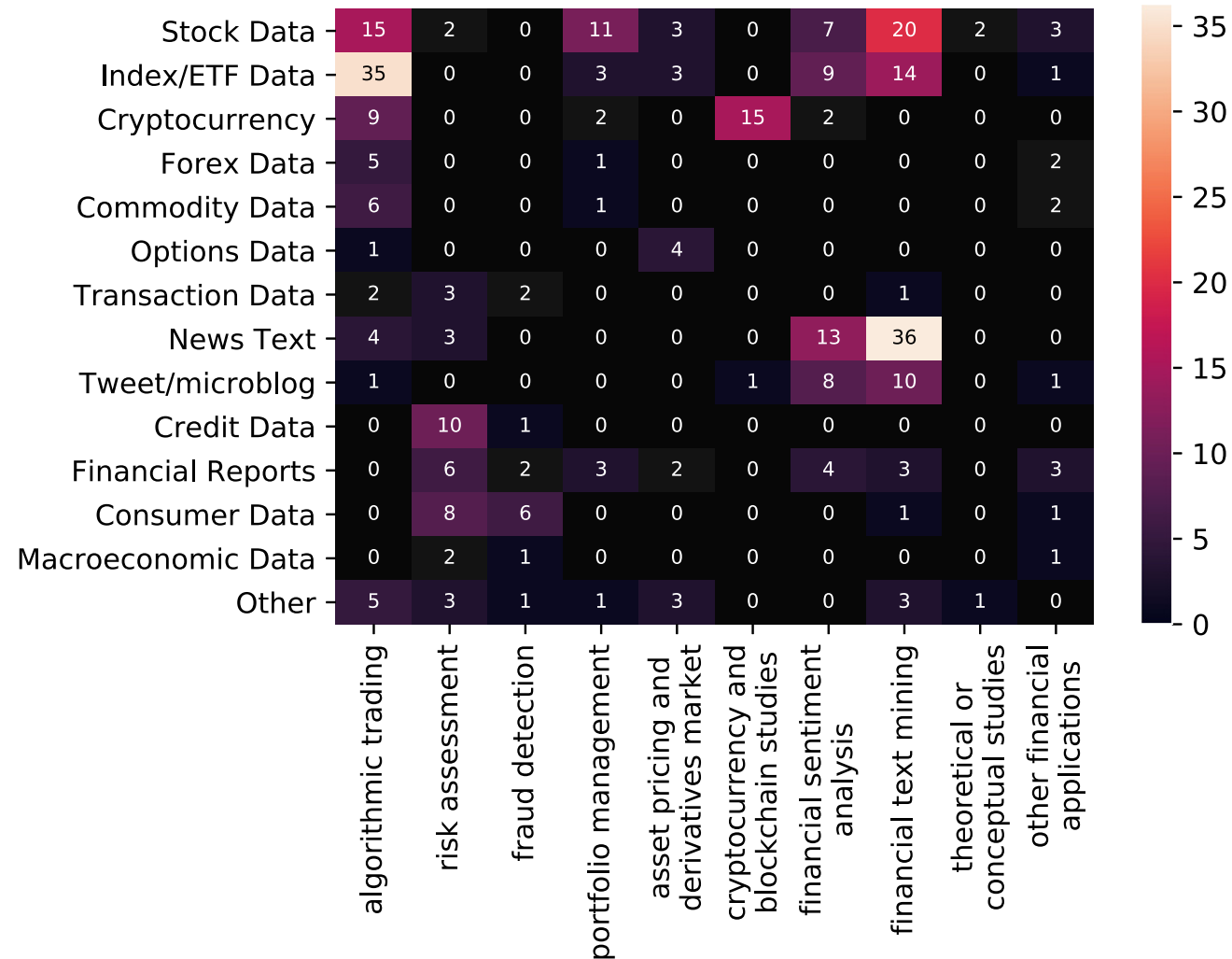
# Deep learning for financial applications: Topic-Model Heatmap



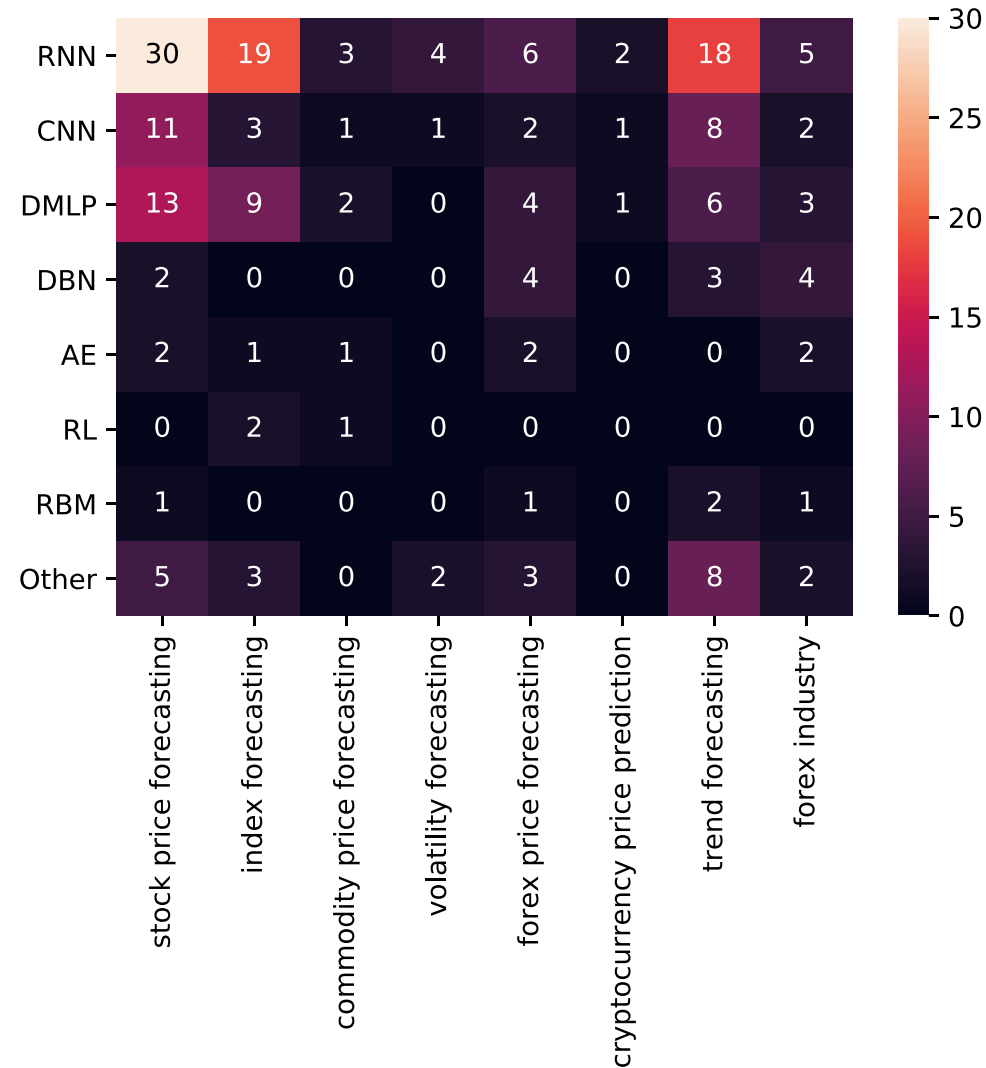
# Deep learning for financial applications: Topic-Feature Heatmap



# Deep learning for financial applications: Topic-Dataset Heatmap

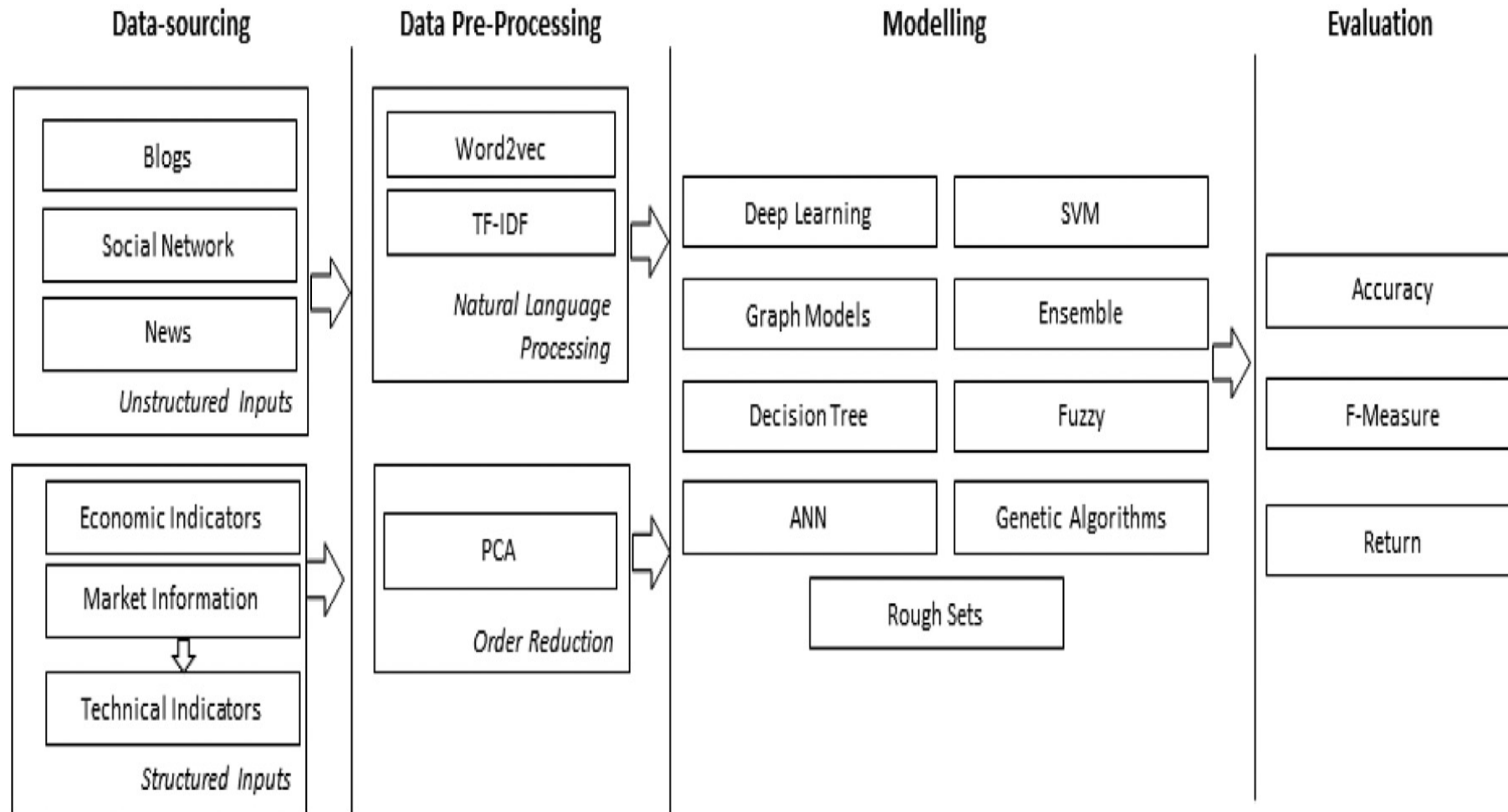


# Financial time series forecasting with deep learning: Topic-model heatmap

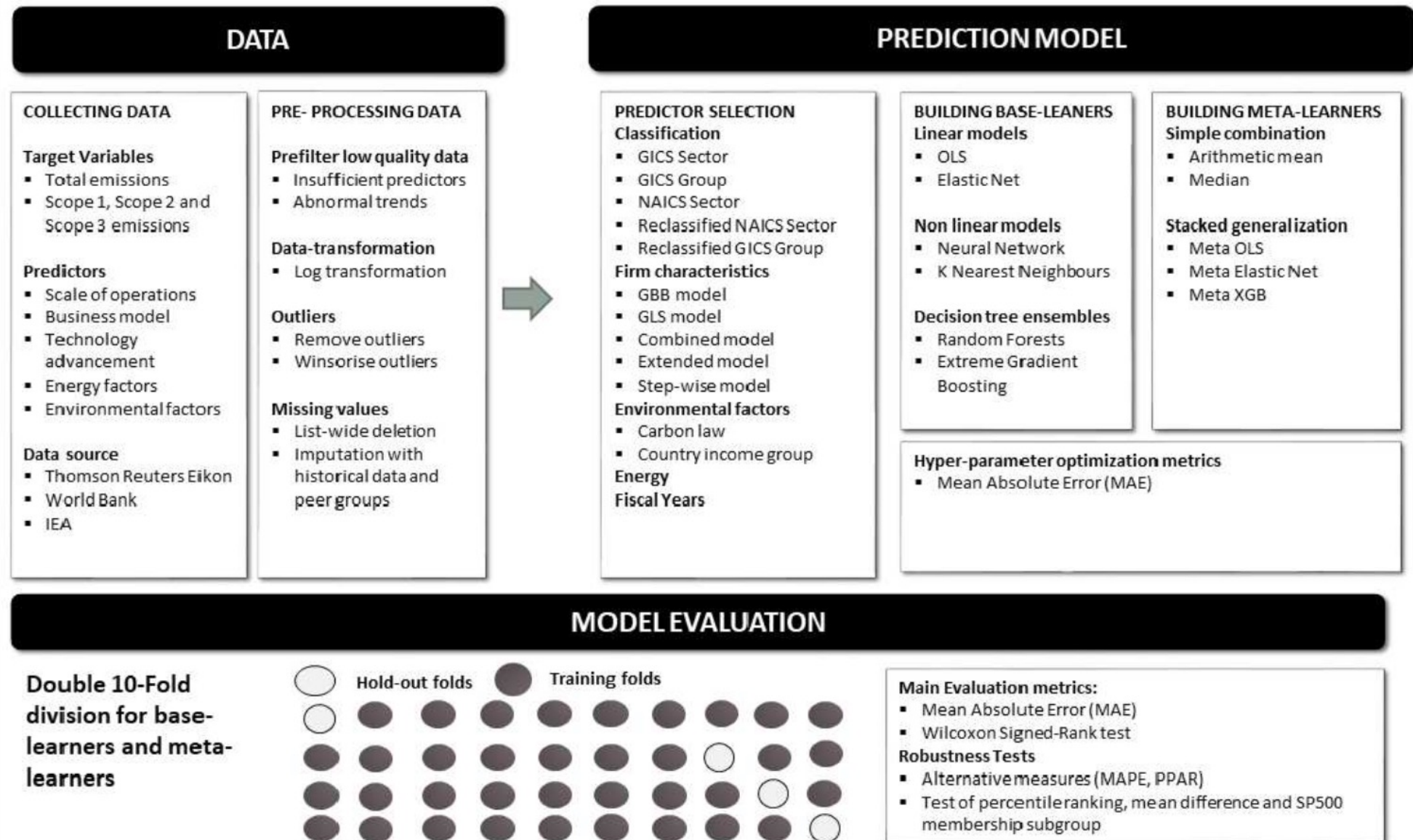


# Stock Market Movement Forecast:

## Phases of the stock market modeling

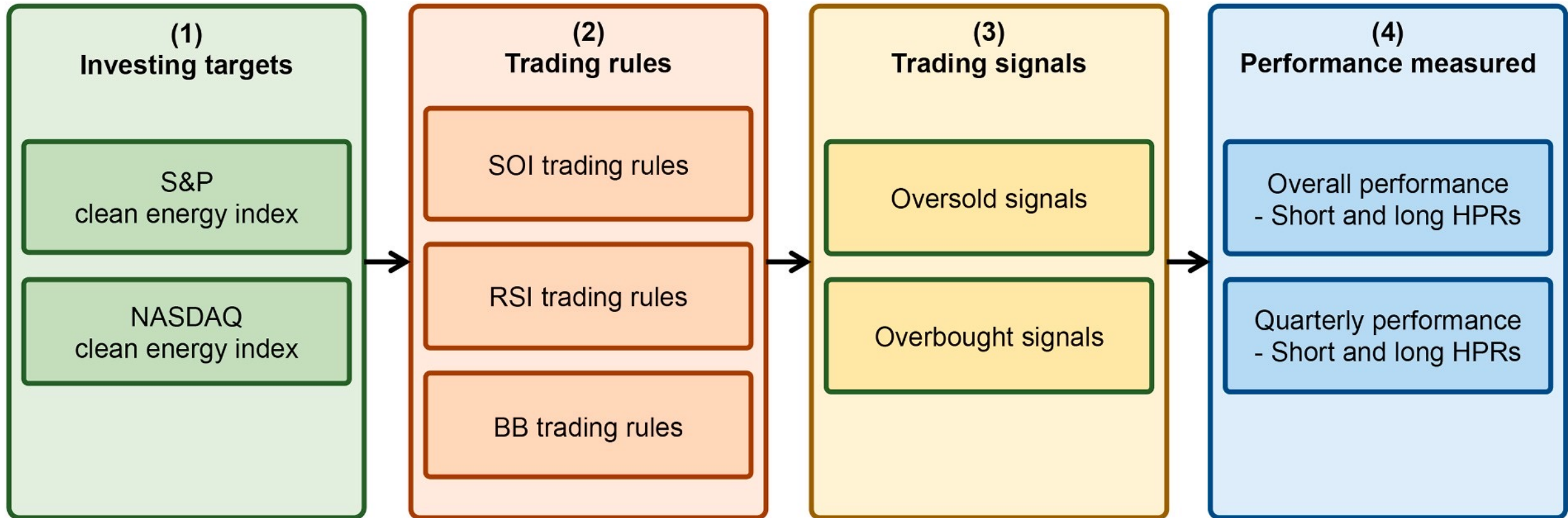


# Modelling Strategy to Forecast Carbon Emissions with AI



# The Research Framework

Do clean energy indices outperform using contrarian strategies



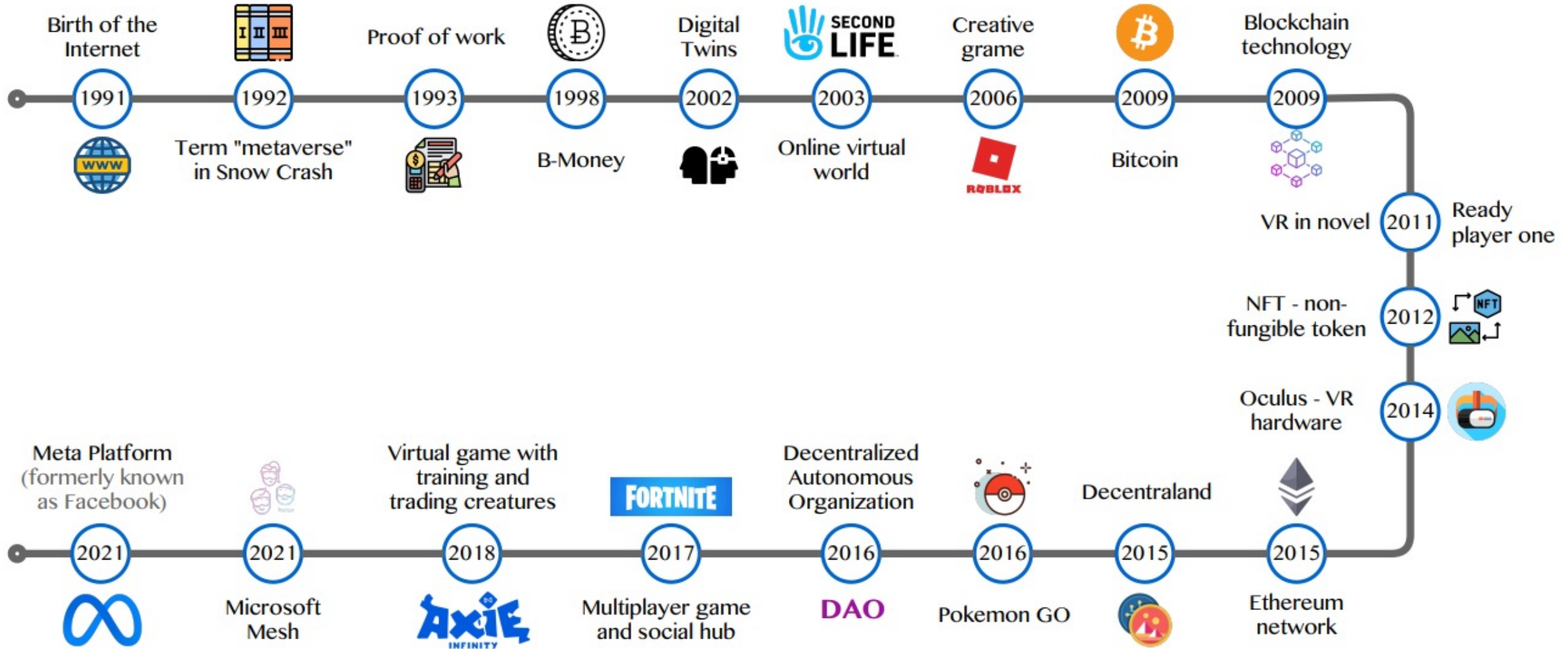
**Metaverse**

**Web3**

**DeFi**

**NFT**

# Metaverse Development from 1991 to 2021

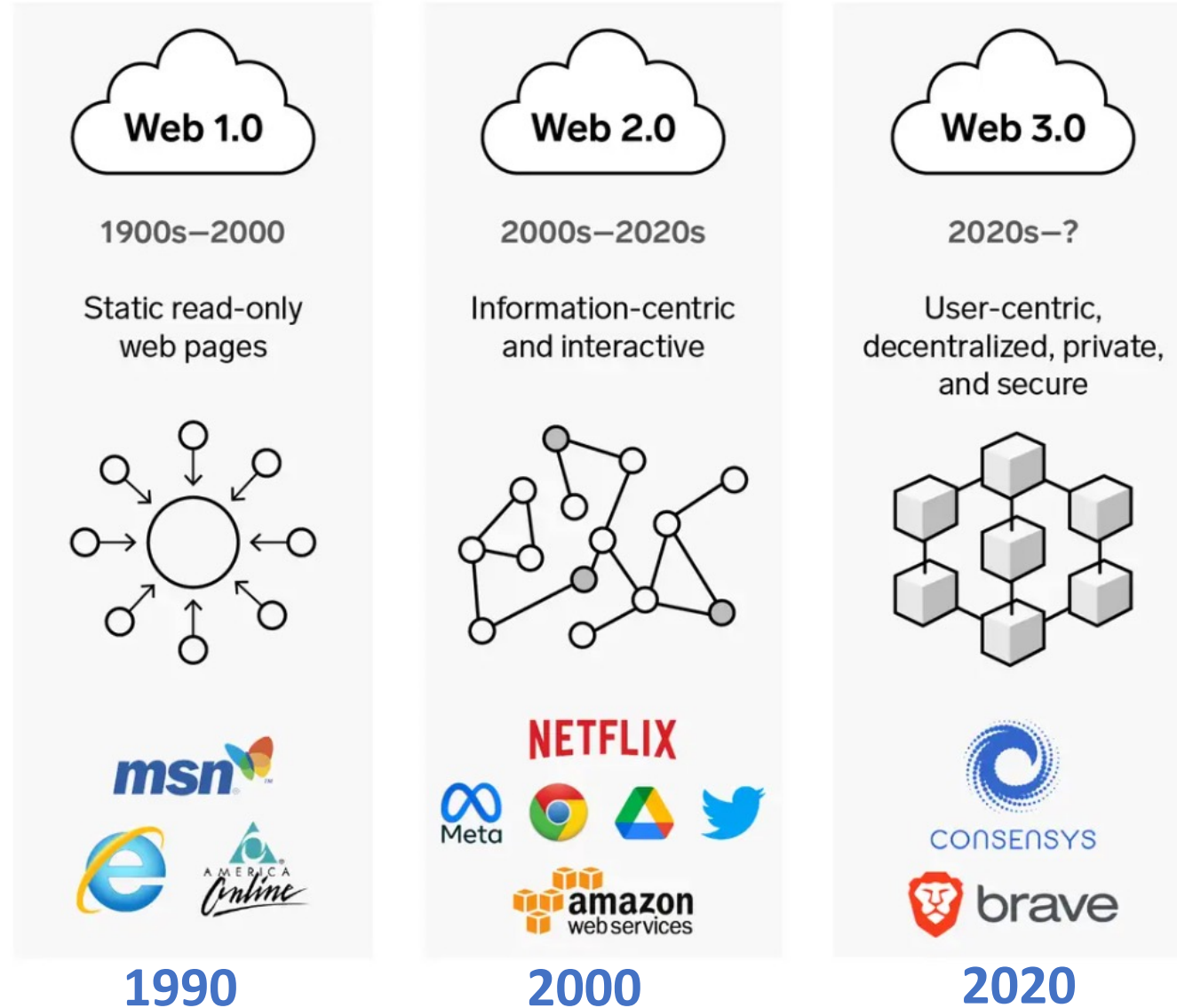


Source: Huynh-The, Thien, Quoc-Viet Pham, Xuan-Quy Pham, Thanh Thi Nguyen, Zhu Han, and Dong-Seong Kim (2022).

"Artificial Intelligence for the Metaverse: A Survey." arXiv preprint arXiv:2202.10336.

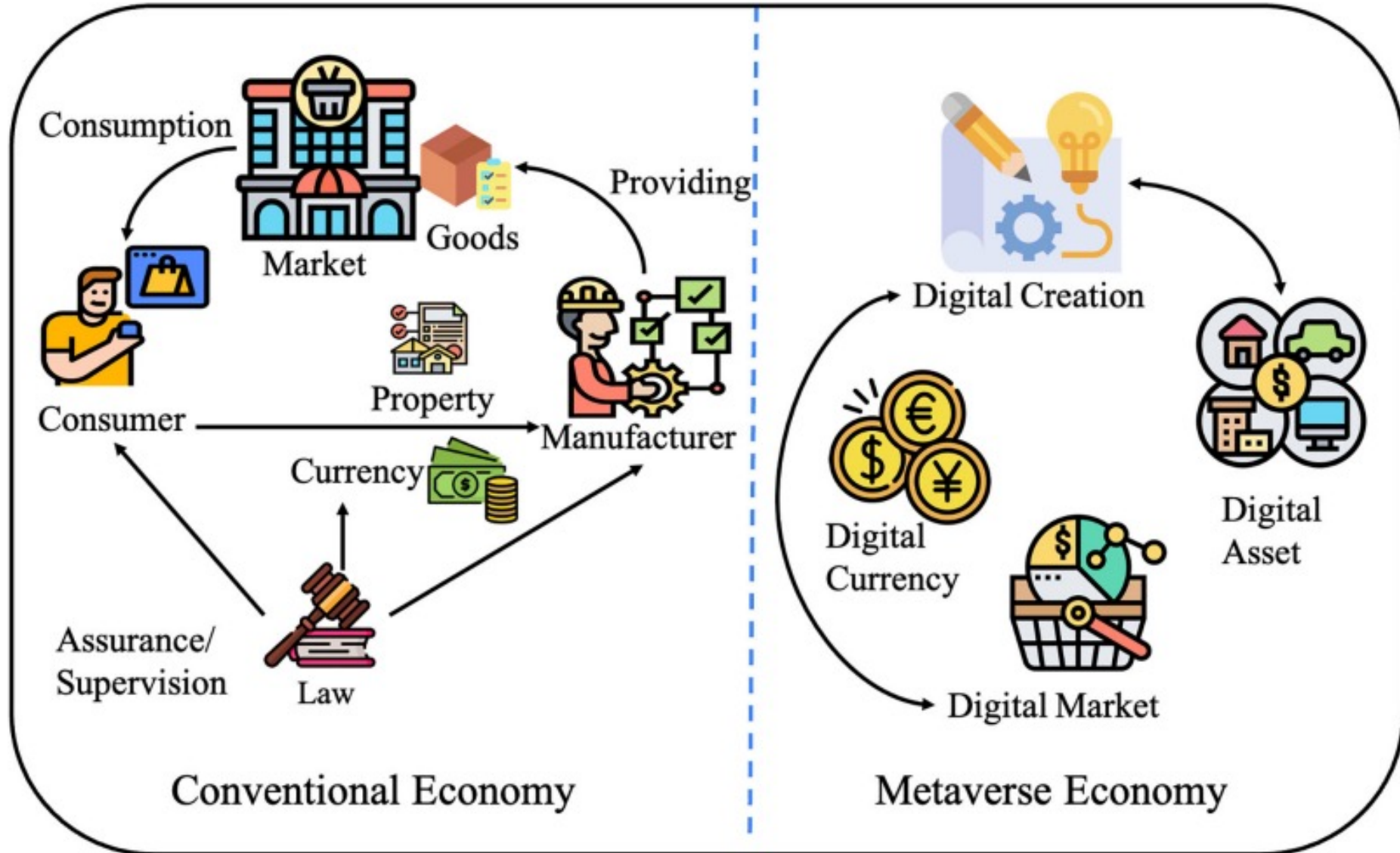
# Web3: Decentralized Web

## Internet Evolution

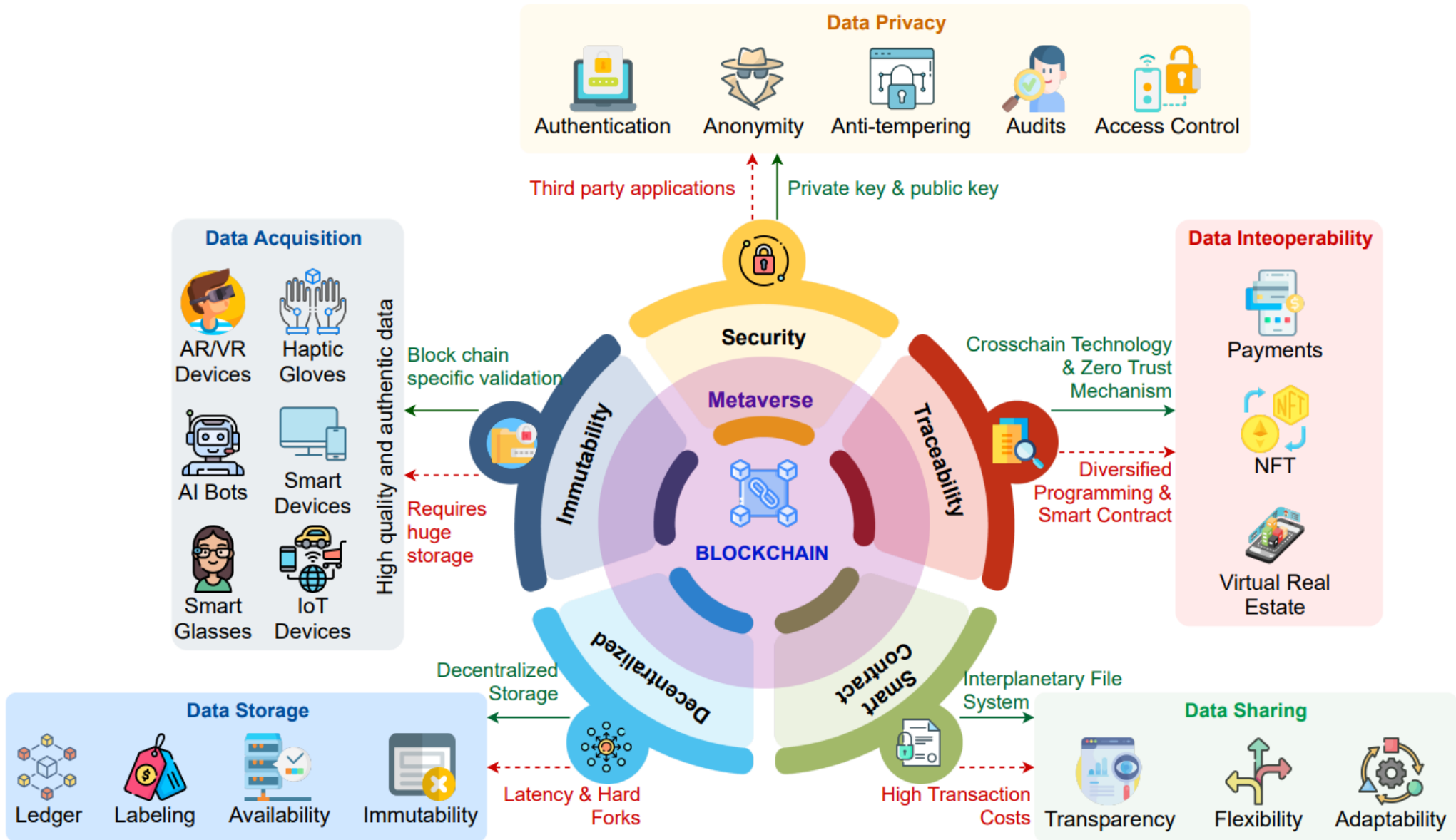


Source: <https://www.businessinsider.com/personal-finance/what-is-web3>

# Metaverse Economy



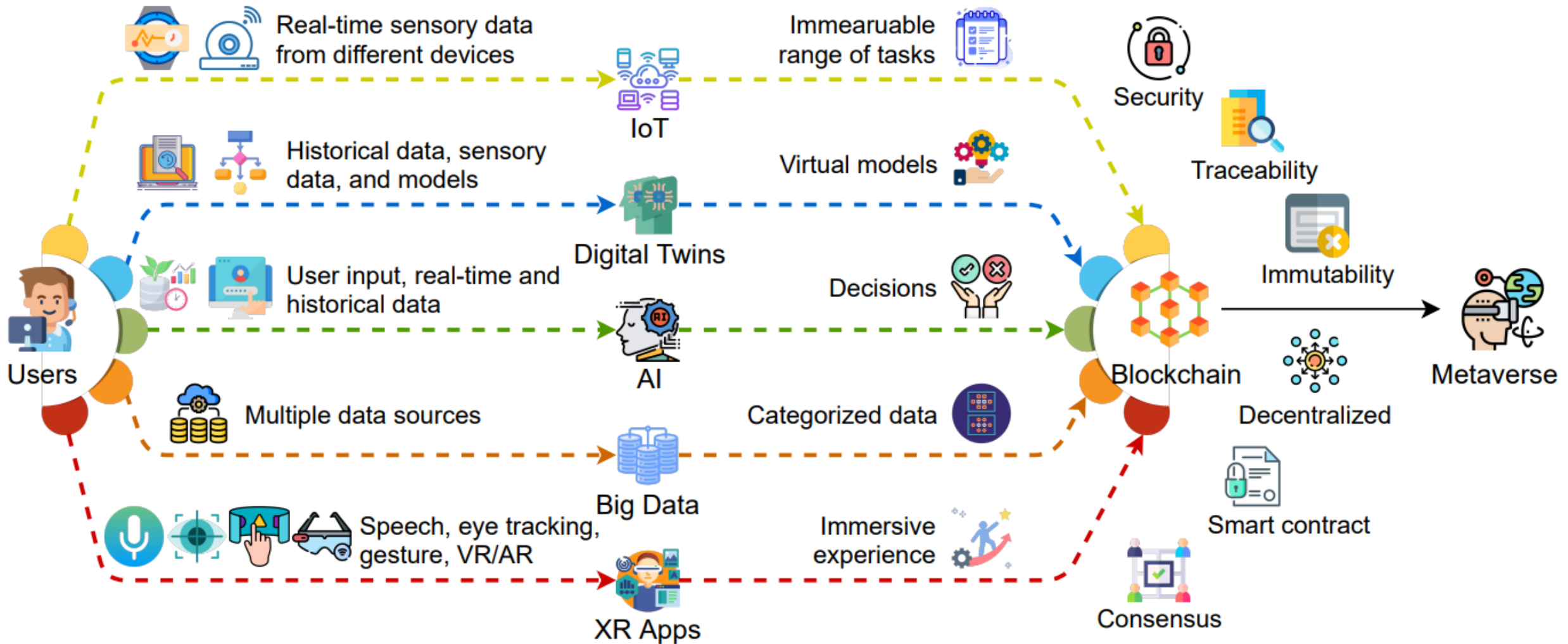
# Blockchain in the Metaverse



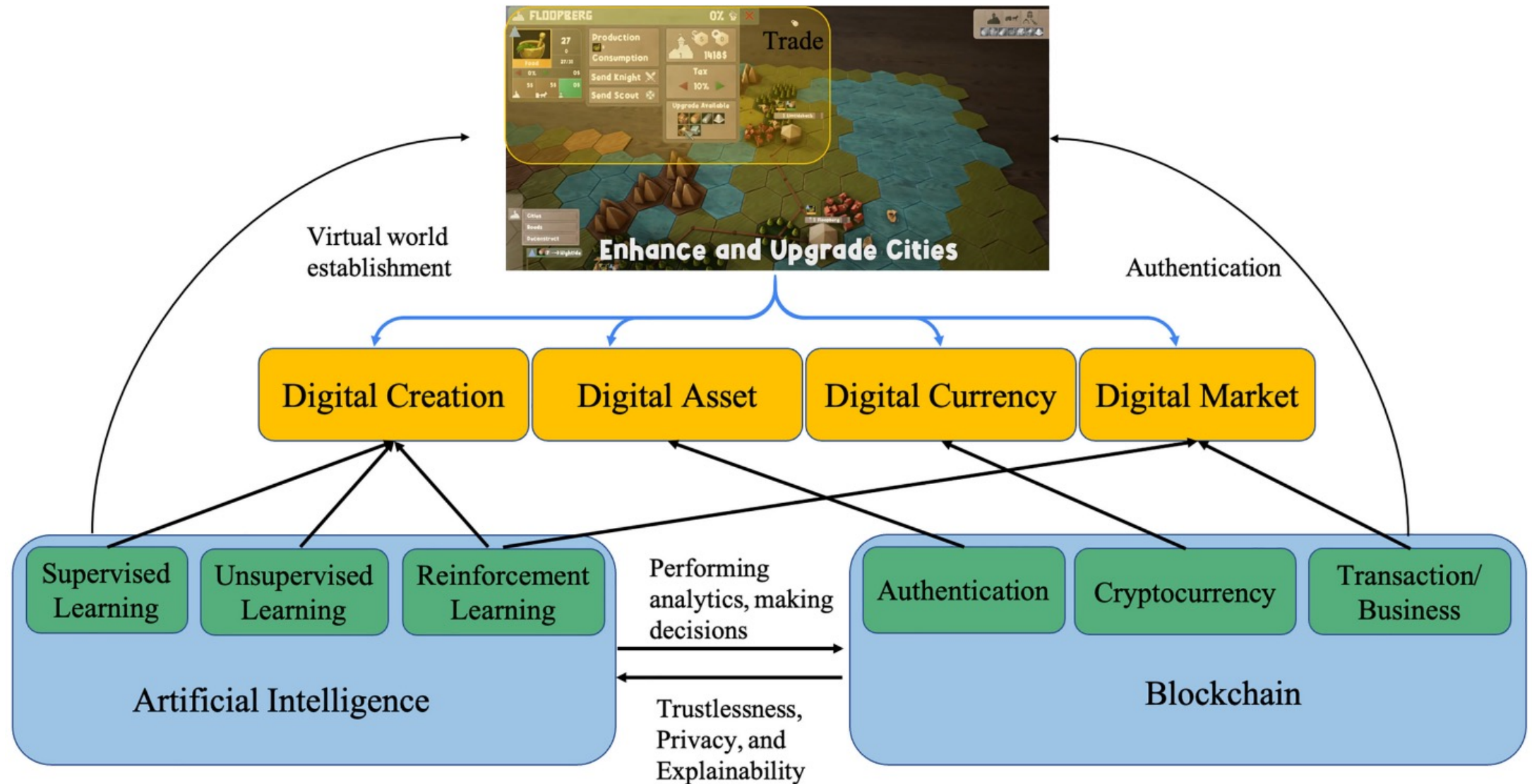
Source: Gadekallu, Thippa Reddy, Thien Huynh-The, Weizheng Wang, Gokul Yenduri, Pasika Ranaweera, Quoc-Viet Pham, Daniel Benevides da Costa, and Madhusanka Liyanage (2022). "Blockchain for the Metaverse: A Review." arXiv preprint arXiv:2203.09738..

# Blockchain

## for Key Enabling Technologies of the Metaverse

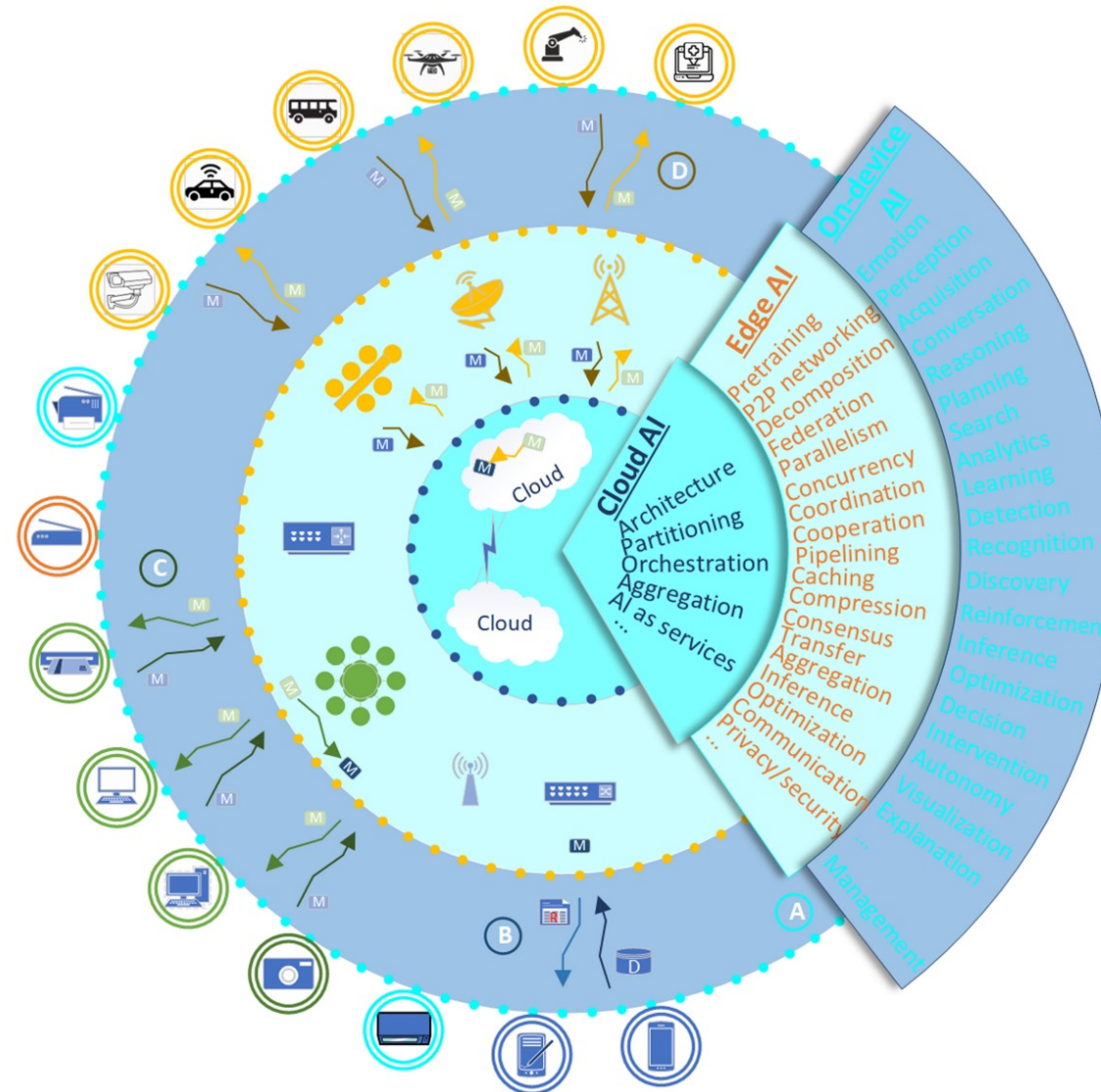


# Fusion of AI and Blockchain in Metaverse



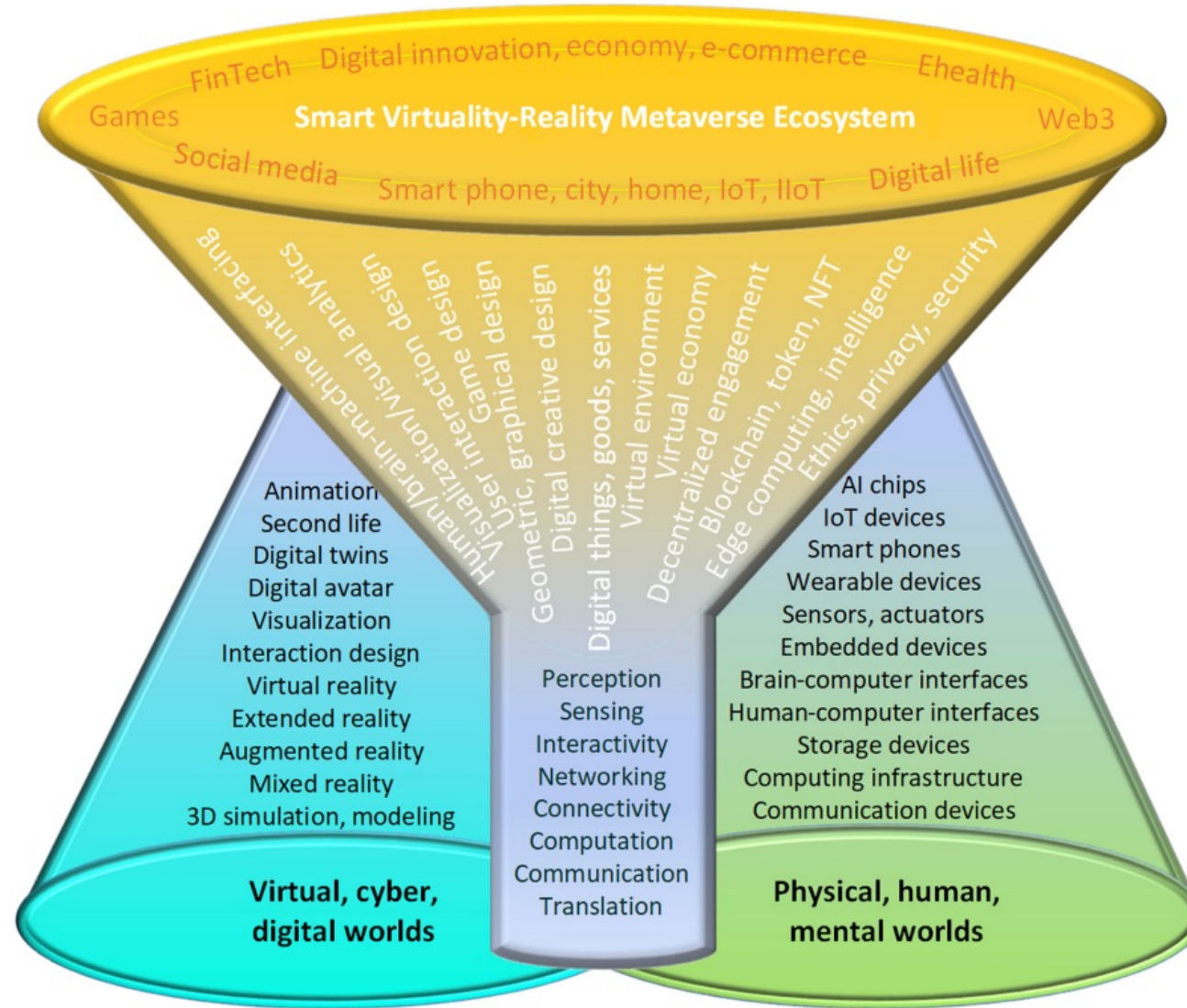
# DeAI:

## Synthesizing On-device AI, Edge AI, and Cloud AI



# Smart Virtuality-Reality Metaverse Ecosystem:

## Metasynthesizing DeAI, Metaverse, Blockchain, Web3



# The difference between AR, MR, and VR under the umbrella of XR

**XR**

**VR**

**MR**

**AR**

## Extended Reality

Entire experience spectrum from fully virtual to fully real



## Virtual Reality

User is completely immersed into a virtual world



## Mixed Reality

Environment aware  
2D/3D content is overlaid onto the physical space



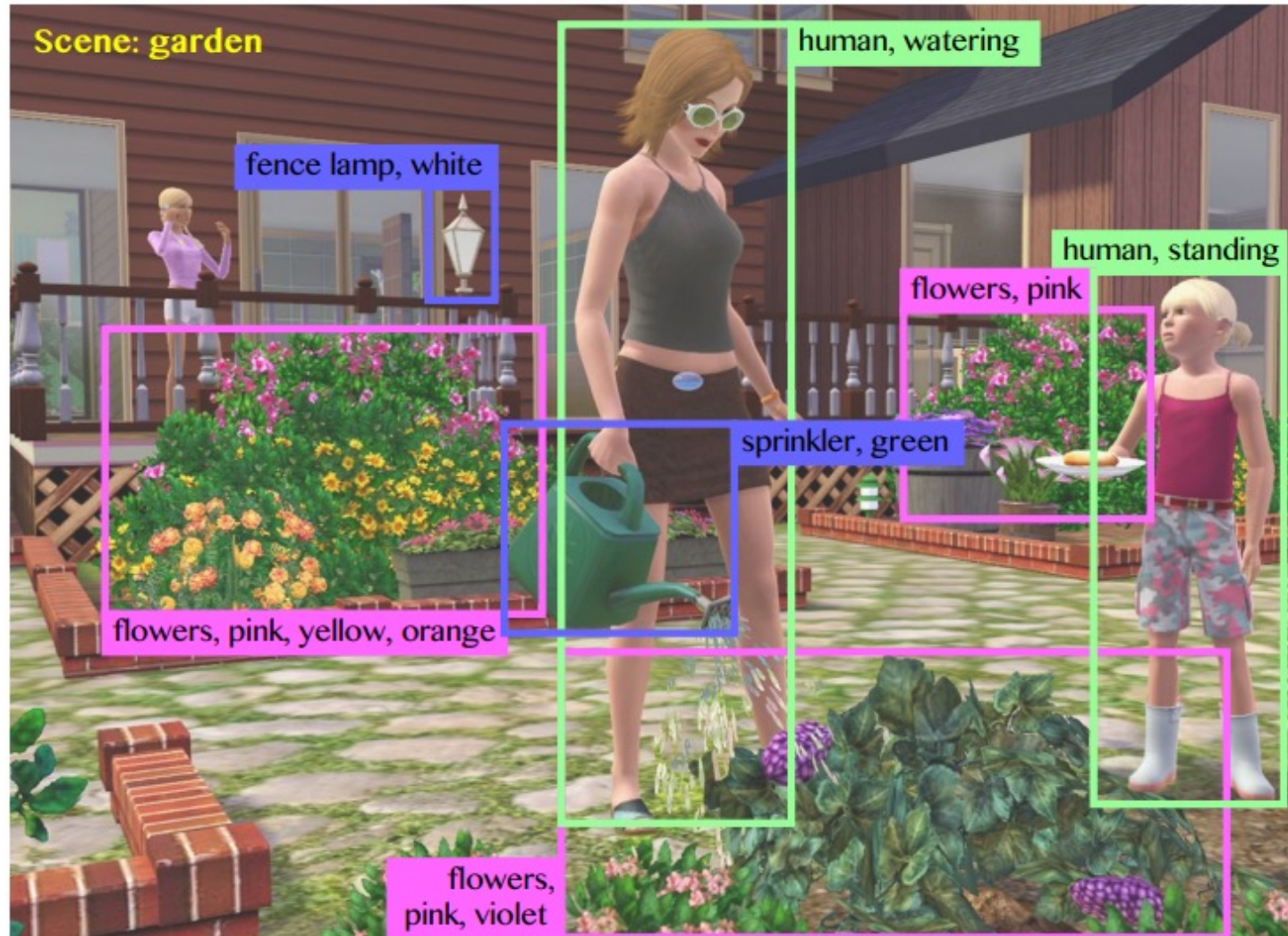
## Augmented Reality

Non-environment aware  
2D/3D content is overlaid onto the physical space



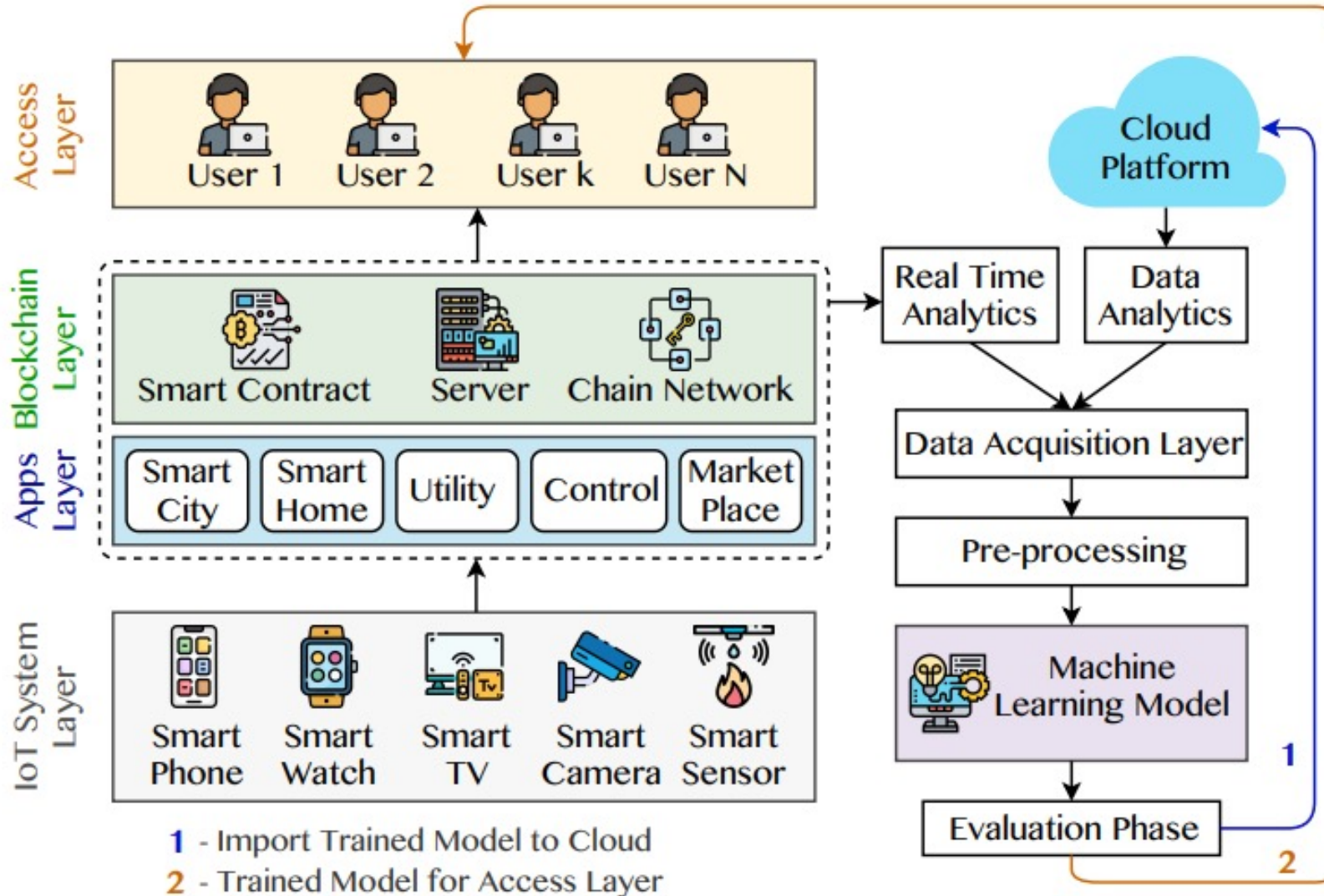
# Computer vision in the metaverse

with scene understanding, object detection, and human action/activity recognition



Source: Huynh-The, Thien, Quoc-Viet Pham, Xuan-Quy Pham, Thanh Thi Nguyen, Zhu Han, and Dong-Seong Kim (2022). "Artificial Intelligence for the Metaverse: A Survey." arXiv preprint arXiv:2202.10336.

# A Blockchain-based IoT Framework with ML to enhance security and privacy

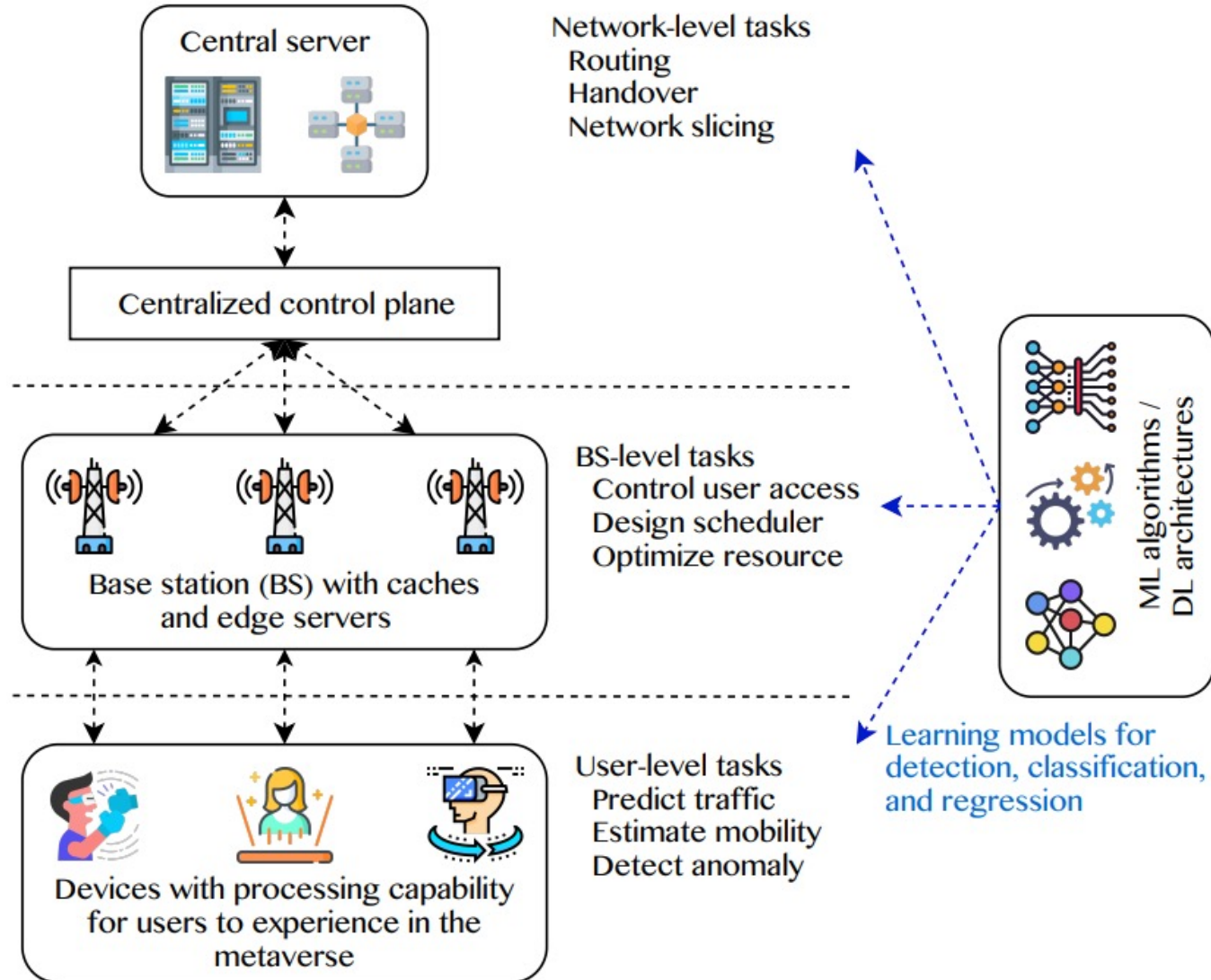


Source: Huynh-The, Thien, Quoc-Viet Pham, Xuan-Quy Pham, Thanh Thi Nguyen, Zhu Han, and Dong-Seong Kim (2022).

"Artificial Intelligence for the Metaverse: A Survey." arXiv preprint arXiv:2202.10336.

# 5G and beyond for Metaverse Services

AI with ML algorithms and DL models contribute in multi-level tasks

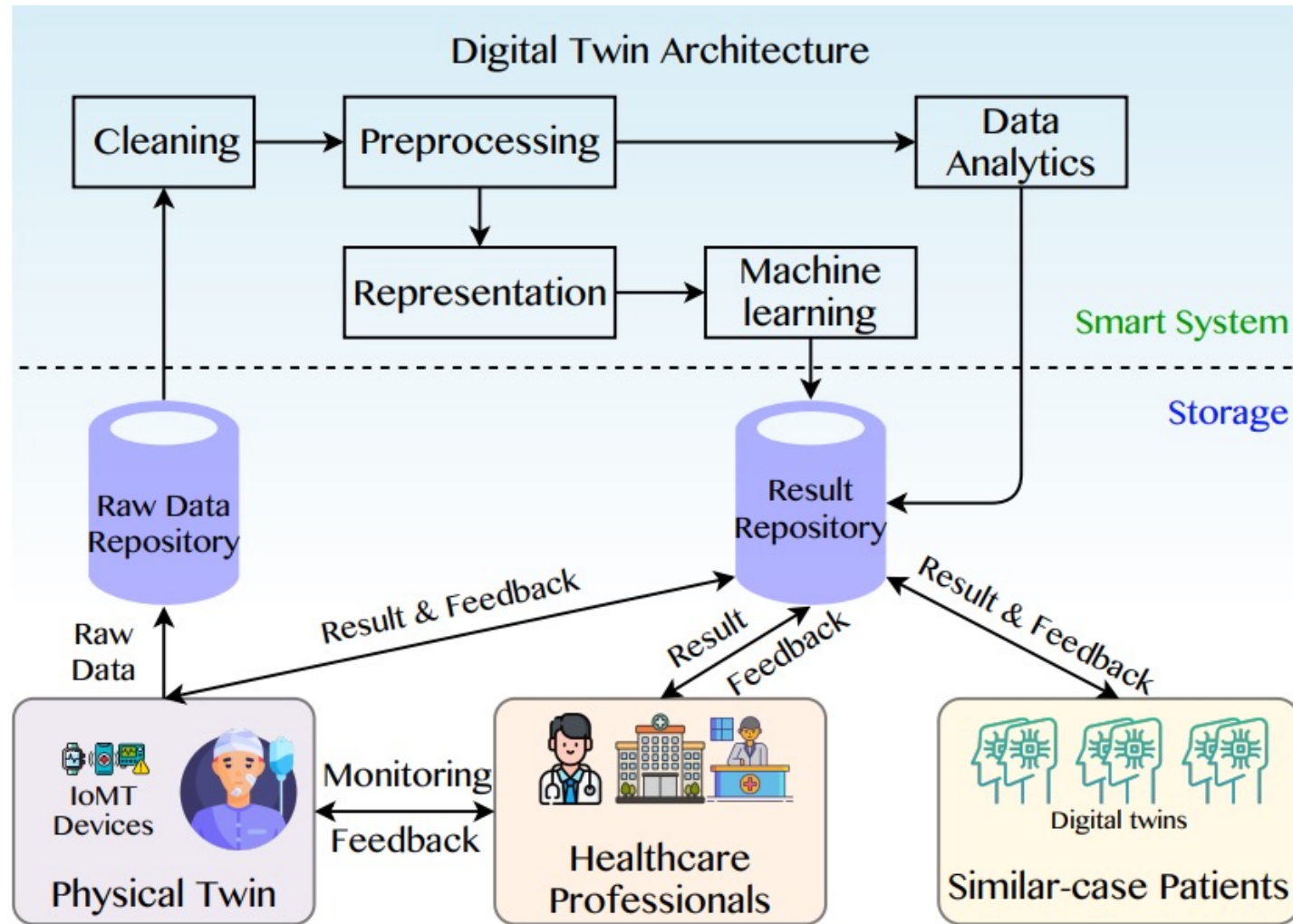


Source: Huynh-The, Thien, Quoc-Viet Pham, Xuan-Quy Pham, Thanh Thi Nguyen, Zhu Han, and Dong-Seong Kim (2022).

"Artificial Intelligence for the Metaverse: A Survey." arXiv preprint arXiv:2202.10336.

# A Data-Driven Digital Twin Architecture

for intelligent healthcare systems using ML to process raw data of IoMedicalThings devices

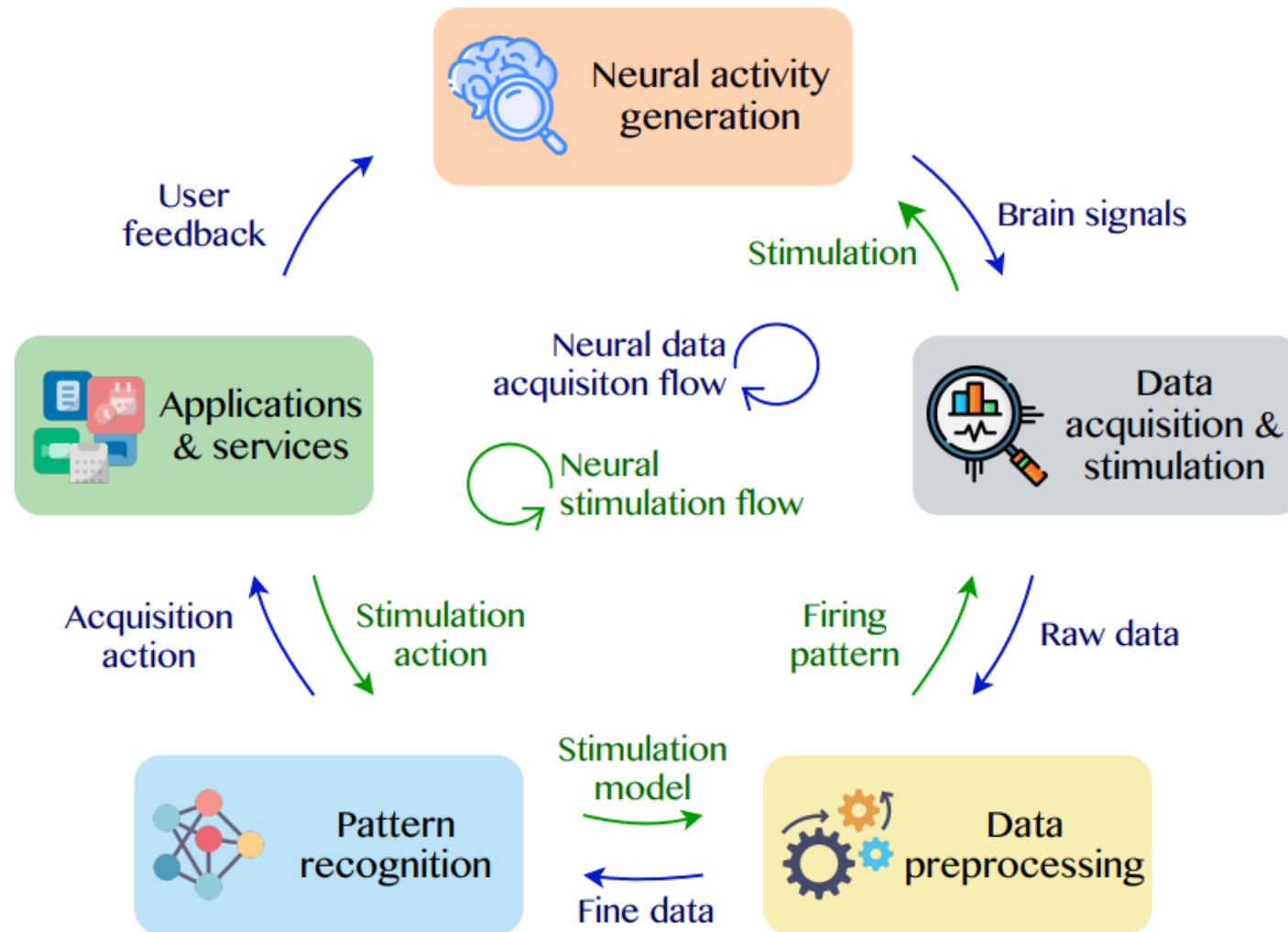


Source: Huynh-The, Thien, Quoc-Viet Pham, Xuan-Quy Pham, Thanh Thi Nguyen, Zhu Han, and Dong-Seong Kim (2022).

"Artificial Intelligence for the Metaverse: A Survey." arXiv preprint arXiv:2202.10336.

# Brain-Machine Interfaces (BMIs)

for processing neural signals and responding neural stimulations

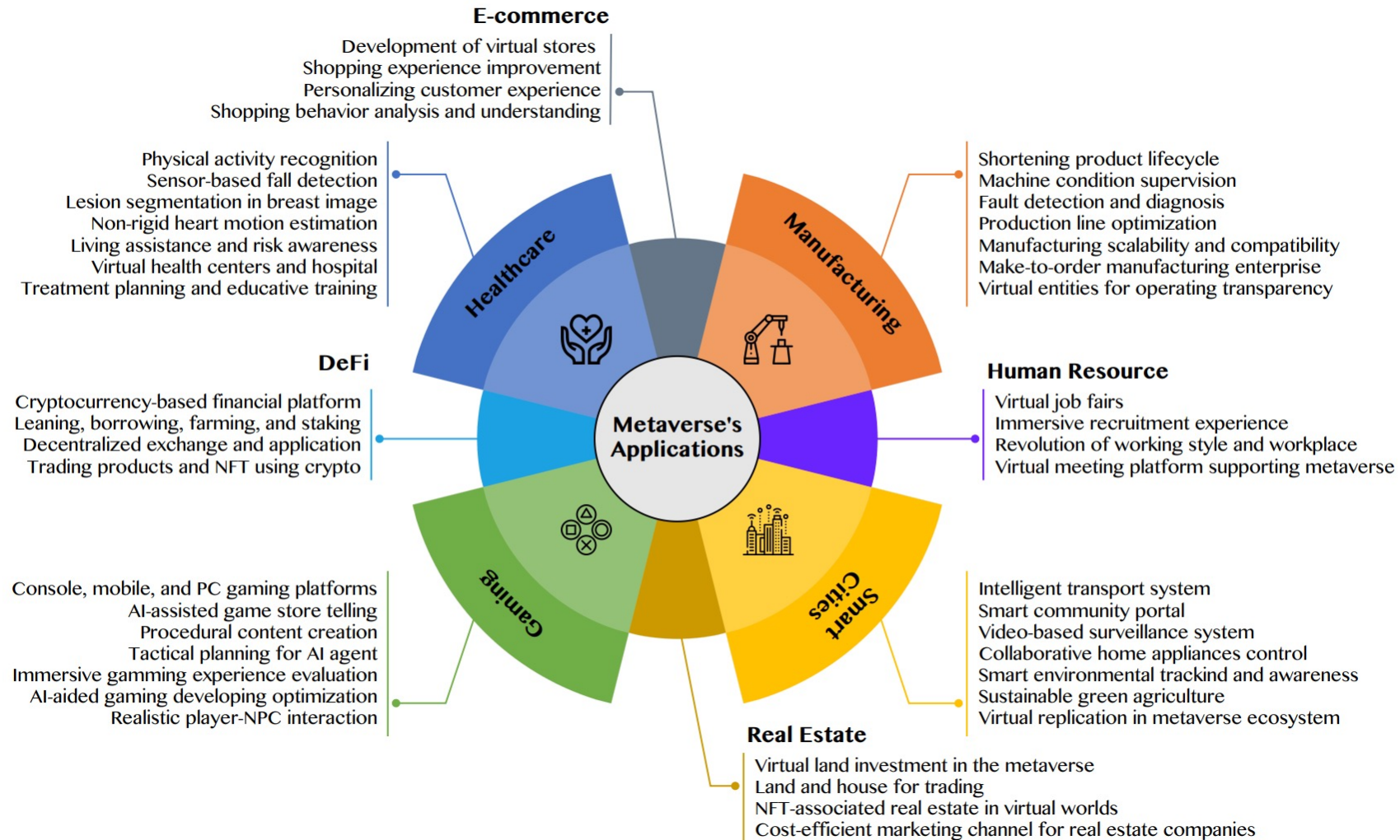


Source: Huynh-The, Thien, Quoc-Viet Pham, Xuan-Quy Pham, Thanh Thi Nguyen, Zhu Han, and Dong-Seong Kim (2022).

"Artificial Intelligence for the Metaverse: A Survey." arXiv preprint arXiv:2202.10336.

# AI for the Metaverse in the Application Aspects

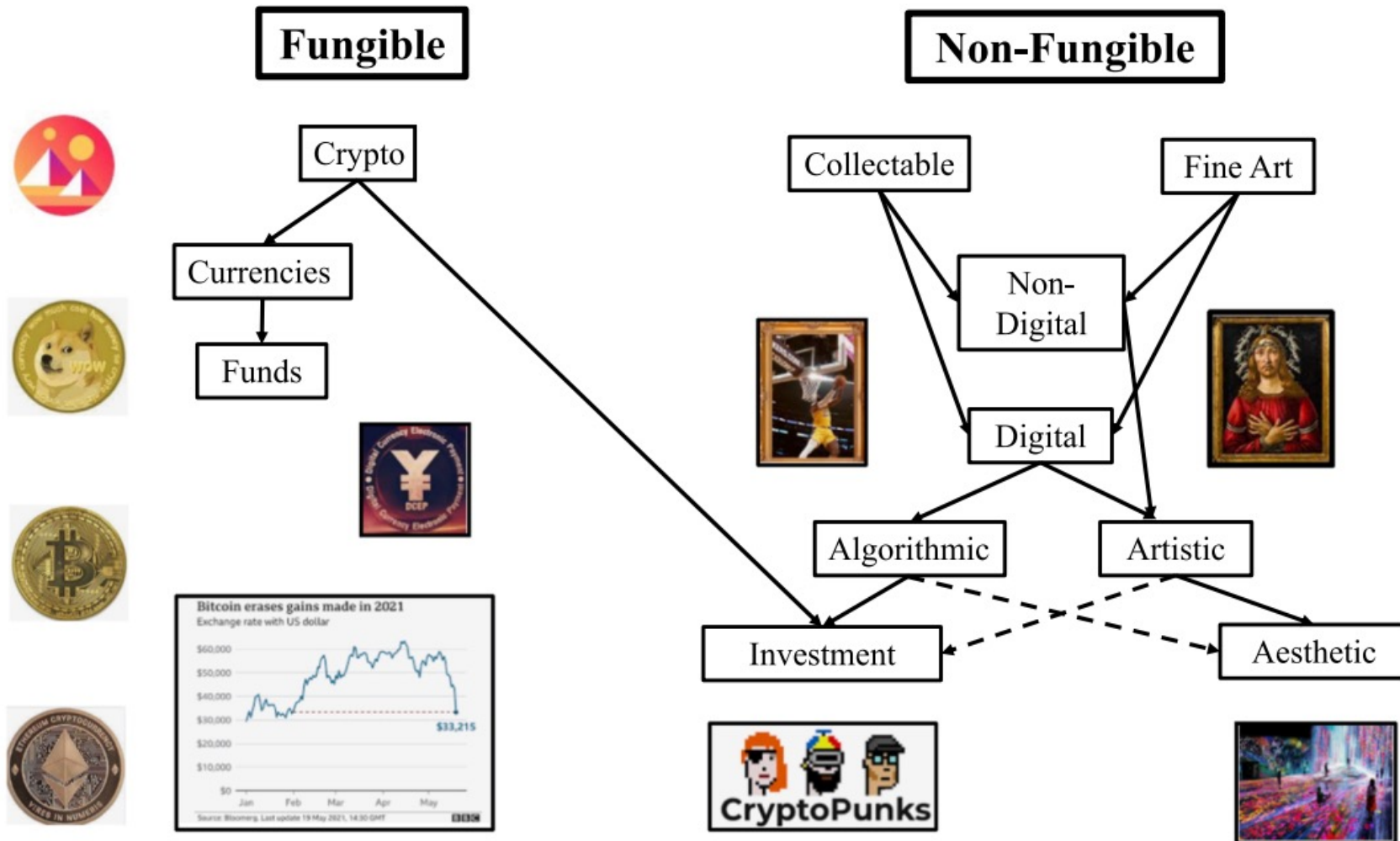
healthcare, manufacturing, smart cities, gaming  
E-commerce, human resources, real estate, and DeFi



Source: Huynh-The, Thien, Quoc-Viet Pham, Xuan-Quy Pham, Thanh Thi Nguyen, Zhu Han, and Dong-Seong Kim (2022).

"Artificial Intelligence for the Metaverse: A Survey." arXiv preprint arXiv:2202.10336.

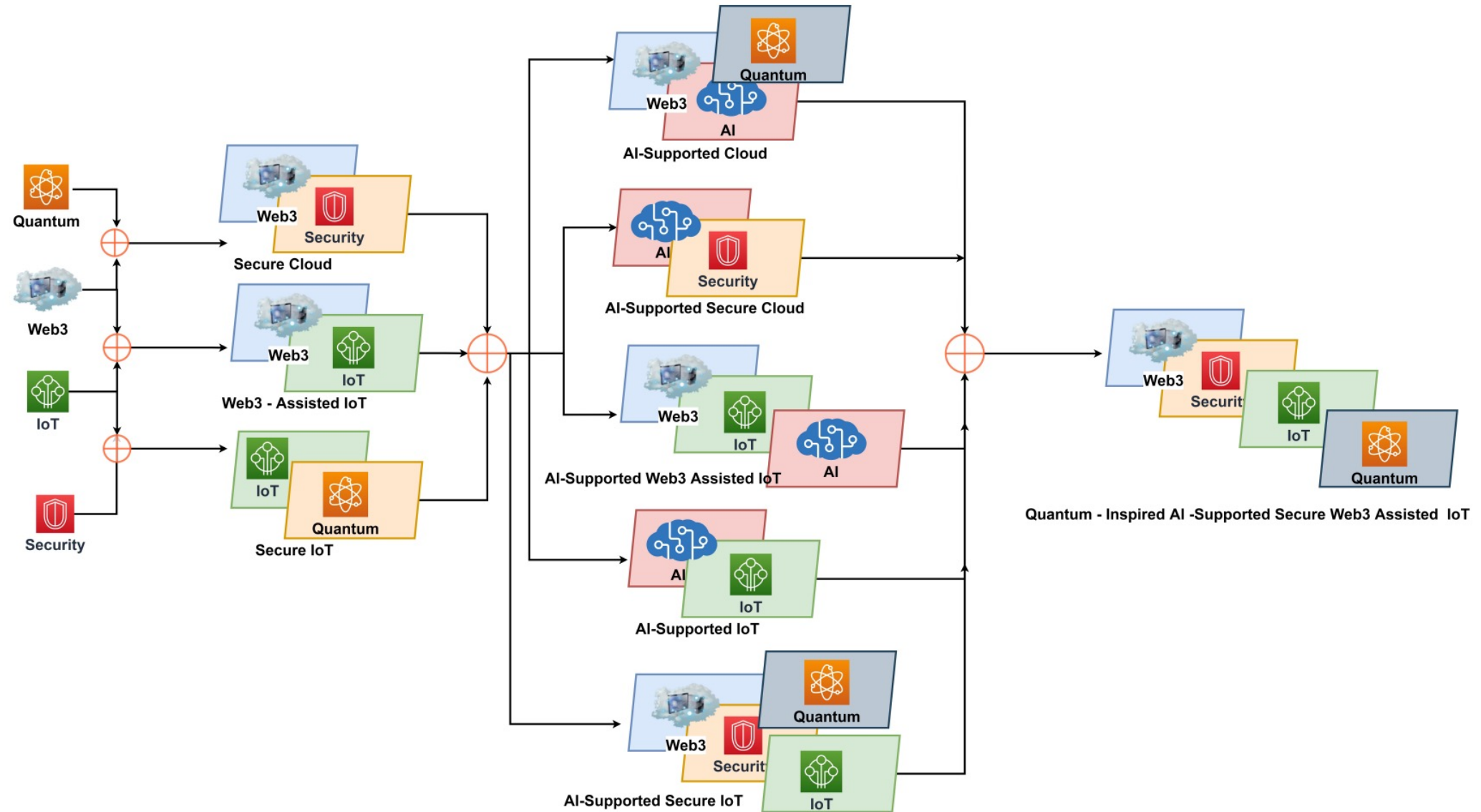
# Blockchain-Registered: Crypto, Collectables, and Art.



Source: Belk, Russell, Mariam Humayun, and Myriam Brouard. (2022)

"Money, possessions, and ownership in the Metaverse: NFTs, cryptocurrencies, Web3 and Wild Markets." Journal of Business Research 153: 198-205.

# Combination of Web3 with other Technologies



Source: Sheridan, Dan, James Harris, Frank Wear, Jerry Cowell Jr, Easton Wong, and Abbas Yazdinejad. (2022) "Web3 Challenges and Opportunities for the Market." arXiv preprint arXiv:2209.02446.

# Decentralized Finance (DeFi)

## Block Chain FinTech

# Decentralized Finance (DeFi)

- A **global, open alternative** to the current **financial system**.
- Products that let you **borrow, save, invest, trade**, and more.
- Based on **open-source technology** that anyone can program with.

# Traditional Finance

## Centralized Finance (CeFi)

- **Some people aren't granted access to set up a bank account or use financial services.**
- **Lack of access to financial services can prevent people from being employable.**
- **Financial services can block you from getting paid.**
- **A hidden charge of financial services is your personal data.**
- **Governments and centralized institutions can close down markets at will.**
- **Trading hours often limited to business hours of specific time zone.**
- **Money transfers can take days due to internal human processes.**
- **There's a premium to financial services because intermediary institutions need their cut.**

# DeFi vs. CeFi

## Decentralized Finance (DeFi)

You hold your money.

You control where your money goes and how it's spent.

Transfers of funds happen in minutes.

Transaction activity is pseudonymous.

DeFi is open to anyone.

The markets are always open.

It's built on transparency – anyone can look at a product's data and inspect how the system works.

## Traditional Finance (Centralized Finance; CeFi)

Your money is held by companies.

You have to trust companies not to mismanage your money, like lend to risky borrowers.

Payments can take days due to manual processes.

Financial activity is tightly coupled with your identity.

You must apply to use financial services.

Markets close because employees need breaks.

Financial institutions are closed books: you can't ask to see their loan history, a record of their managed assets, and so on.

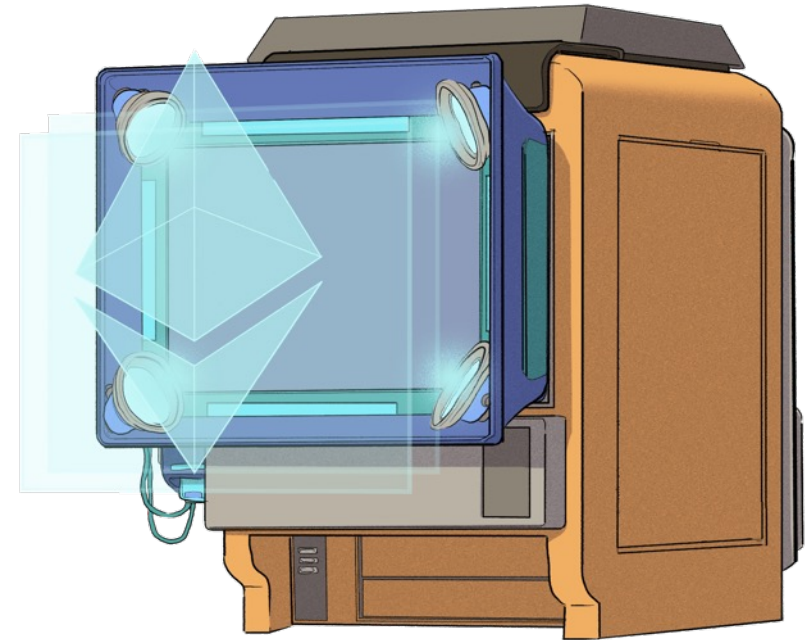
# (DeFi)

## Decentralized Applications (Dapps)

- **Ethereum-powered tools and services**
- **Dapps are a growing movement of applications that use Ethereum to disrupt business models or invent new ones**

# The Internet of Assets

- **Ethereum** isn't just for **digital money**.
- **Anything you can own can be represented, traded and put to use as non-fungible tokens (NFTs).**

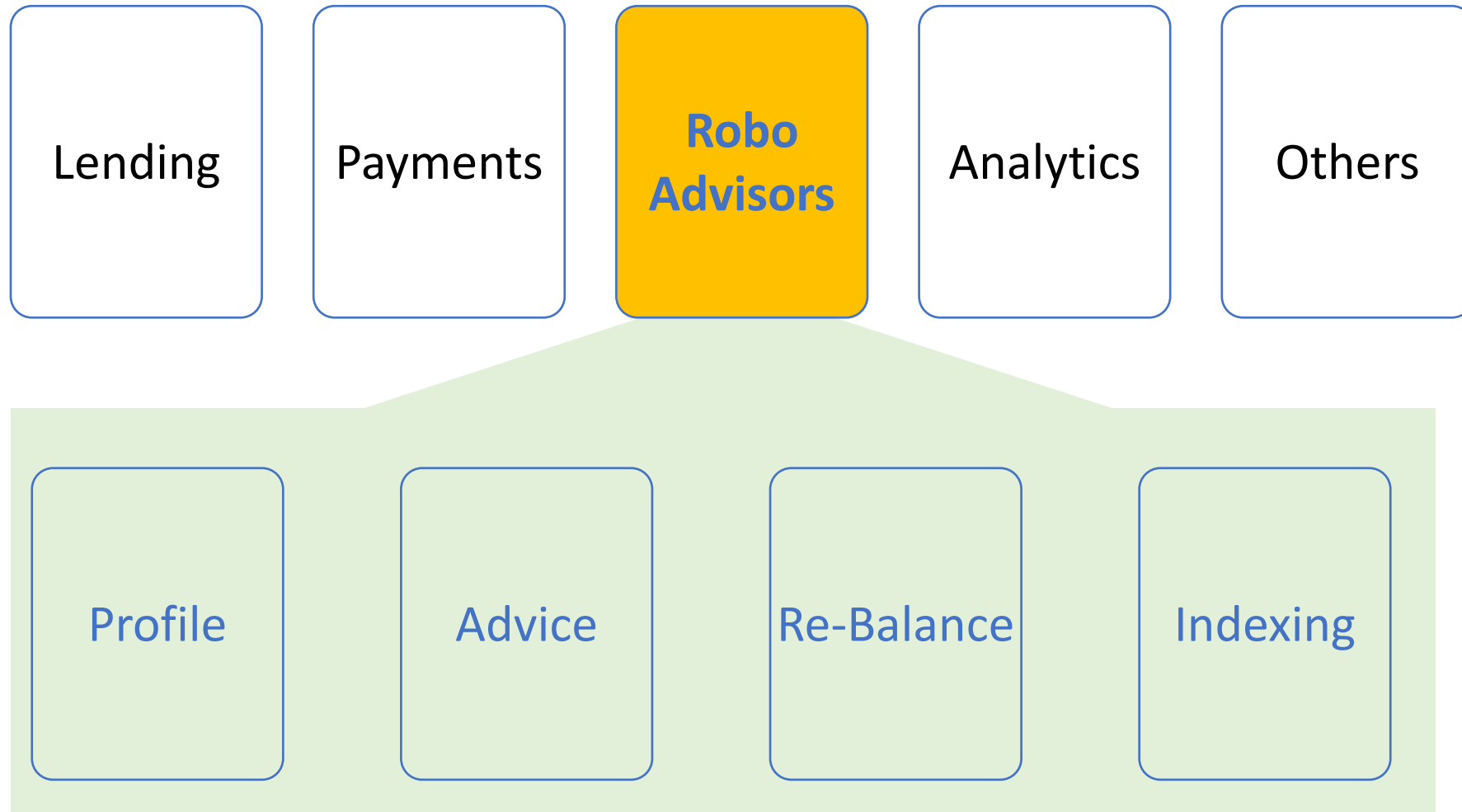


# Financial Services

# Technology Innovation

# FinTech Innovation

## FinTech high-level classification



**Generative AI and  
Agentic AI  
for  
Financial Innovation  
Applications**

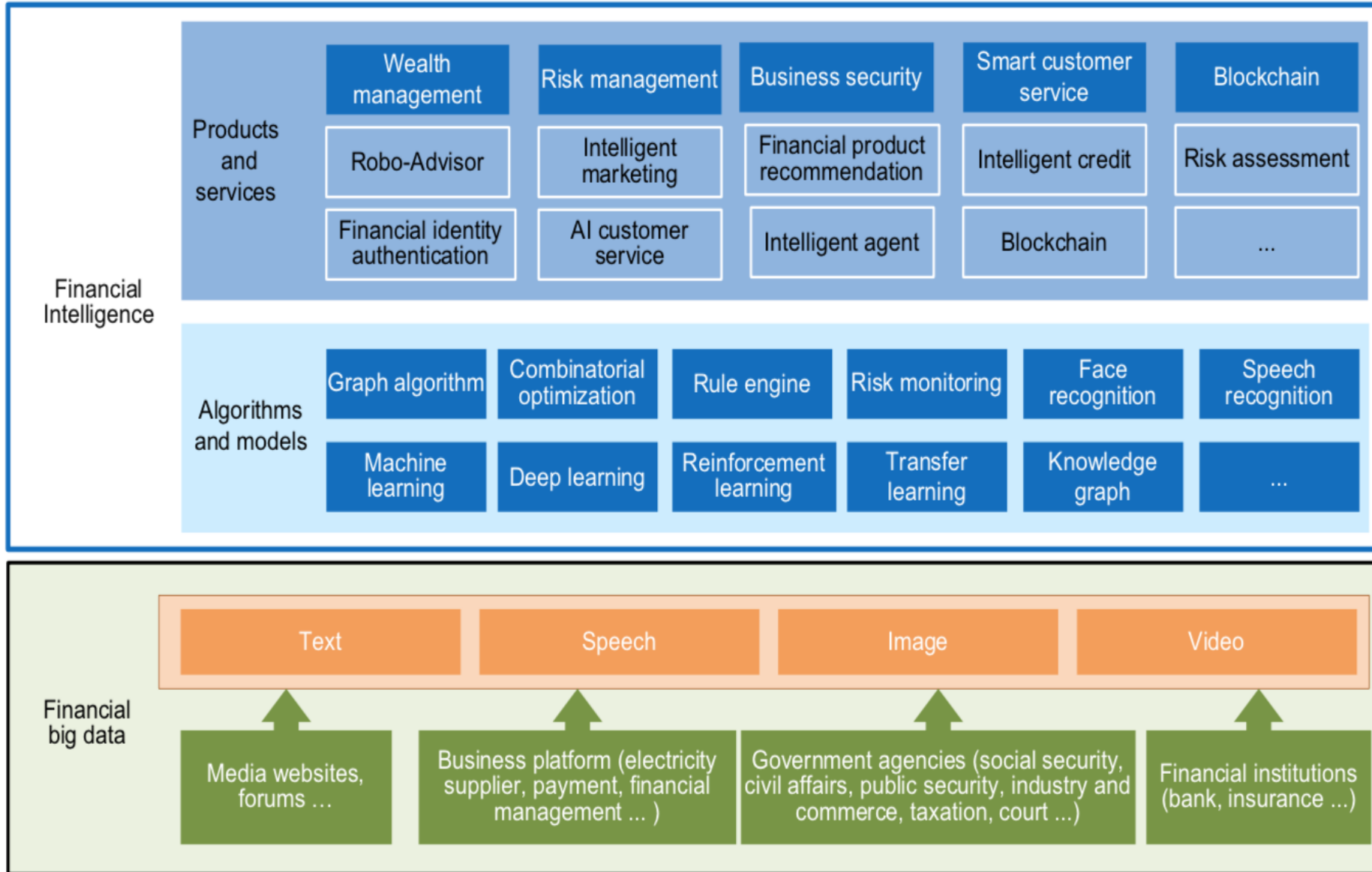
# Generative AI for Financial Innovation Applications

- **Security & Compliance**
- **Personalized Financial Services**
- **Trading & Investment**
- **Customer Service & Operations**

# Technology-driven Financial Industry Development

# FinBrain: when Finance meets AI 2.0

(Zheng et al., 2019)



Source: Xiao-lin Zheng, Meng-ying Zhu, Qi-bing Li, Chao-chao Chen, and Yan-chao Tan (2019), "Finbrain: When finance meets AI 2.0." Frontiers of Information Technology & Electronic Engineering 20, no. 7, pp. 914-924

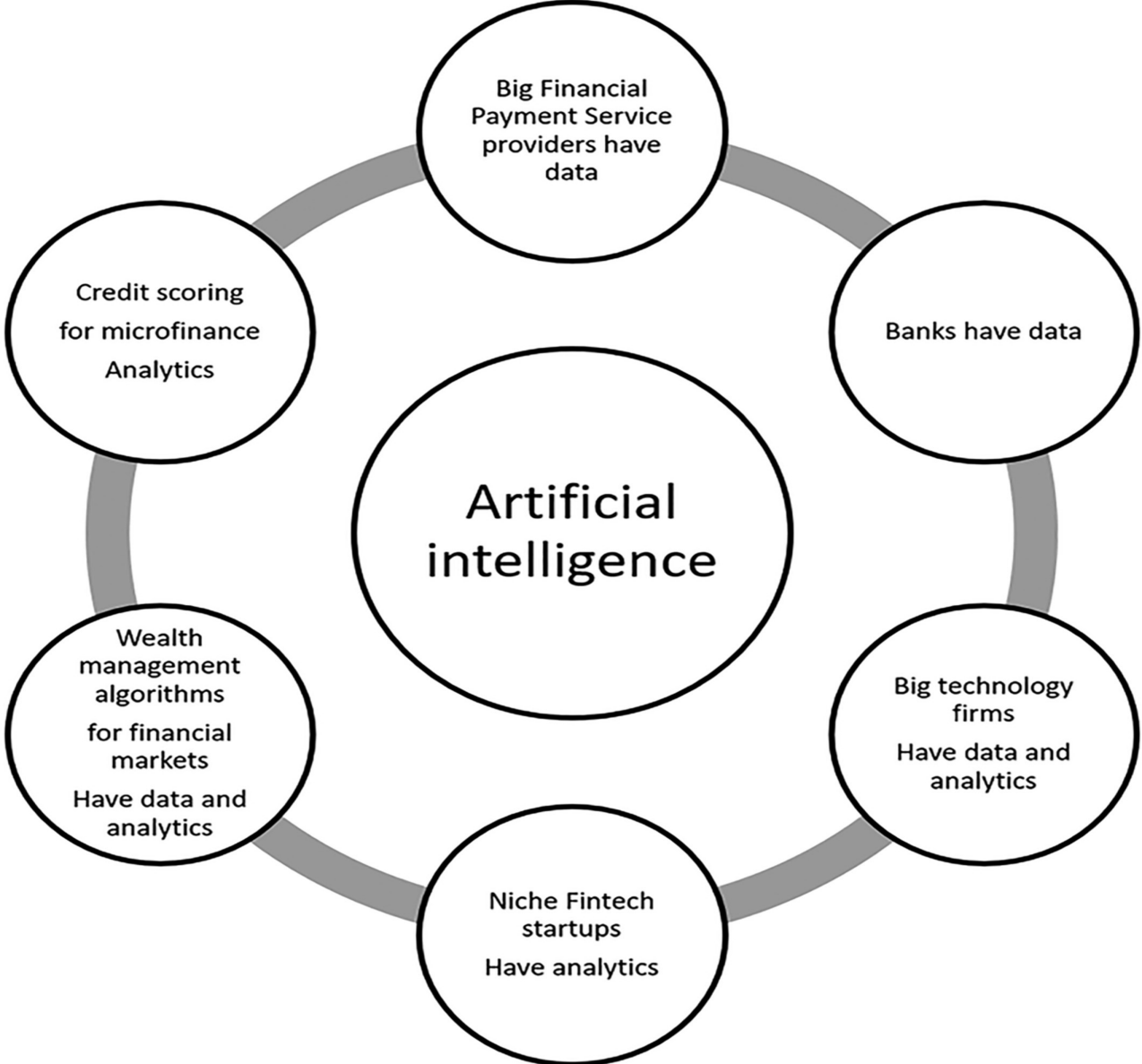
# AI 2.0

**a new generation of AI  
based on the  
novel information environment of  
major changes and  
the development of  
new goals.**

# Technology-driven Financial Industry Development

Development stage	Driving technology	Main landscape	Inclusive finance	Relationship between technology and finance
Fintech 1.0 (financial IT)	Computer	Credit card, ATM, and CRMS	Low	Technology as a tool
Fintech 2.0 (Internet finance)	Mobile Internet	Marketplace lending, third-party payment, crowdfunding, and Internet insurance	Medium	Technology- driven change
Fintech 3.0 (financial intelligence)	AI, Big Data, Cloud Computing, Blockchain	Intelligent finance	High	Deep fusion

# Artificial Intelligence in the Financial Markets



Source: Ashta, Arvind, and Heinz Herrmann (2021). "Artificial intelligence and fintech: An overview of opportunities and risks for banking, investments, and microfinance." Strategic Change 30, no. 3 (2021): 211-222.

# AI in Managerial Blind Spots: Unknown Knowns and Unknown Unknowns

		Do I know?	
		Yes	No
Do I know whether I know?	Yes	ERP, CRM, MIS, Transaction Processing Systems	Data Science & Business Intelligence
	No	Data Mining & Supervised Machine Learning	Big Data & Unsupervised Machine Learning

# Generative AI for Financial Innovation

- **Security & Compliance**
  - **Fraud detection using synthetic data**
  - **AI Risk Decisioning with knowledge fabric & natural language interfaces**
  - **Risk management through economic scenario simulation**
  - **Automated regulatory compliance monitoring**

# Generative AI for Financial Innovation

- **Personalized Financial Services**
  - **Custom financial planning & investment recommendations**
  - **Intelligent budgeting with predictive expense analysis**
  - **Lifestyle-based financial guidance**

# Generative AI for Financial Innovation

- **Trading & Investment**
  - **Advanced algorithmic trading strategies**
  - **Finance-specific Large Language Models (LLMs)**
  - **Multi-agent frameworks with layered memories**

# Generative AI for Financial Innovation

- **Customer Service & Operations**
  - **24/7 AI chatbots and virtual assistants**
  - **Automated financial reporting**
  - **Earnings call analysis**
  - **Data-driven market research**
  - **Portfolio performance optimization**

# Generative AI Financial Risk Agents

Paper	Model/Approach	Key Findings	Gaps	Future Work
[1]	Generative AI for credit evaluation	20% reduction in loan default rates	Limited explainability of models	Develop interpretable AI models for credit scoring
[7]	AI risk management frameworks	25% improvement in risk model accuracy	Insufficient focus on real-time risk assessment	Real-time, adaptive risk frameworks
[9]	Generative AI for operational risk	30% reduction in operational inefficiencies	Lack of generalization across financial domains	Cross-domain adaptable risk models

# Generative AI Investment Risk Agents

Paper	Model/Approach	Key Findings	Gaps	Future Work
[16]	Collaborative AI-agent framework	15% increase in ROI	Limited scalability for large datasets	Scalable AI frameworks for big data
[15]	Multi-agent stock prediction system	20% improvement in prediction accuracy	Lack of robustness under market volatility	Develop robust models for dynamic markets

# Generative AI Fraud Risk Agents

Paper	Model/Approach	Key Findings	Gaps	Future Work
[10]	Generative AI for fraud detection	40% decrease in false positives	Limited focus on new fraud patterns	Adaptive models for evolving fraud tactics
[8]	AI for SEC filing irregularities	92% accuracy in fraud detection	Over-reliance on historical data	Integrate real-time data sources

# Generative AI Stock Market Agents

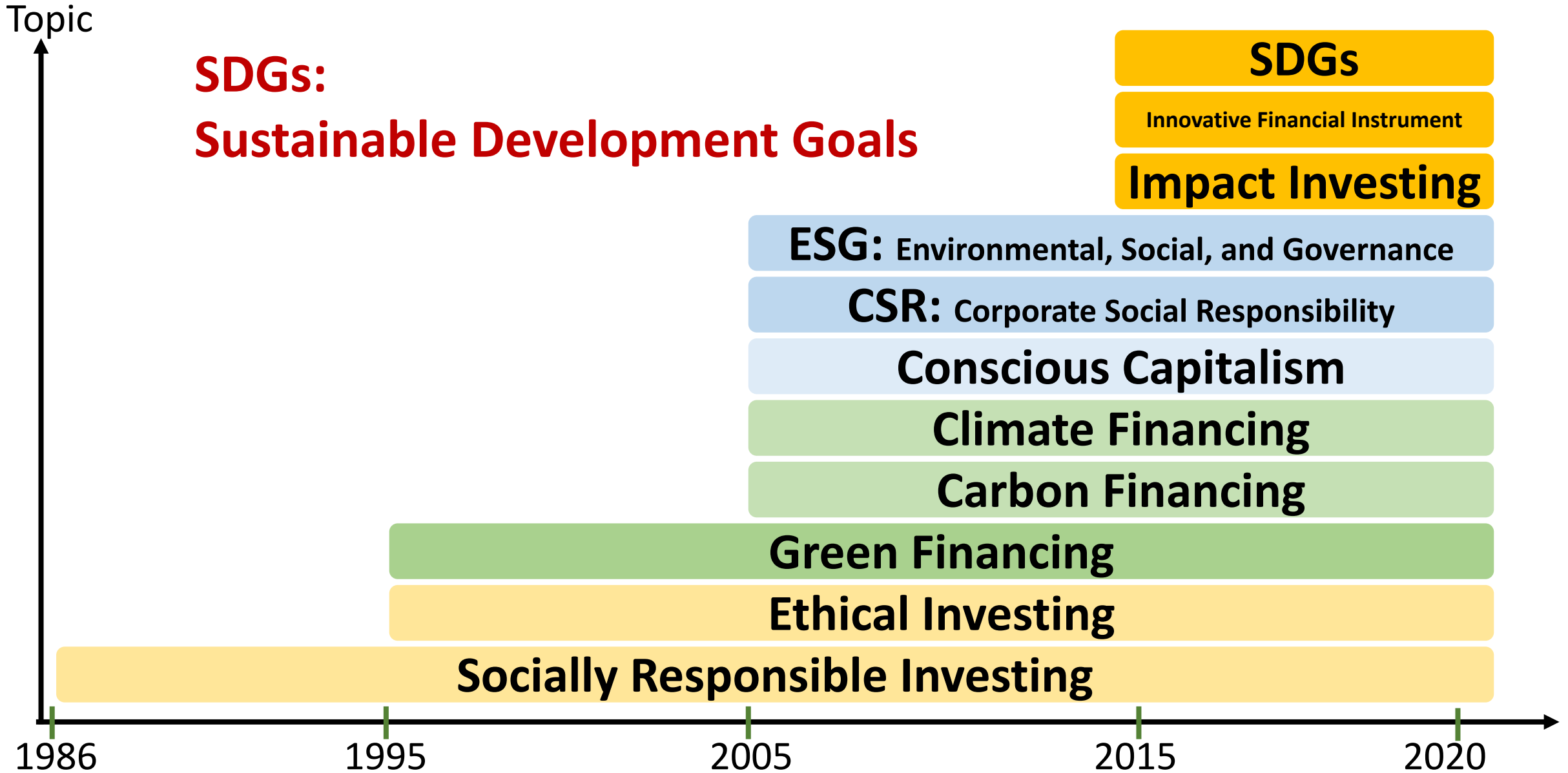
Paper	Model/Approach	Key Findings	Gaps	Future Work
[6]	Multimodal trading AI agent	12% increase in profit margins	Limited application to small-cap markets	Extend to small-cap and emerging markets
[17]	Multi-agent market model	Price stabilization, reduced volatility	Focused on single-agent interactions	Investigate multi-agent interactions in real-time

# Generative AI Customer Support Agents

Paper	Model/Approach	Key Findings	Gaps	Future Work
[5]	Generative AI-powered support agents	35% reduction in response time	Limited personalization in customer interactions	Personalized support using customer behavioral data
[3]	Executive strategies for AI agents	50% increase in customer satisfaction	Limited adoption in SMEs	Adapt strategies for small and medium enterprises

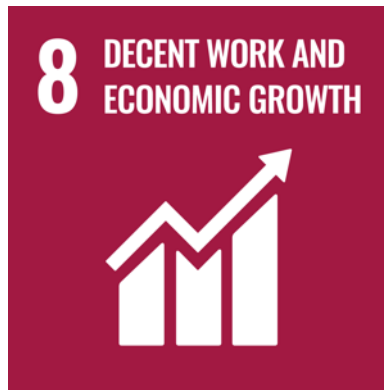
# **Green Finance and Sustainable Finance**

# Evolution of Sustainable Finance Research



Source: Kumar, S., Sharma, D., Rao, S., Lim, W. M., & Mangla, S. K. (2022). Past, present, and future of sustainable finance: Insights from big data analytics through machine learning of scholarly research. *Annals of Operations Research*, 1-44.

# Sustainable Development Goals (SDGs)



# Sustainable Development Goals (SDGs)

Partnership

Peace

Prosperity

People

Planet



# ESG to 17 SDGs

## ENVIRONMENT



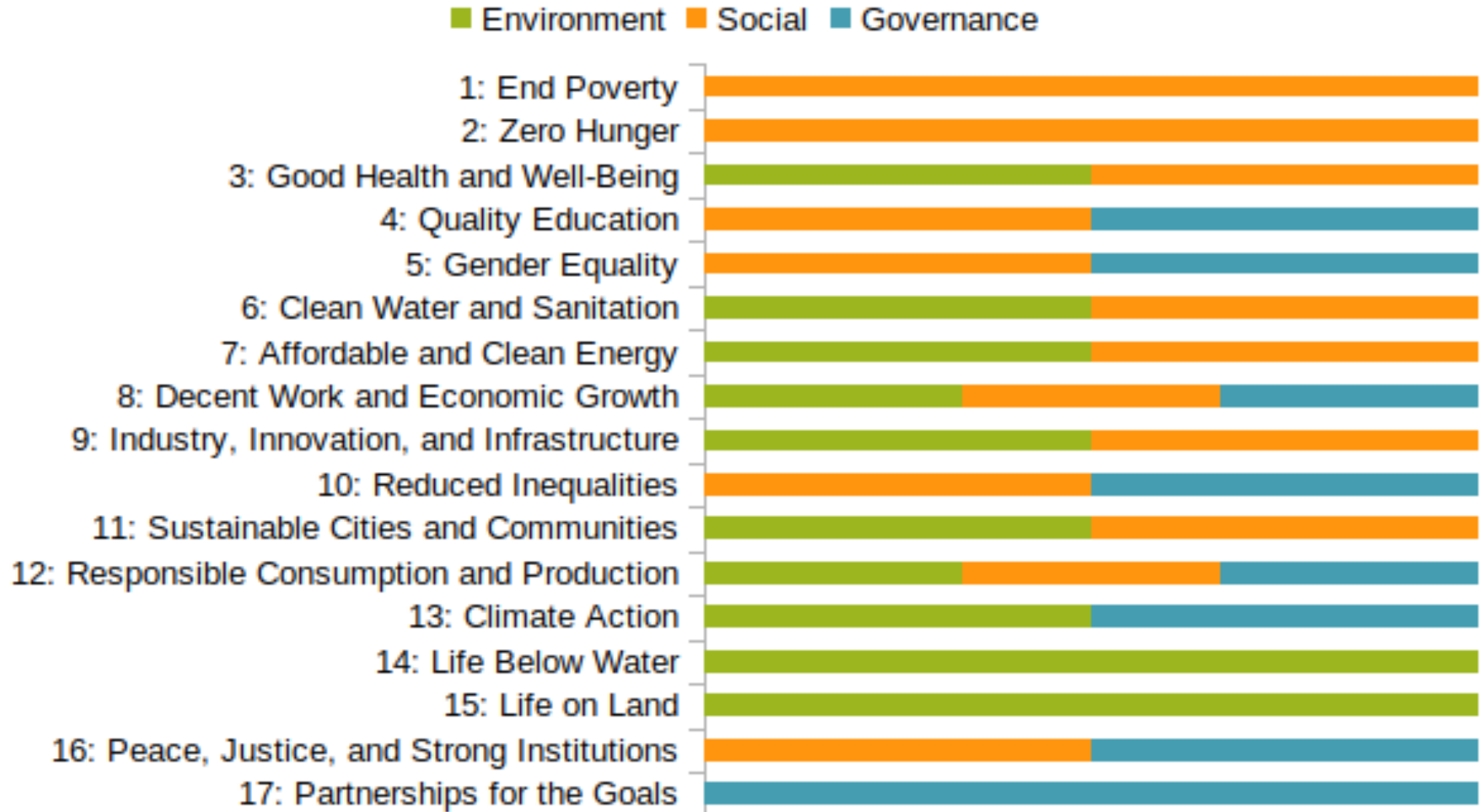
## SOCIAL



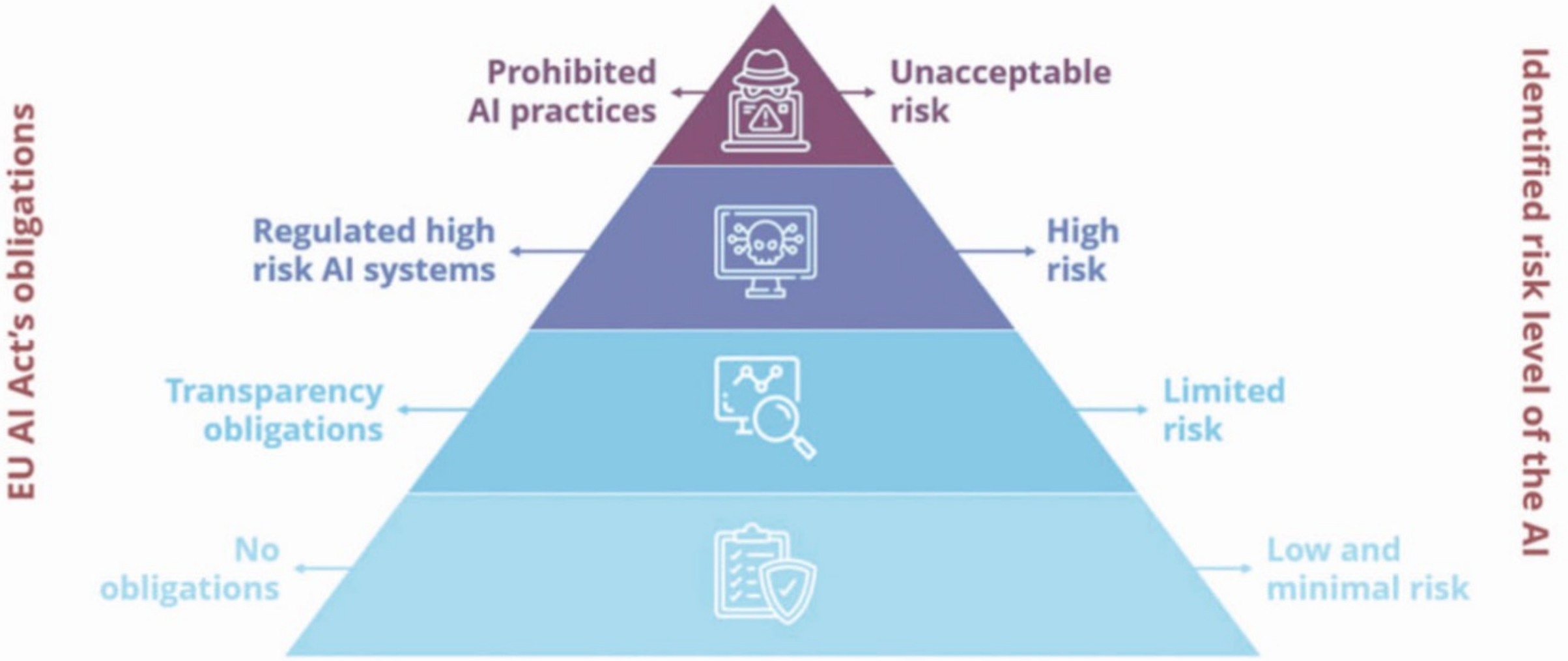
## GOVERNANCE



# ESG to 17 SDGs

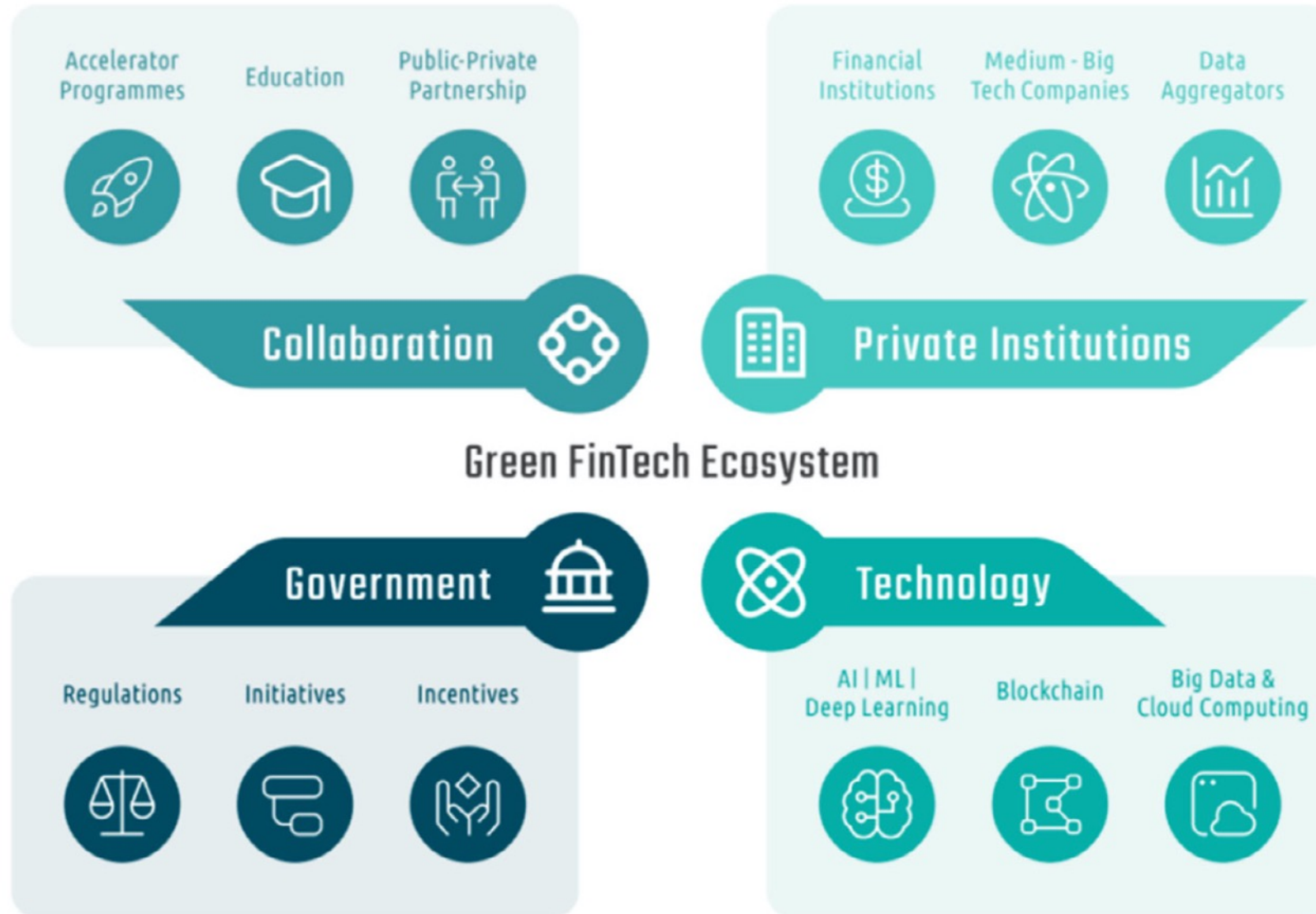


# Green FinTech Ecosystem

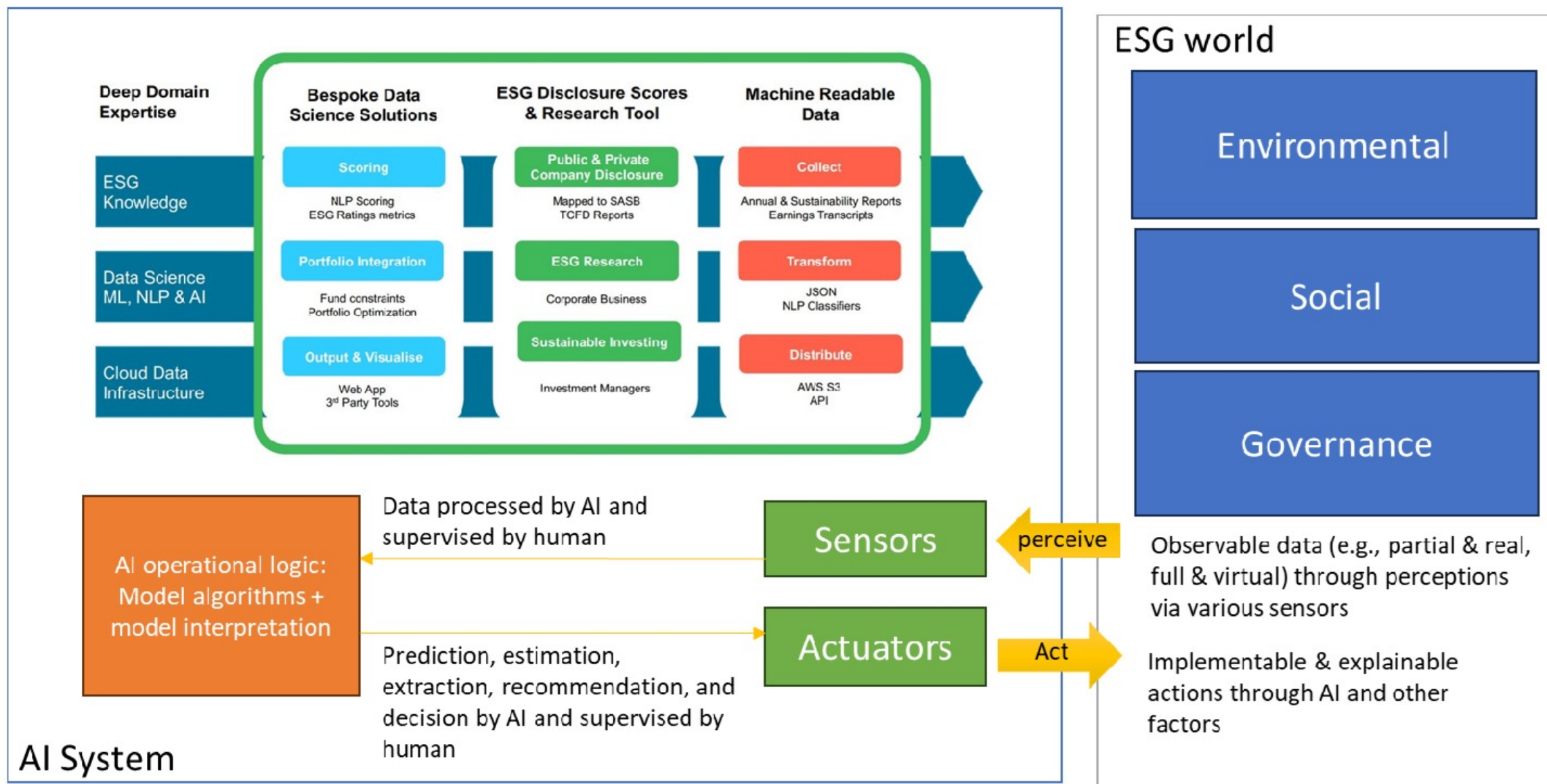


Source: Lee, Haein, Jang Hyun Kim, and Hae Sun Jung. "Deep-learning-based stock market prediction incorporating ESG sentiment and technical indicators." Scientific Reports 14, no. 1 (2024): 10262.

# The EU AI Act Regulatory Framework



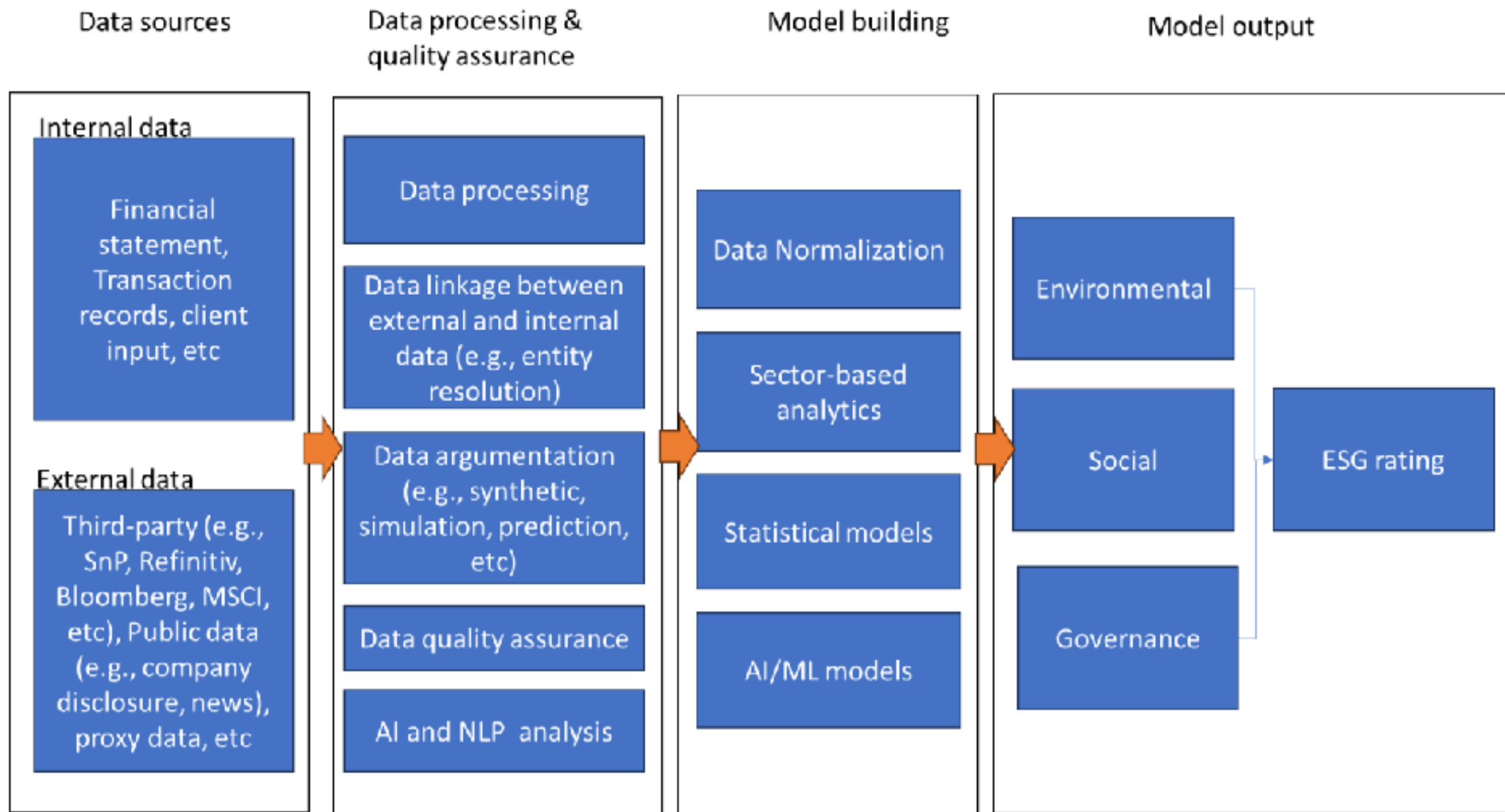
# AI System and ESG World



# AI Solution for Net Zero Model

Challenges	Description	Potential AI Solution
Data Complexity and Volume	Handling vast and complex data related to emissions across various industries.	Use of big data analytics and ML to process and analyze large datasets efficiently.
Dynamic Nature of Emissions	Emissions vary over time and by industry, requiring adaptable models. Different scopes may need different approaches.	Development of flexible AI models that can adapt to varying emission patterns and industry-specific factors.
Integration of Diverse Data Sources	Combining data from different sources and sectors for comprehensive analysis.	Implementing AI algorithms capable of integrating and synthesizing diverse data streams for holistic insights.
Predictive Accuracy	Accurately predicting future emissions and the effectiveness of mitigation strategies.	Employing predictive analytics and advanced ML techniques for precise forecasting of emissions and strategy outcomes.
Balancing Economic and Environmental Goals	Ensuring that net zero strategies are economically viable.	AI-driven optimization models that balance economic factors with environmental impact to identify cost-effective sustainability strategies.

# Data Analytics for ESG Ranking & Scoring



# Traditional and AI-Power ESG Rating

Aspect	Traditional ESG Rating Agencies	AI-Powered ESG Rating Organizations
Data Processing and Analysis	Rely on manual data collection and analysis, subject to human bias, e.g., analyst.	Use algorithms, ML, and NLP to analyze large data sets efficiently, reducing human bias.
Speed and Scalability	Slower due to manual processes; limited in the number of companies assessed. Usually, update semiannually or annually	Faster updates and ability to scale up to assess more companies due to automation. Typically, update in daily or weekly.
Consistency and Objectivity	Potential for inconsistencies and subjective interpretations.	More consistent and objective, though not immune to underlying data biases.
Predictive Insights	Focus on current and past performance based on available data.	Capable of offering predictive insights about future ESG performance and risks.
Customization and Flexibility	Limited customization and flexibility due to manual processes.	Greater customization and flexibility, adapting quickly to new data sources or changing ESG criteria.

# ESG Data Providers

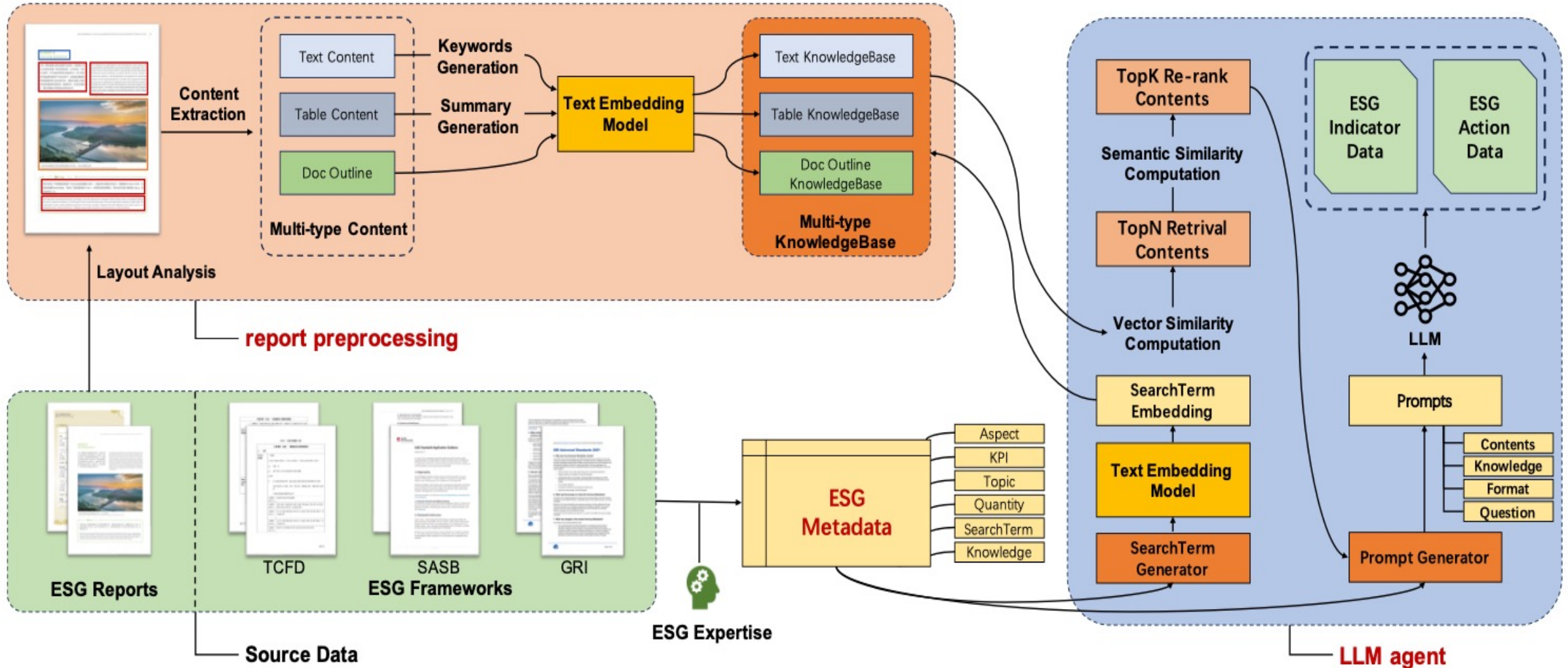
Provider	Description	Website
Bloomberg	Provide global coverage of ESG data; mainly on listed or public companies	<a href="https://finance.com/en/blog/esg/top-5-esg-data-providers-rating-and-report/">https://finance.com/en/blog/esg/top-5-esg-data-providers-rating-and-report/</a>
BvD (Moody's)	Provide ESG ratings, analytics, sustainability ratings, and sustainable finance reviewer/certifier services using data from Moody's. The BvD Orbis users can now add RepRisk's ESG risk metrics to the already substantial arsenal of company information available to you through our flagship global database of more than 200 million private companies	<a href="https://www.bvdinfo.com/en-gb/blog/compliance-and-financial-crime/product-update-using-orbis-to-assess-environmental-social-and-governance-esg-risk">https://www.bvdinfo.com/en-gb/blog/compliance-and-financial-crime/product-update-using-orbis-to-assess-environmental-social-and-governance-esg-risk</a>
CDP	CDP (formerly the Carbon Disclosure Project) ESG Rating is a unique rating that identifies the best ESG-integrated investment funds, based on their ESG performance	<a href="https://www.cdp.net/en/scores/cdp-scores-explained">https://www.cdp.net/en/scores/cdp-scores-explained</a>
FTSE Russell / LSEG	Provide ESG ratings using a company's Theme Exposure and Theme level score assessment to calculate range of assessments that allow investors to understand a company's ESG practices in multiple dimensions.	<a href="https://www.ftserussell.com/products/indices/esg">https://www.ftserussell.com/products/indices/esg</a>
ISS	Provide ESG data and research on companies. The system's goal is to take the ESGY Scorecard directly to the industry level.	<a href="https://www.issgovernance.com/esg/">https://www.issgovernance.com/esg/</a>

# ESG Data Providers

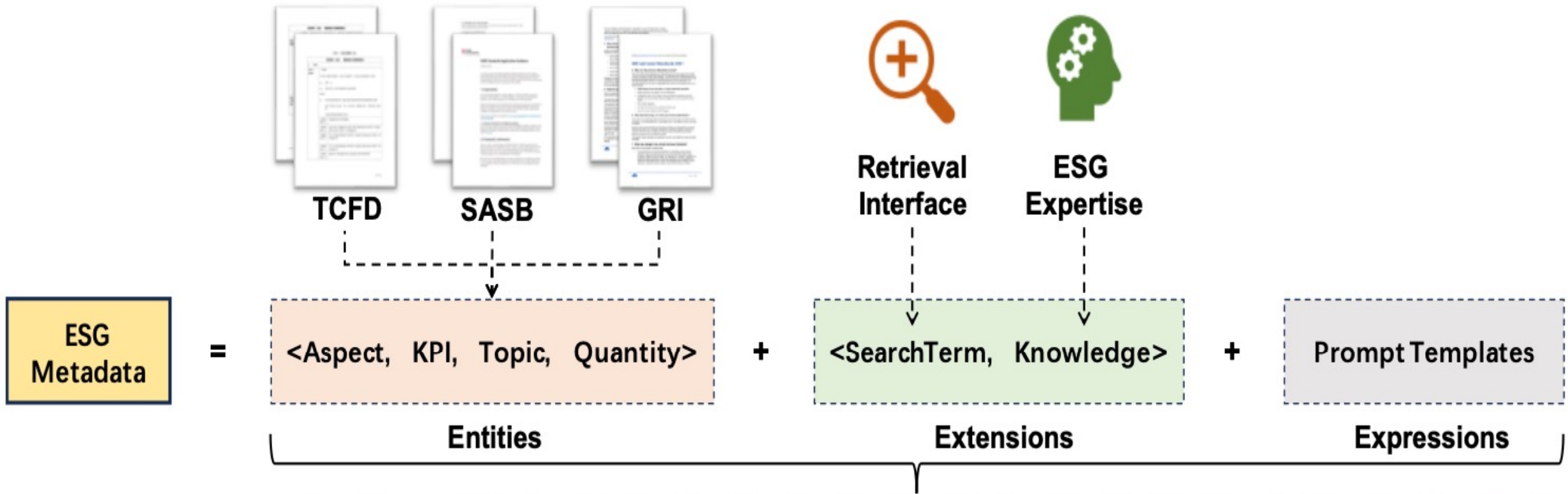
Provider	Description	Website
MSCI	Offer data on ESG. Its ratings aim to measure a company's management of financially relevant ESG risks and opportunities.	<a href="https://www.msci.com/our-solutions/esg-investing/esg-ratings">https://www.msci.com/our-solutions/esg-investing/esg-ratings</a>
Refinitiv / LSEG	Provides comprehensive ESG data. Their ESG scores are designed to transparently and objectively measure a company's relative ESG performance, commitment and effectiveness across 10 main themes (emissions, environmental product innovation, diversity and inclusion, human rights, shareholders, etc.) based on publicly-reported data	<a href="https://www.refinitiv.com/content/dam/marketing/en_us/documents/methodology/refinitiv-esg-scores-methodology.pdf">https://www.refinitiv.com/content/dam/marketing/en_us/documents/methodology/refinitiv-esg-scores-methodology.pdf</a>
Sustainalytics	An independent ESG research and rating agency that provides data and research on the environmental and social performance of companies.	<a href="https://connect.sustainalytics.com/hubfs/SFS/Sustainalytics%20ESG%20Risk%20Rating%20-%20FAQs%20for%20Corporations.pdf">https://connect.sustainalytics.com/hubfs/SFS/Sustainalytics%20ESG%20Risk%20Rating%20-%20FAQs%20for%20Corporations.pdf</a>
S&P Global	Provide access to transparently disclosed ESG data points for companies assessed in the S&P	<a href="https://www.spglobal.com/esg/solutions/esg-data-intelligence">https://www.spglobal.com/esg/solutions/esg-data-intelligence</a>

# ESGReveal:

## LLM for Data Analytics from ESG Reports



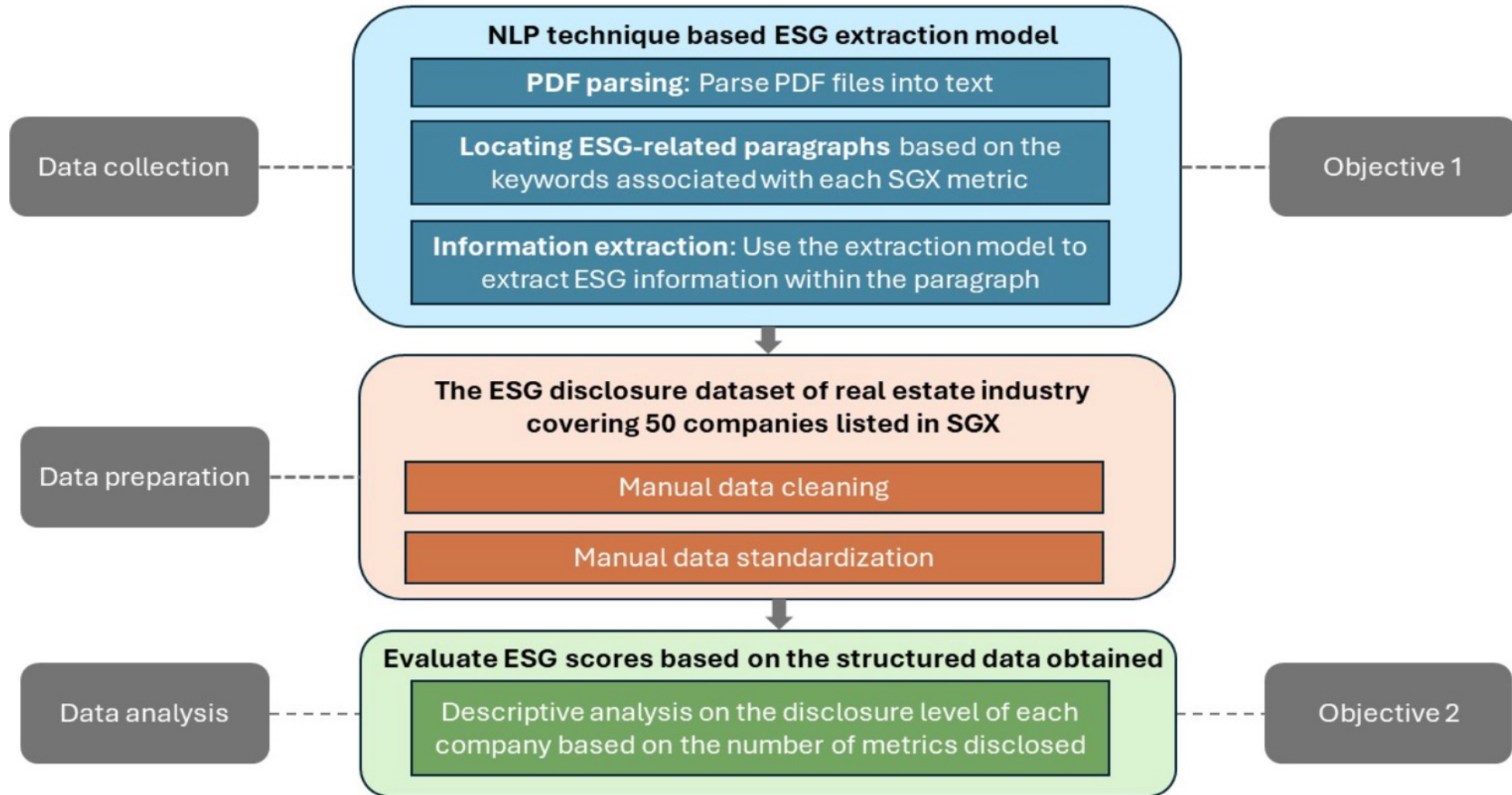
# Structure of ESG Metadata Module: Entities, Extensions, and Expressions



Please use the above information, do not deviate from the given material answer:  
In terms of [Aspect], extract the [KPI] of the last year with [Topic], and give [Quantity]. Return the answer in the following JSON format: {"KPI": "<KPI>", "Topic": "<topic>", "value": "<value>", "Unit": "<unit>"}

# Information Extraction:

## Unstructured to Structured for ESG Reports



# SGX Suggested ESG Metrics

## Environmental

Total GHG absolute emissions  
GHG Emission intensities  
Total energy consumption  
Energy intensity consumption  
Total water consumption  
Water consumption intensity  
Total waste generated

## Social

Current employees by gender  
New hires by gender  
Turnover by gender  
Current employees by age groups  
New hires by age groups  
Turnover by age groups  
Total turnover  
Total number of employees  
Average training hours per employee  
Average training hours per employee  
by gender  
Fatalities  
High-consequence injuries  
Recordable injuries  
Recordable work-related ill health  
cases

## Governance

Board independence  
Women on the board  
Women in the management team  
Anti-corruption disclosures  
Anti-corruption training for  
employees  
List of relevant certifications  
Alignment with frameworks and  
disclosure practices  
Assurance of sustainability report

# AI and Sustainability Development Goals (SDGs)

SDGs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	No poverty	Zero hunger	Good health and well-being	Quality education	Gender equality	Clean water and sanitation	Affordable and clean energy	Decent work and economic growth	Industry, innovation and infrastructure	Reduces inequalities	Sustainable cities and communities	Responsible consumption and production	Climate action	Life below water	Life on land	Peace, justice and strong institutions	Partnerships for the goals
<b>Economic</b>								●	●	●	○						●
<b>Ecological</b>		○					○				○	○	●	●	●		
<b>Social</b>	●	●	●	●	●	●	●				●	●				●	
<b>Positive impact of AI*</b>	100%	76%	69%	10%0	56%	100%	100%	92%	100%	90%	100%	82%	80%	90%	100%	58%	26%

Note: ● adopted from Vinuesa et al. (2020), ○ added based on our analysis.

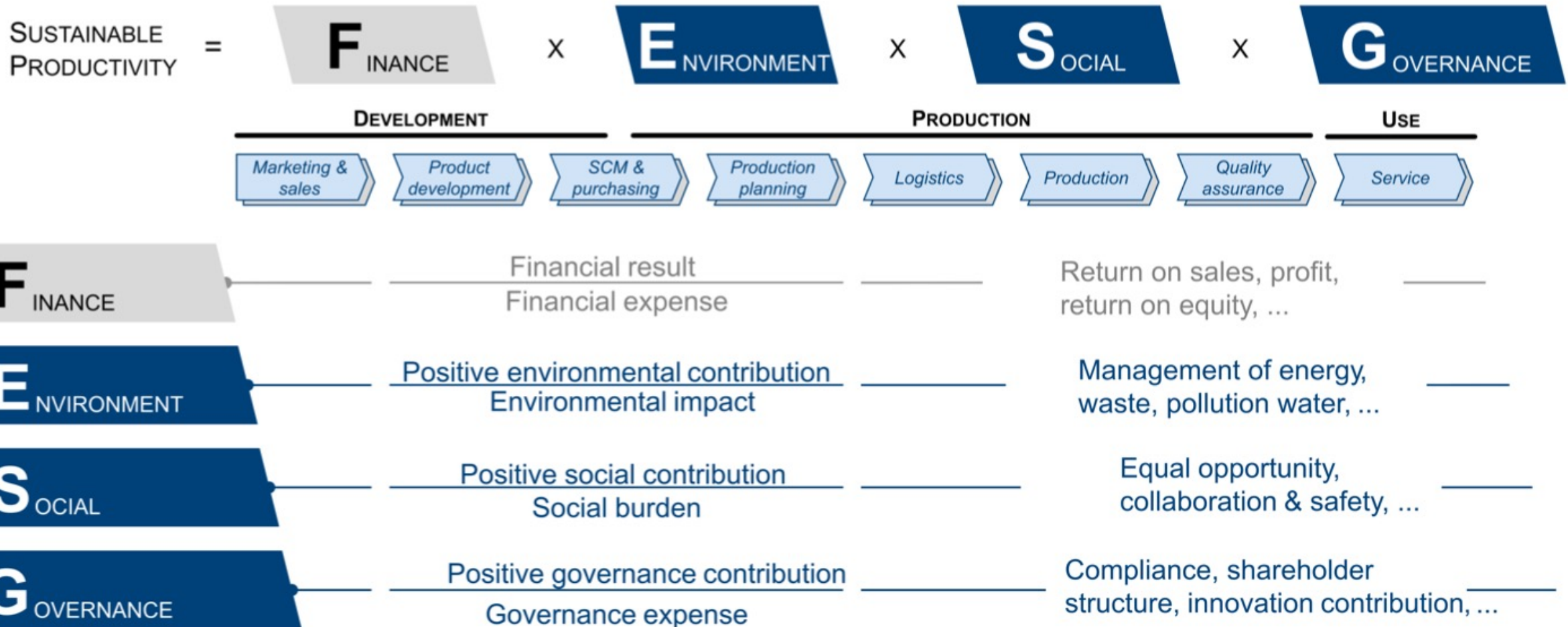
\*The assessment of AI's possible positive impact is based on a consensus-based expert elicitation process (Vinuesa et al., 2020).

# AI for Sustainability

Dimension	Code characteristics					
Primary objective <sup>1</sup>	Develop new (AI) methods (11/95)	Compare (AI) methods (39/95)	Apply (AI) methods (53/95)	Develop new system (20/95)	Other objective (4/95)	
Sustainability dimension	Economic (23/95)		Ecological (17/95)		Social (72/95)	
Sustainable Development Goals (SDGs)	SDG 1 (0/95)	SDG 2 (2/95)	SDG 3 (55/95)	SDG 4 (6/95)	SDG 5 (0/95)	SDG 6 (0/95)
	SDG 7 (9/95)	SDG 8 (7/95)	SDG 9 (8/95)	SDG 10 (1/95)	SDG 11 (9/95)	SDG 12 (8/95)
	SDG 13 (2/95)	SDG 14 (0/95)	SDG 15 (2/95)	SDG 16 (11/95)	SDG 17 (0/95)	
Data source	Reviews (12/95)	Social media/ Online forums (31/95)	Health records (21/95)	Environment/ Weather (10/95)	Energy (5/95)	
Data source plurality	Single source (50/95)		Multiple sources (44/95)		N/A (1/95)	
Data sensitivity	Publicly available data (64/95)	Internal data (16/95)		Other (11/95)	N/A (9/95)	
Manual labeling	Yes (32/95)			No (63/95)		
Technology	ML (91/95)	NLP (42/95)		CV (12/95)	Other (21/95)	
Type of learning for ML approach	Supervised learning (85/95)			Unsupervised learning (23/95)		
Neural vs. non-neural	Non-neural (45/95)		Neural (50/95)		Deep learning (38/95)	
Evaluation	Technical evaluation (83/95)			Domain evaluation (25/95)		
Paradigm	DSR/ADR (30/95)			Non-DSR/ADR (64/95)		
			0-9	10-29	30-54	55-69
						70-95
Notes: Code dimensions are not mutually exclusive; one article can be classified into one or more code characteristics; <sup>1</sup> 'Compare' does include 'apply'.						

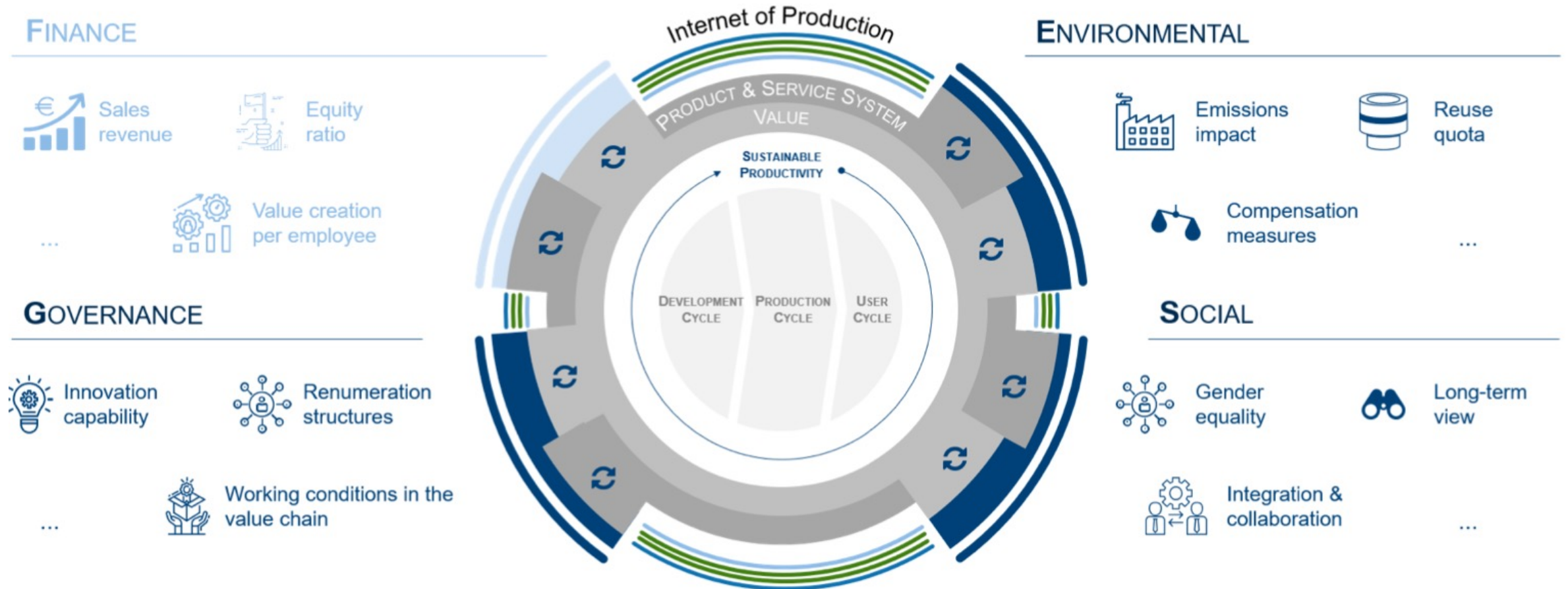
Source: Schoormann, T., Strobel, G., Möller, F., Petrik, D., & Zschech, P. (2023).

# Sustainable Productivity: Finance ESG



# Sustainable Resilient Manufacturing

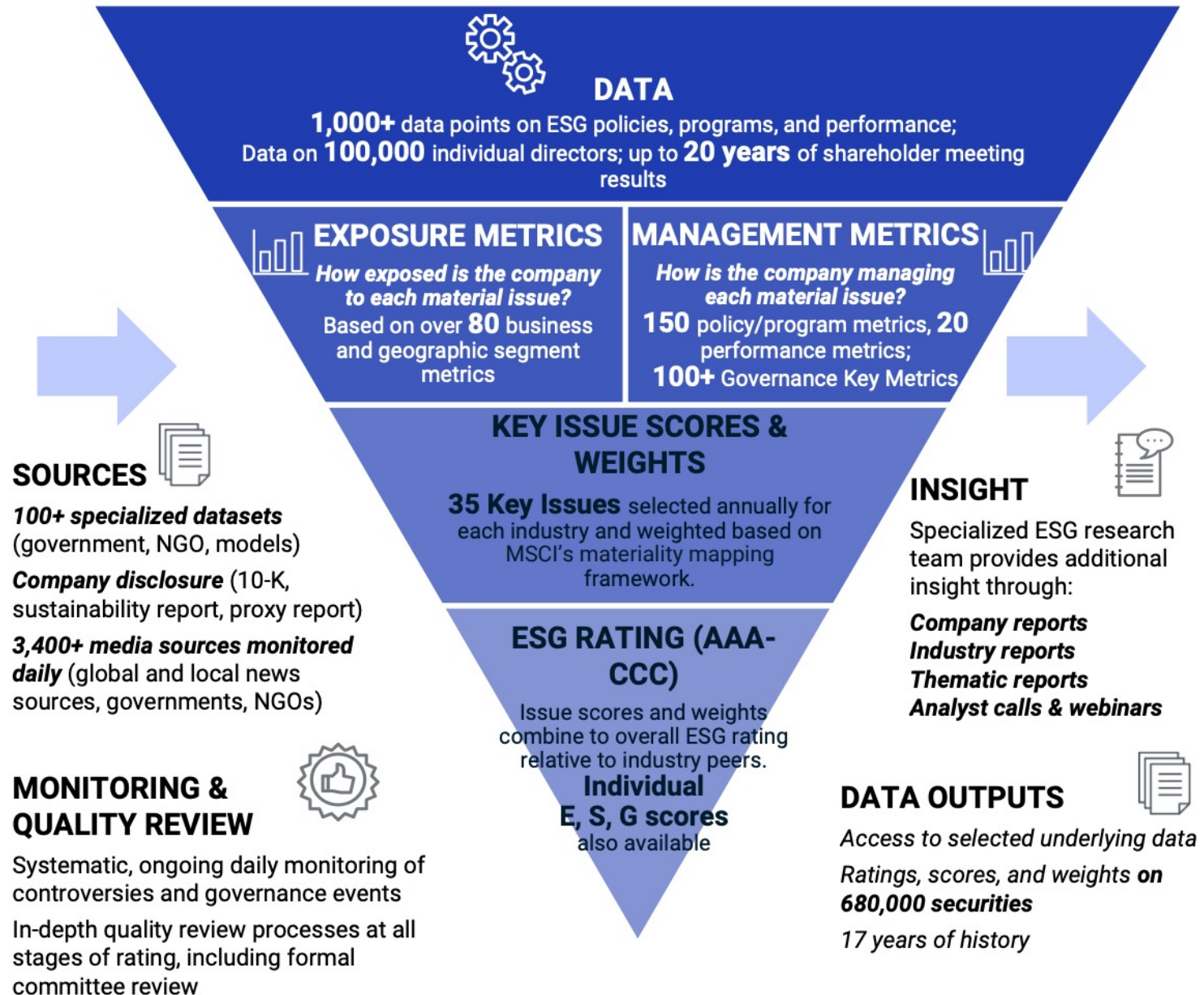
## ESG



# ESG Indexes

- **MSCI ESG Index**
- **Dow Jones Sustainability Indices (DJSI)**
- **FTSE ESG Index**

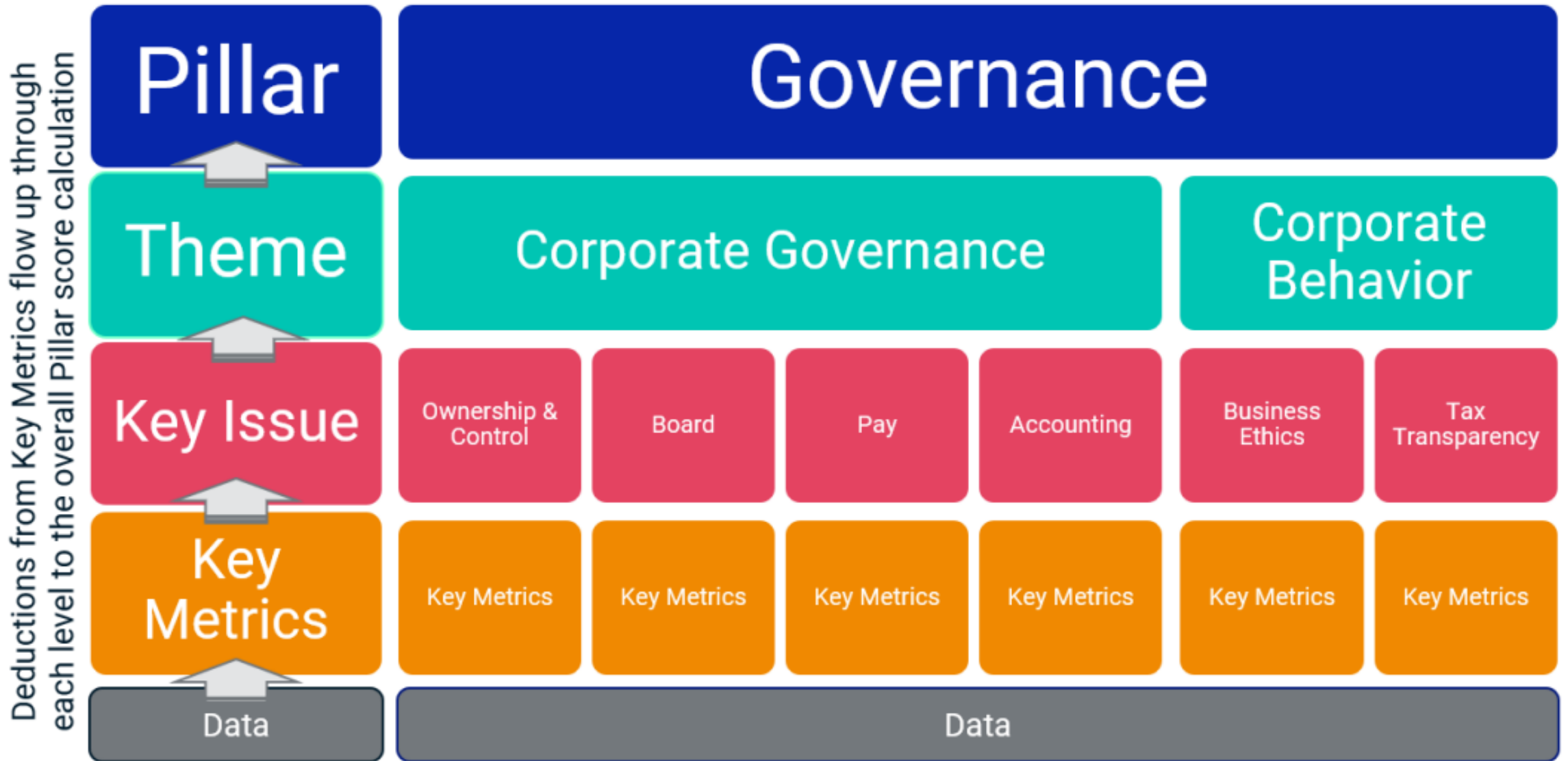
# MSCI ESG Rating Framework



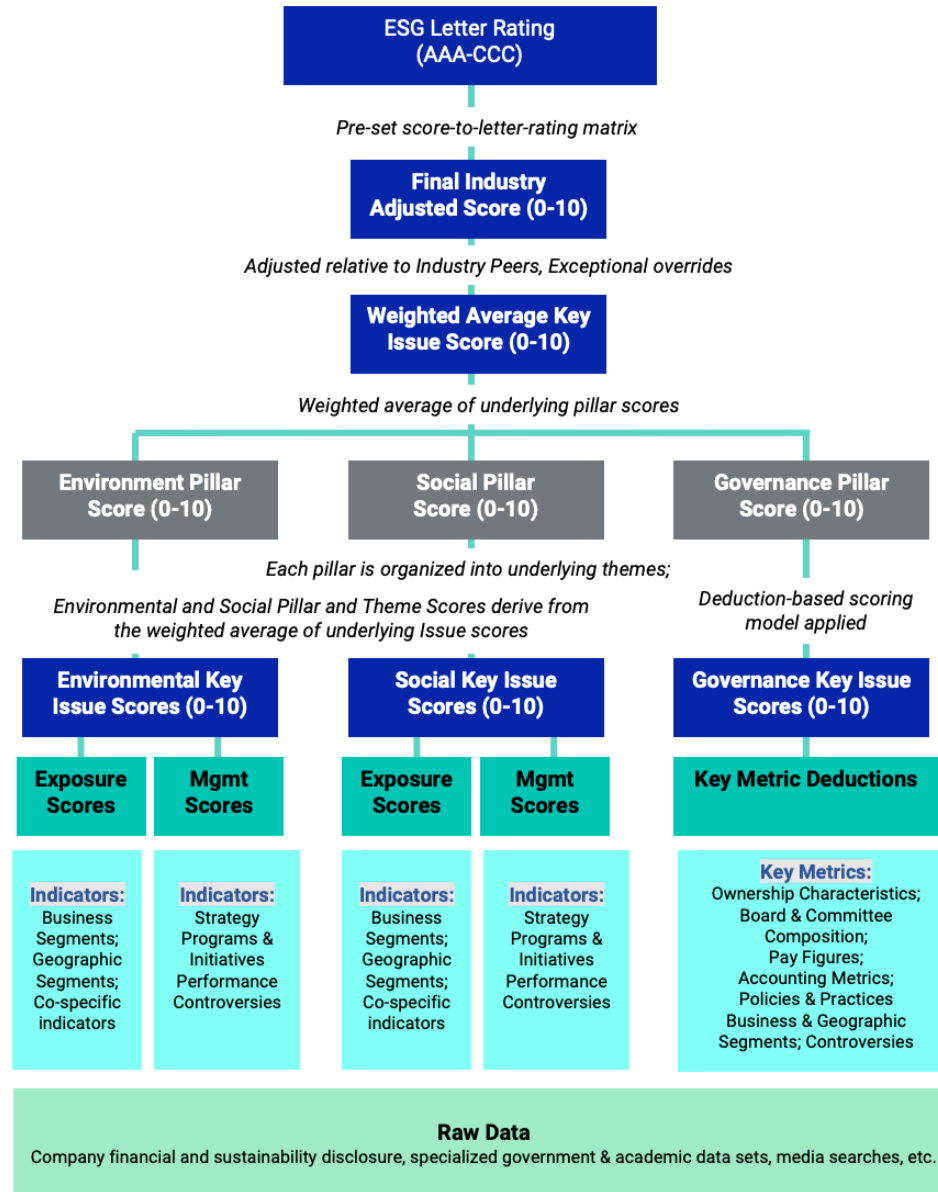
# MSCI ESG Key Issue Hierarchy

3 Pillars	10 Themes	35 ESG Key Issues	
<b>Environment</b>	<b>Climate Change</b>	Carbon Emissions Product Carbon Footprint	Financing Environmental Impact Climate Change Vulnerability
	<b>Natural Capital</b>	Water Stress Biodiversity & Land Use	Raw Material Sourcing
	<b>Pollution &amp; Waste</b>	Toxic Emissions & Waste Packaging Material & Waste	Electronic Waste
	<b>Environmental Opportunities</b>	Opportunities in Clean Tech Opportunities in Green Building	Opportunities in Renewable Energy
<b>Social</b>	<b>Human Capital</b>	Labor Management Health & Safety	Human Capital Development Supply Chain Labor Standards
	<b>Product Liability</b>	Product Safety & Quality Chemical Safety Consumer Financial Protection	Privacy & Data Security Responsible Investment Health & Demographic Risk
	<b>Stakeholder Opposition</b>	Controversial Sourcing Community Relations	
	<b>Social Opportunities</b>	Access to Communications Access to Finance	Access to Health Care Opportunities in Nutrition & Health
<b>Governance</b>	<b>Corporate Governance</b>	Ownership & Control Board	Pay Accounting
	<b>Corporate Behavior</b>	Business Ethics Tax Transparency	

# MSCI Governance Model Structure



# MSCI Hierarchy of ESG Scores



# DJSI S&P Global ESG Score

**8,000**  
Companies

**90%**  
Global market capitalization

**340,000+**  
Current Research Universe and Active Securities



Approx.  
**1,000**  
Datapoints

**Assessed values, text, checkboxes, documents**

Sources: Web-based questionnaire and company documents

**130+**  
Questions

**Weighted data point scores**

Up to 50% industry-specific

Ave.  
**30+**  
Criteria scores

**Weighted question scores**

61 industry specific approaches, with tailored questions, criteria and related weightings

**3**  
Dimension scores

**Weighted criteria scores**

Adjusted for corporate ESG controversies where applicable

**1**

**S&P Global ESG Score**

**Sum of weighted dimension scores**

# FTSE Russell ESG Ratings



# Sustainalytics

## ESG Risk Ratings

Analyst-based  
approach

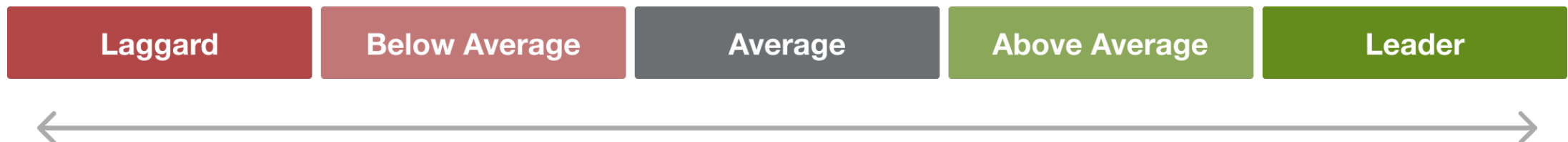
Sustainalytics' ESG Risk Ratings measure a company's exposure to industry-specific material ESG risks and how well a company is managing those risks.

Negligible	Low	Medium	High	Severe
0 - 10	10 - 20	20 - 30	30 - 40	40+

# Truvalue ESG Ranks

Machine-based  
approach

- **Truvalue Labs** applies **AI** to analyze over **100,000 sources** and uncover **ESG risks** and opportunities hidden in **unstructured text**.
- The ESG Ranks data service produces an overall company rank based on industry percentile leveraging the **26 ESG categories** defined by the **Sustainability Accounting Standards Board (SASB)**.
- The data feed covers **20,000+** companies with more than **13 years** of history.



# Analyst-driven vs. AI-driven ESG

## Analyst-driven ESG research

Derives ratings in a structured data model

## Sustainalytics



*Analyst role at the end of the process allows subjectivity to color results*

## AI-driven ESG research

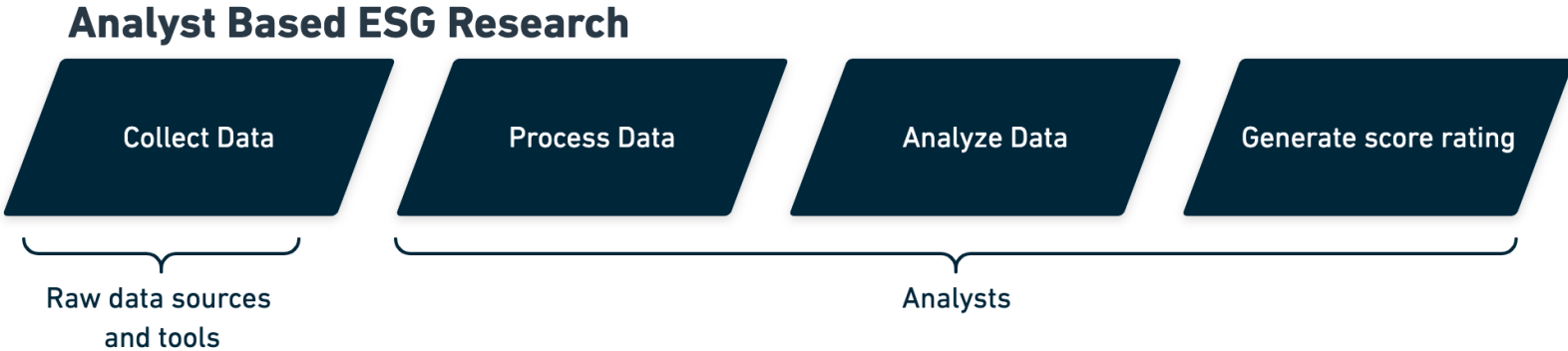
Derives signals from unstructured data

## Truvalue Labs

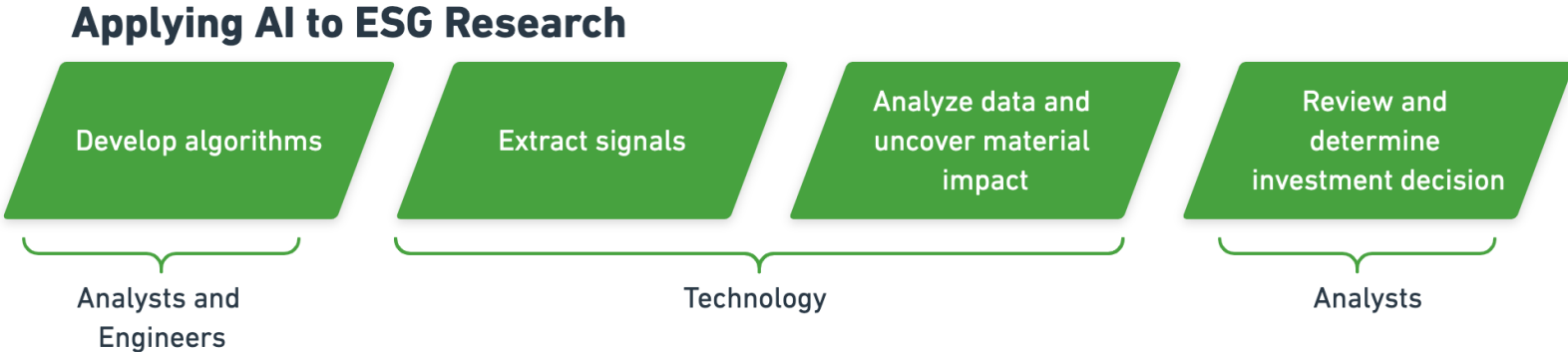


*Analyst expertise at the beginning of the process produces consistent results*

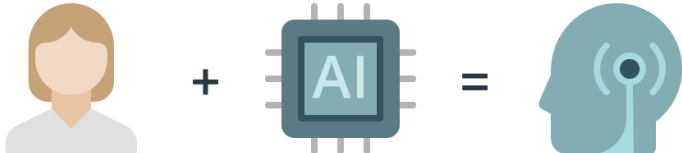
# Analyst based ESG Research



# AI based ESG Research

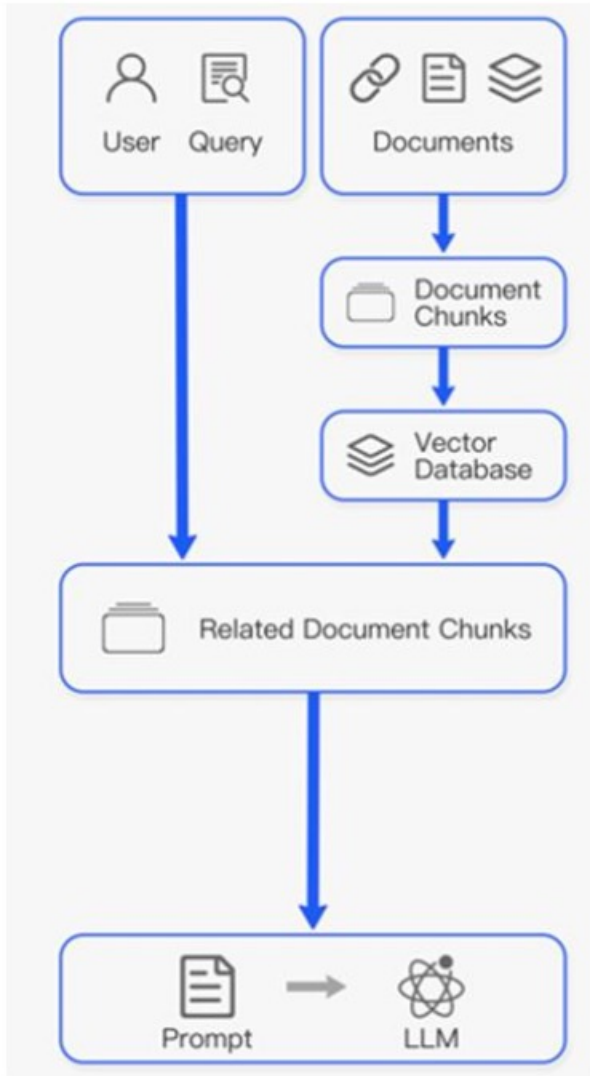


**It would take an analyst over 5 years to do what our AI can in 1 week**  
Combining analysts with AI creates gives you the full picture

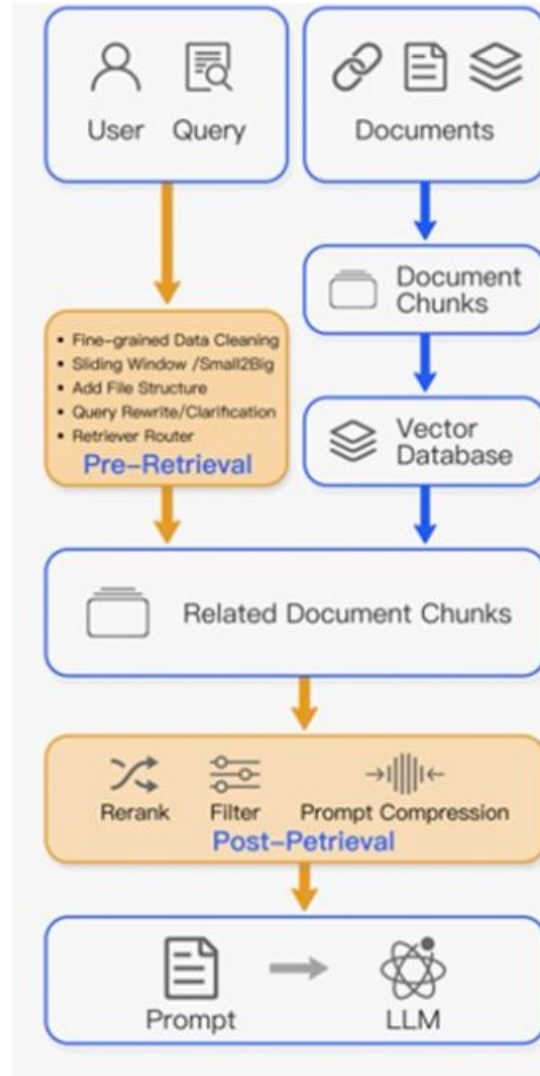


**ESG ANALYTICS**  
Invest where it matters.

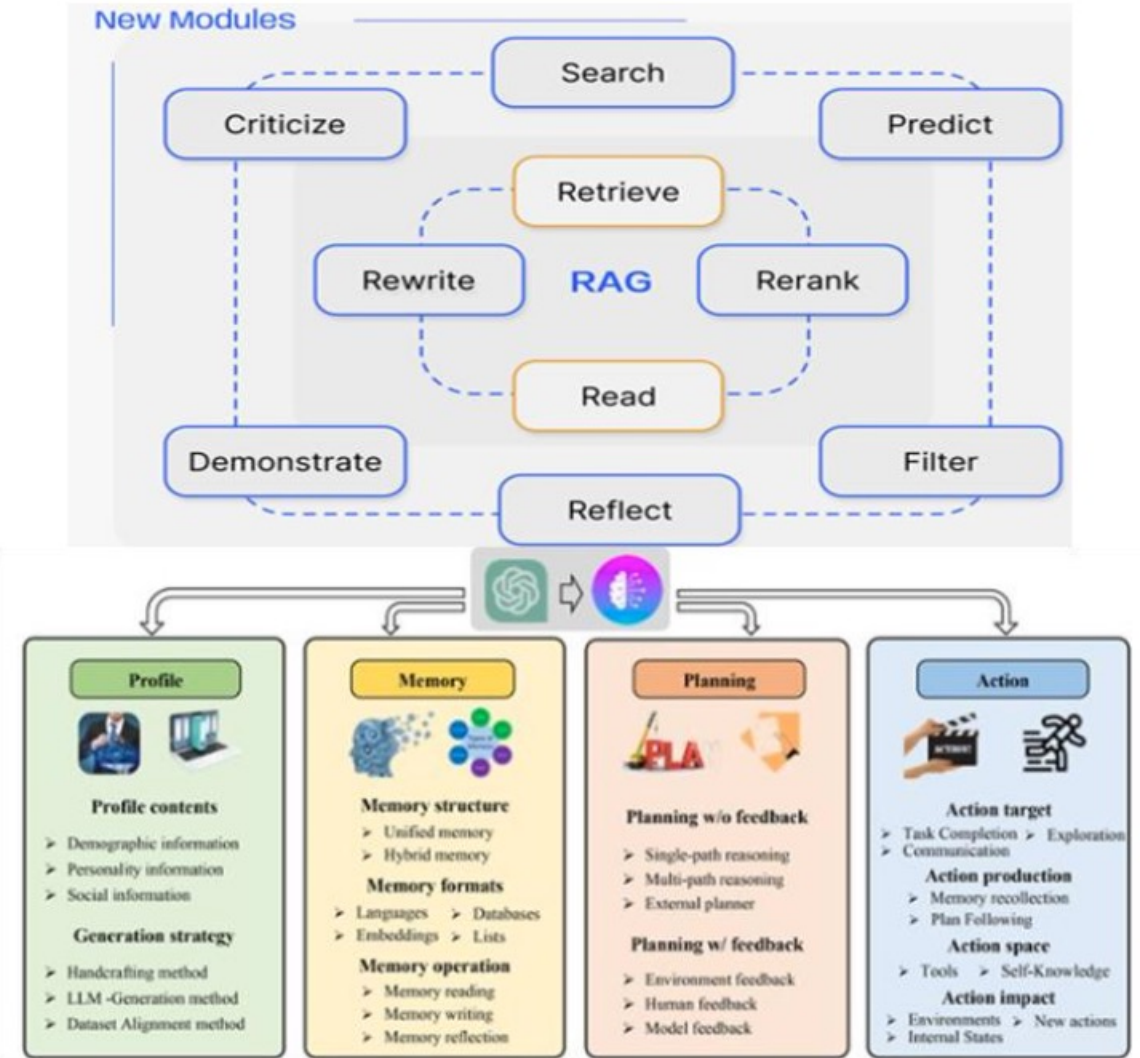
# Native RAG, Advanced RAG, Agentic RAG



Native RAG

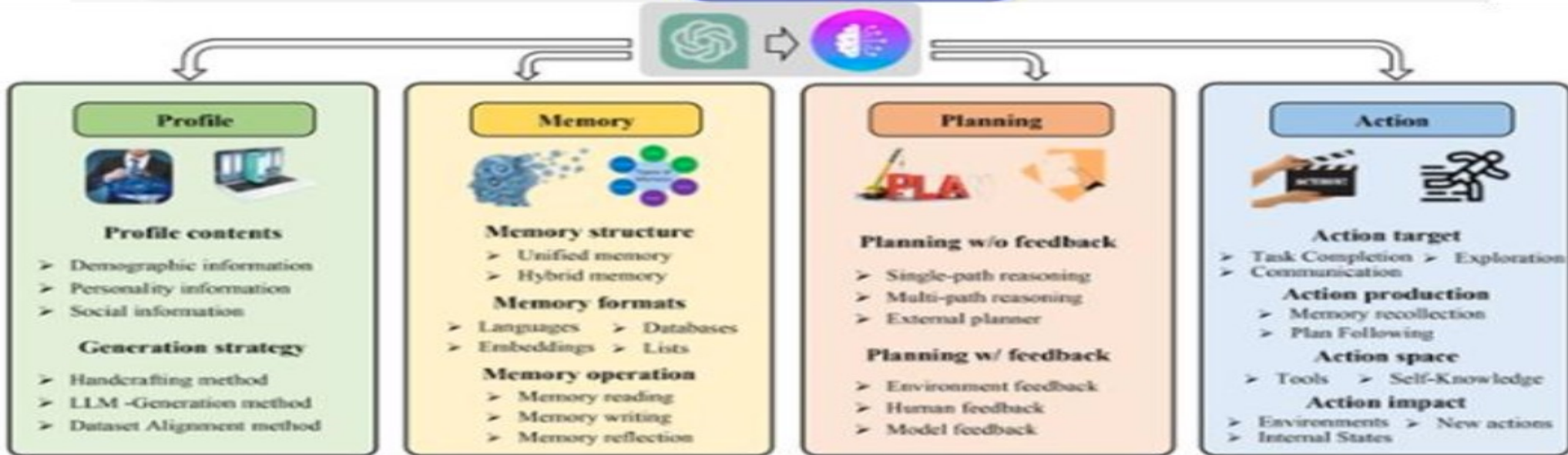
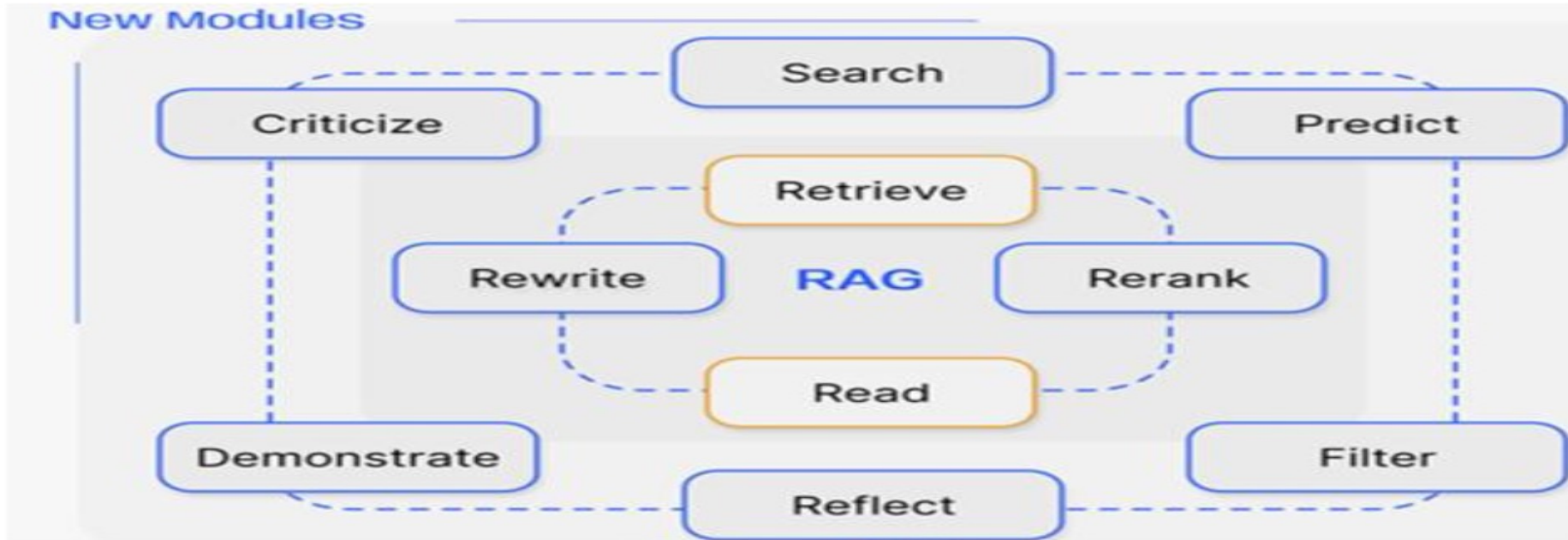


Advanced RAG

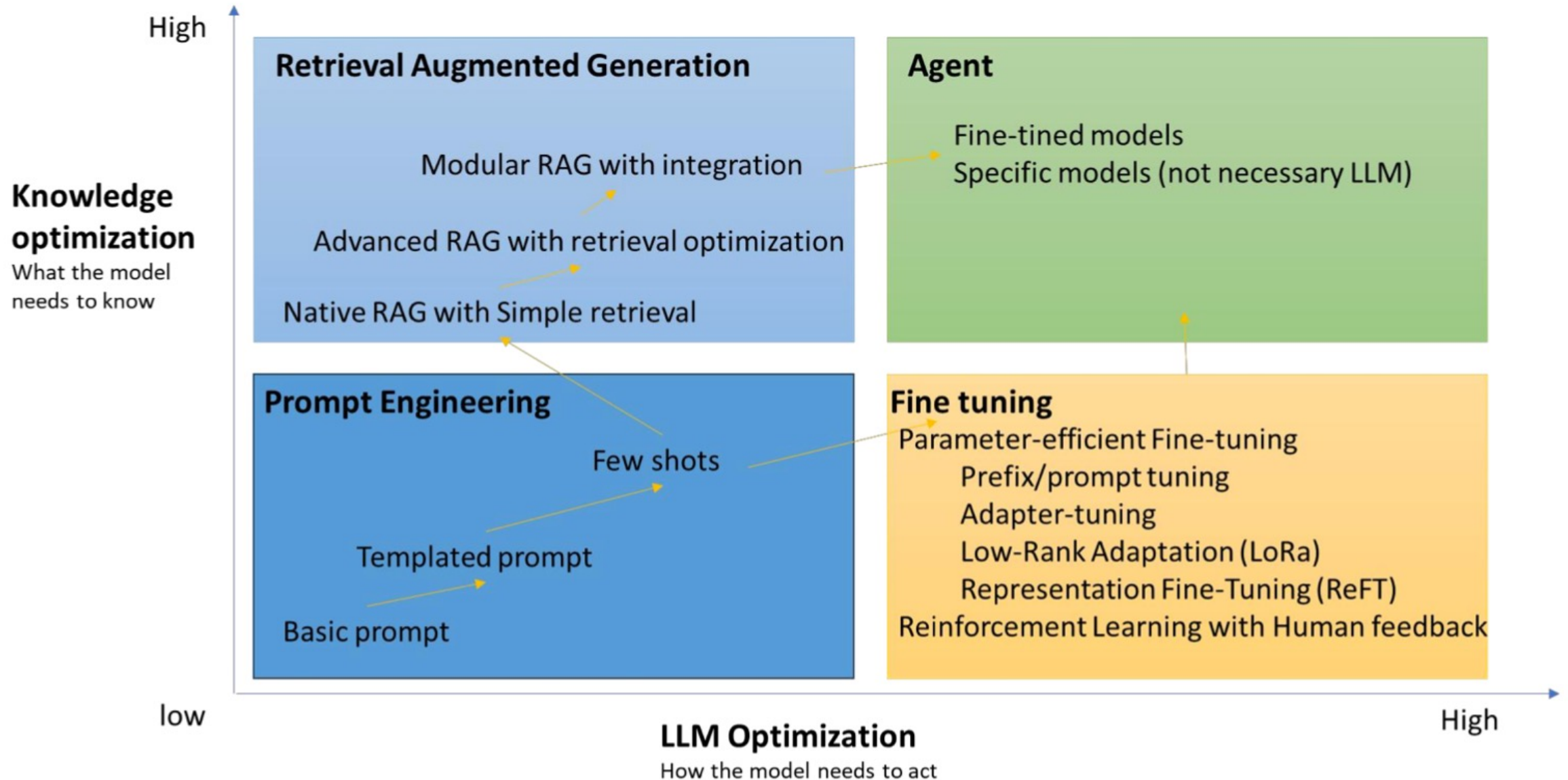


Modular + Agentic RAG

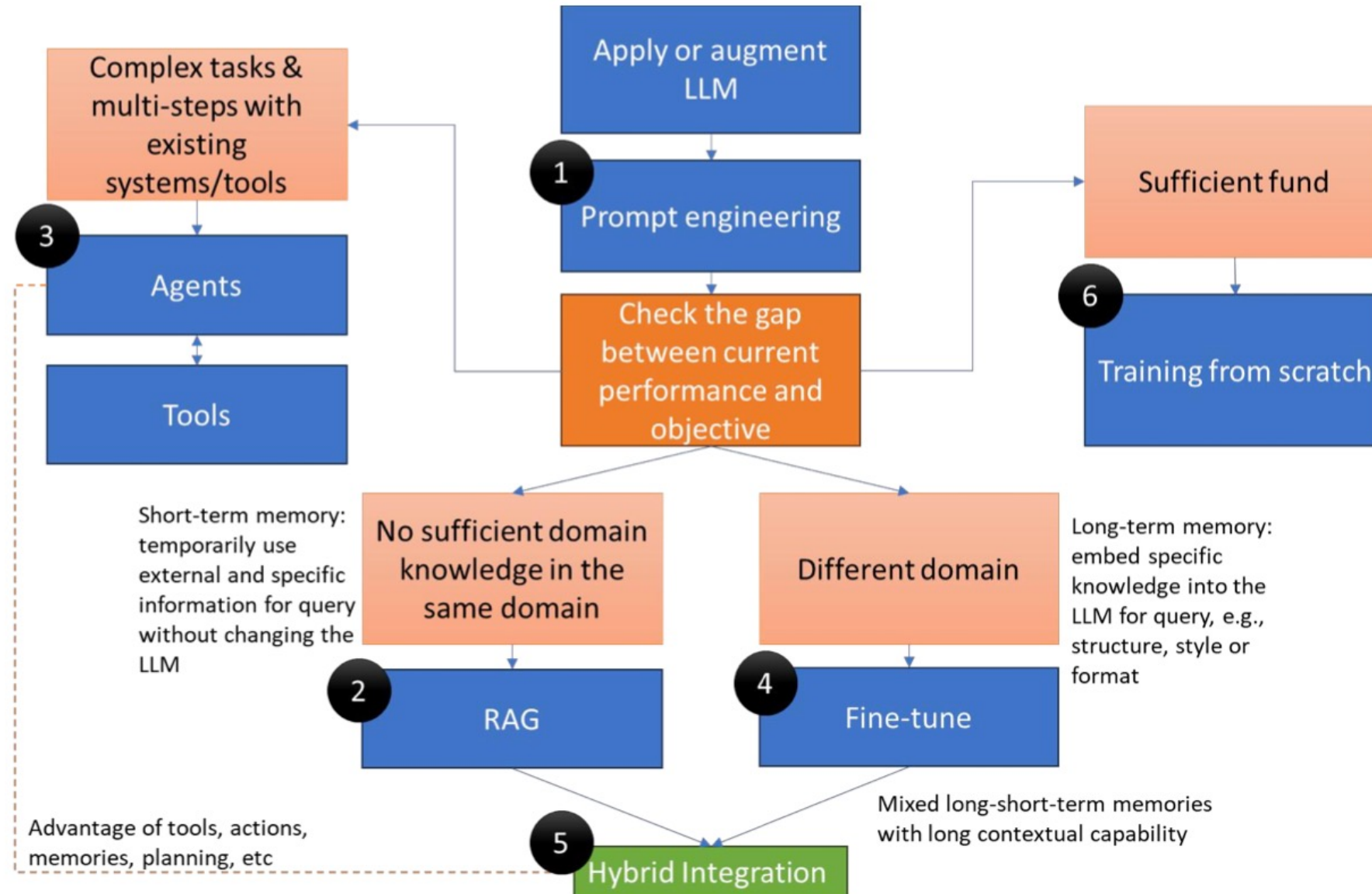
# Modular + Agentic RAG



# LLM Prompt, RAG, Agent, Fine tuning



# LLM Decision Path for Suitable Techniques



# LLM Stack

Layer	Sub-layer	
Application	Front-end service	Web services   Playground
	Back-end service	Input handler   output handler   Response formation
Orchestration		Deployment service   Governance service integration   Monitoring and reporting service   logging service   CI/CD pipeline
	LLM utility	Training   Fine-tuning   Prompt template   Agent service   Evaluation & Validation   Model hub   Guardrails
LLM	LLM API service	Embedding service   Generation service   Reasoning service   Planning service   LLM cache   LLM memory   Tooling API
	LLM API gateway	External LLM gateway   Internal LLM gateway   Application unified gateway
	Data storage	Data Analytics Store   KG / semantic layer   Vector database   Feature store   Application database
Data	Data engineering	Access control   Data processing   Quality control & review   Privacy & security   Data asset (active metadata)
	Data provision	Data lakehouse   Data lake   Data warehouse   In-memory storage
Infrastructure	Hardware	Cloud / on-premise / hybrid   Accelerator (GPU/TPU/FPGA/APU/ASIC/etc)   Quantum   Security   Network   Distributed/elastic / cluster

# LLM Functionalities

Service management

Scenario management	
Configuration	Task creation
Knowledge management	Application management
pipeline	Automated test

Model/data management		
Metadata / data annotation	Collaboration	Content moderation
Data mining & synthesis	Security and privacy: PII detection & masking	

Agent/prompt management		
Prompt studio / recipe	Agent studio / template	Tool management
NLP recipe	Safety and compliance	

Online services		
Security/personal Auth	Monitoring /Logging / cost reporting	audit trail
guardrails	Validation evaluation	
QC	API gateway	

Engineering

Prompt engineering	
Zero-short/ few-short	Chain/tree/graph-of-thought
Pattern-based template: co-star/automate	self-criticism / role-playing

RAG engineering		
Query rewriting	Routing	Rerank
Auto-merging	Recursive	Hybrid fusion
compression		Dense x

Agent engineering		
ReAct	self-criticism	memory
tooling	planning	decision
workflow	collaboration	

Fine-tuning engineering		
LoRa / QLoRa	quantization	SFT / RLHF
distillation	ReFT	Adaptor
PEFT	ZeRo /DeepSpeed	

Technology foundation

LLM (generation)		
OpenAI	Gemini / gemma	Claudia
ChatGLM	Llama	Mistral / Mixtral
Phi-MoE	Yi / Qwen	WizardLM
deepseek	Kimi	Blossom

Embedding	
BGE	FinGPT
Bert/ FinBert	M3E / ERNIE
Core algorithms	
Context fusion	memory
multimodal	Long context

Framework	
Langchain	Lammaindex
GPTflow	graphGPT
AutoAgent	HF Agents
Langroid	Haystack

Vector database		
pinecore	Chroma	pgvector
Faiss	Milvus	Qdrant

Feature store		
Feathr	Databricks	Feast
Vertex AI FS	Hopsworks	AWS FS

Source: Jun Xu (2024). "GenAI and LLM for Financial Institutions: A Corporate Strategic Survey." Available at SSRN 4988118.

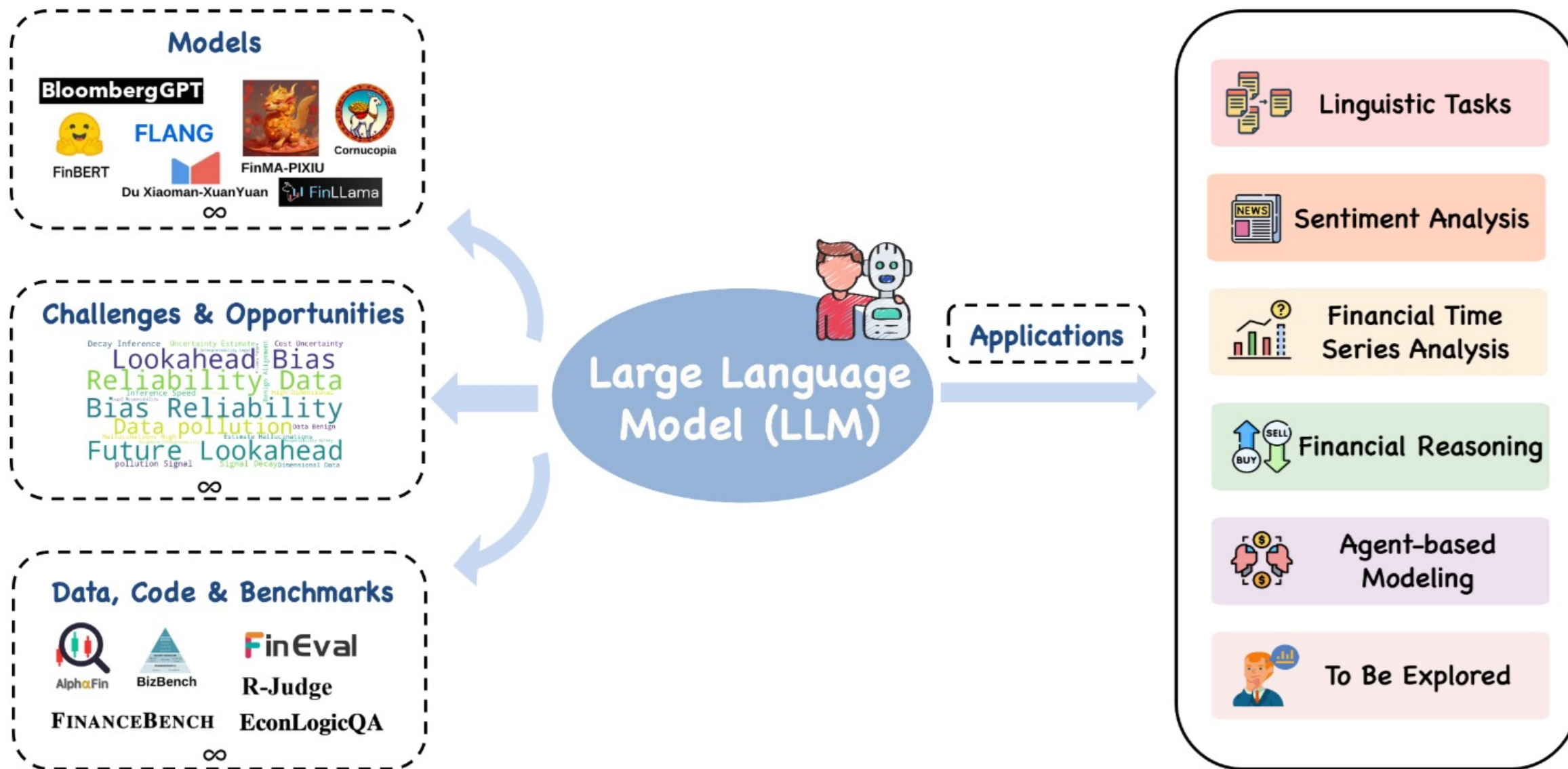
# Domain-Specific Language Model (DSLML) for ESG

Model Architecture	Base Model	Parameter Count	Training Focus	Primary Use Case	Key Performance Metric
<b>ClimateBERT</b>	DistilRoBERTa	~82M	Climate news, science, & corporate reports	Fact-checking, Climate Specific Classification	48% improvement in domain MLM tasks (Webersinke et al., 2021)
<b>ESG-BERT</b>	BERT-Base	~110M	Sustainable investing corpora	Sentiment Analysis, Category Classification	F1-score of 0.90 on ESG text mining (Mehra et al., 2022)
<b>SusGen-GPT</b>	Llama/Mistral	7B - 8B	SusGen-30K (Financial + ESG tasks)	TCFD Report Generation, Relation Extraction	~2% performance gap to GPT-4 on specialized tasks (Wu et al., 2024)
<b>ClimateChat</b>	Llama 2 (tuned)	7B+	ClimateChat-Corpus (Q&A pairs)	Climate Science Q&A, Policy Analysis	Improved accuracy on scientific discovery tasks (ClimateChat Team, 2025)

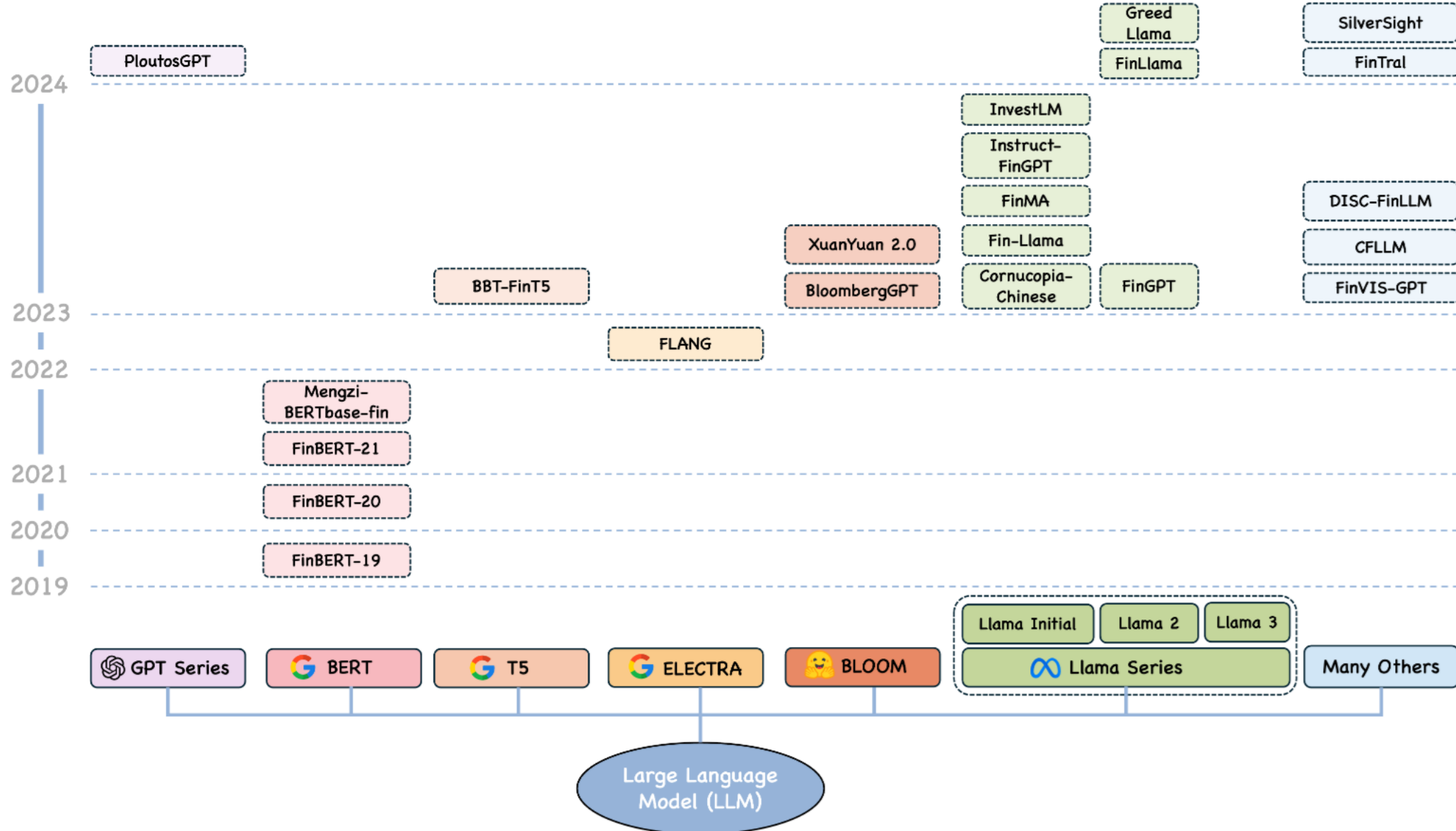
# GenAI in ESG Datasets

Dataset Name	Size / Composition	Primary Application	Source
<b>SusGen-30K</b>	30,000 samples; 7 financial/ESG tasks. Sourced from TCFDHub & Hugging Face.	Training SusGen-GPT; Balancing financial NLP with ESG reporting tasks.	Wu et al. (2024)
<b>ClimateChat-Corpus</b>	Instruction-tuned Q&A pairs derived from scientific docs and web scraping.	Fine-tuning conversational agents for climate science.	ClimateChat Team (2025)
<b>A3CG</b>	1,679 sustainability reports (SGX companies); Annotated Aspect-Action pairs.	Greenwashing detection; Cross-category generalization testing.	Ong et al. (2025)
<b>ESG-Activities</b>	1,325 labeled text segments classified by EU ESG taxonomy.	Benchmarking LLM performance on granular ESG activity identification.	Intelligent ESG Evaluation Team (2025)
<b>FinRpt</b>	Chinese & English Equity Research Reports.	Evaluating automated generation of comprehensive financial reports.	Li et al. (2025)

# Large Language Models for Financial Applications

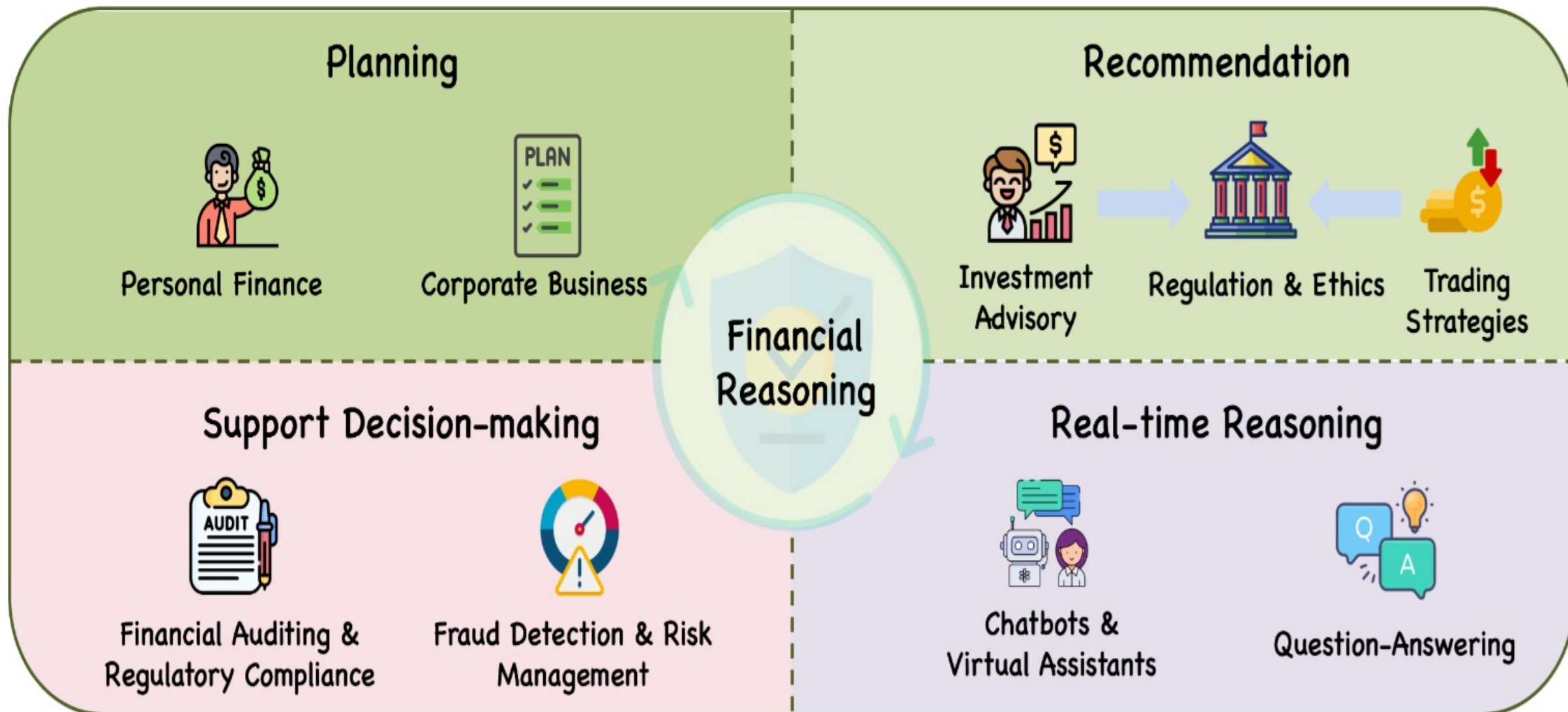


# Financial Large Language Models (Fin LLMs)

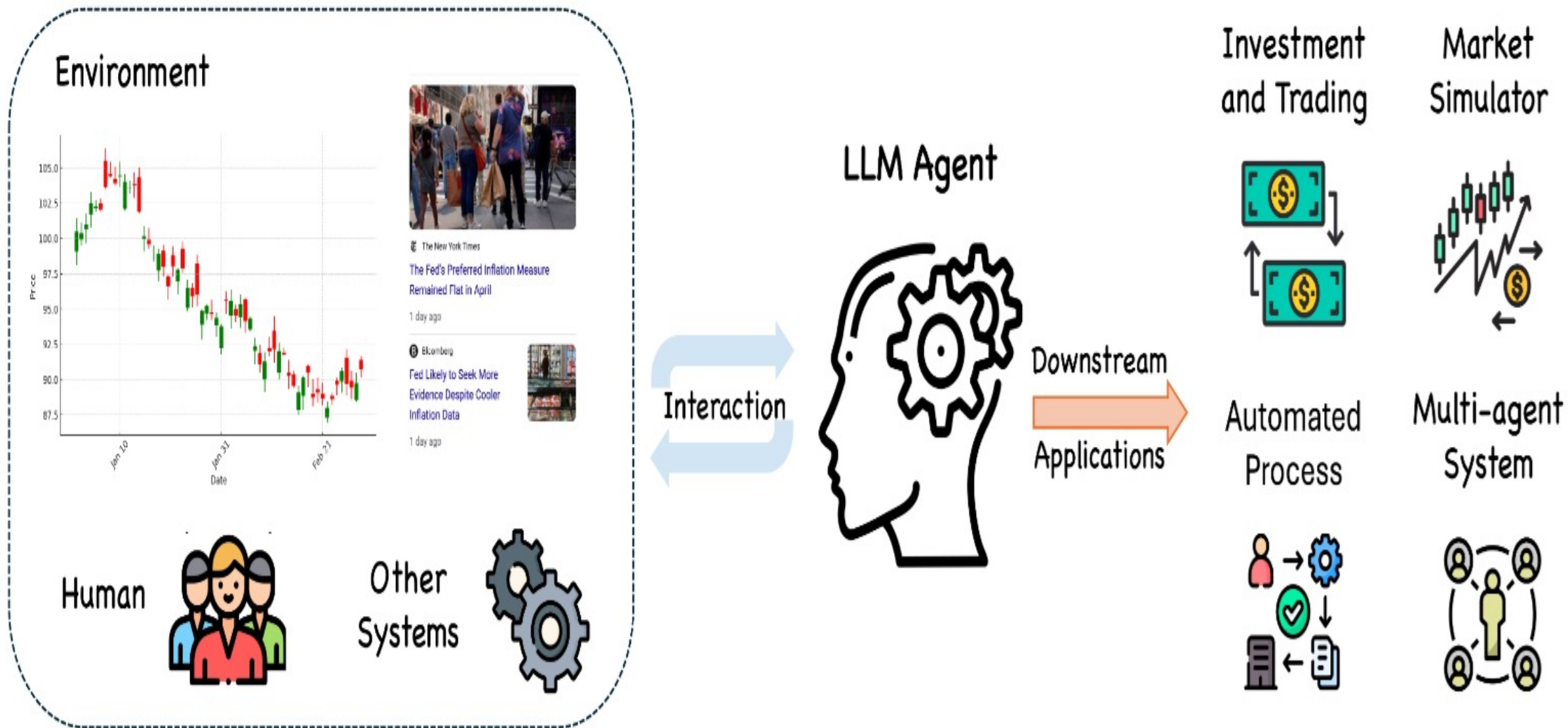


Source: Yuqi Nie, Yaxuan Kong, Xiaowen Dong, John M. Mulvey, H. Vincent Poor, Qingsong Wen, and Stefan Zohren (2024). "A Survey of Large Language Models for Financial Applications: Progress, Prospects and Challenges." arXiv preprint arXiv:2406.11903.

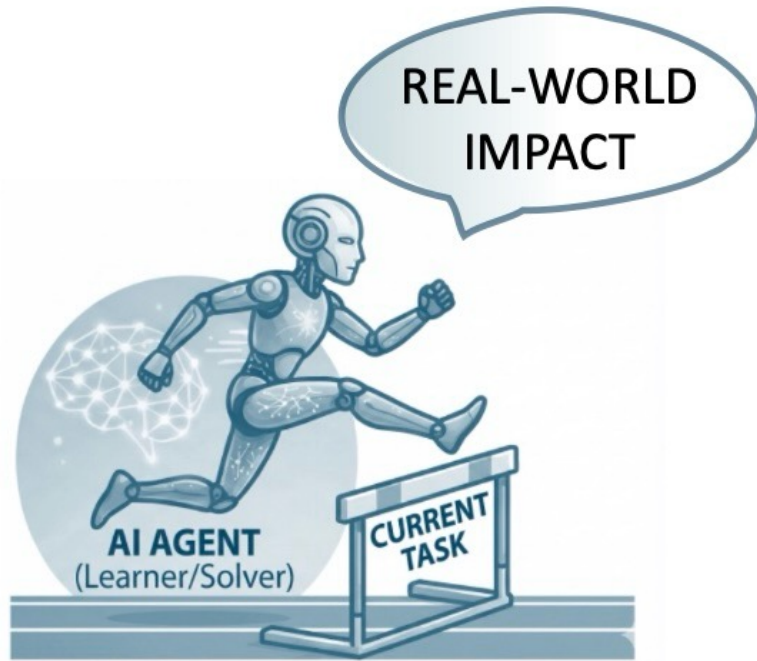
# Financial Reasoning Tasks



# Financial LLM Agent



# ESG Agent and ESG Benchmark



## ESG Agent



## ESG Benchmark



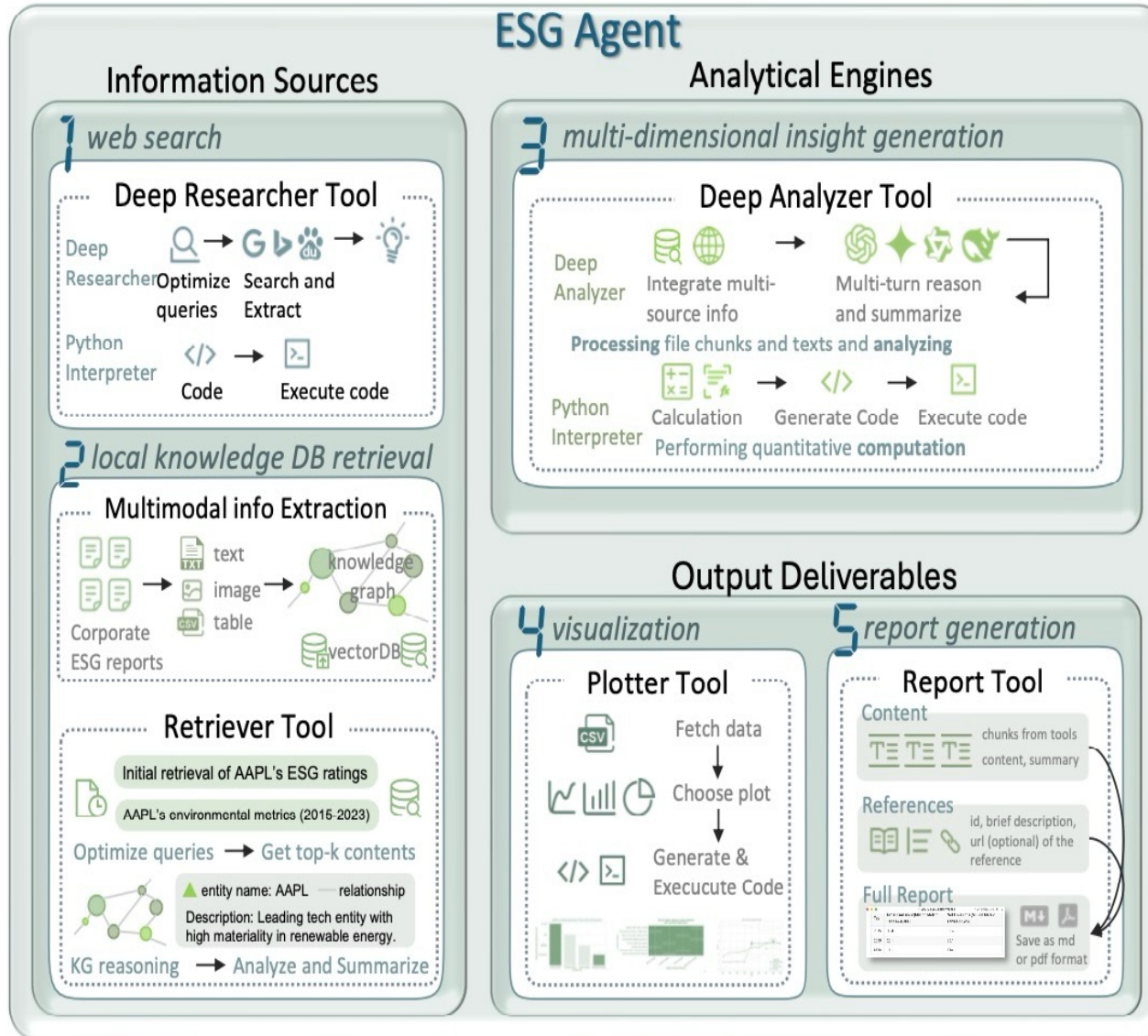
## Evaluation & Feedback



# ESG Agent Overall Architecture and Workflow

## Query / Task

Evaluate **AAPL's** environmental sustainability performance from 2015 to 2023 based on the provided corpus. Your response should include a quantitative trend of **ESG rating analysis** and at least one comparative insight regarding their **carbon neutrality goals**. Formulate your findings into a professional report structure.



Year	Gross Emissions (Million Metric Tons \$CO_2e\$)	Net Emissions (Million Metric Tons \$CO_2e\$)
2015	38.4	38.4
2019	25.1	25.1
2023	16.1	15.6

#### Apple 2030 vs. Industry Peers

Apple's 'Apple 2030' goal is to be carbon neutral across its entire value chain by 2030, which involves a 75% reduction in gross emissions from 2015 levels.

**Comparative Insight:** Compared to the IPCC recommendation of reaching net zero by 2050, Apple's target is 20 years ahead of global benchmarks. While peers like Microsoft have set ambitious 'carbon negative' targets by 2030, Apple's focus on a 75% absolute reduction in gross emissions highlights a rigorous approach to physical decarbonization rather than relying solely on offsets. [30, 31, 36]

#### 1.4 Visualizing the ESG Evolution

The following visualizations track Apple's ESG performance metrics and the strategic pivot in 2019 where environmental performance became a primary driver of the overall score.

Note: The chart highlights the significant improvement in Environmental and Social scores over the nine-year period, alongside the stability of Governance ratings. [36]

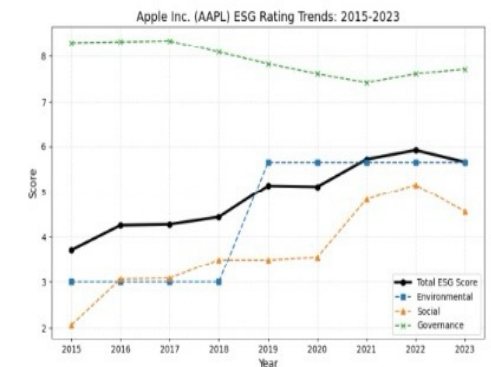


Chart: AAPL ESG Score Breakdown (2015-2023). Note the 2019 inflection point in Environmental scoring corresponding to 100% renewable energy achievement for global

# Innovation

# Innovation:

a new idea,  
method, or  
device

**Innovation:**

**something**

**new**

**Novelty :**  
**something new or unusual**

**the novelty of a self-driving car**

**Creativity is not a  
new Idea.**

**Creativity is  
an old belief  
you leave behind**

# Innovation

“a process of  
searching and recombining  
existing knowledge  
elements”

# Search and recombination process to innovate: A review of the empirical evidence and a research agenda



Source: Savino, Tommaso, Antonio Messeni Petruzzelli, and Vito Albino. "Search and recombination process to innovate: A review of the empirical evidence and a research agenda." *International Journal of Management Reviews* (2017).

# **Innovation** Research in Economics, Sociology and Technology Management

Source: Gopalakrishnan, Shanti, and Fariborz Damanpour.

"A review of innovation research in economics, sociology and technology management." *Omega* 25, no. 1 (1997): 15-28.

# Innovation Research in Economics, Sociology and Technology Management

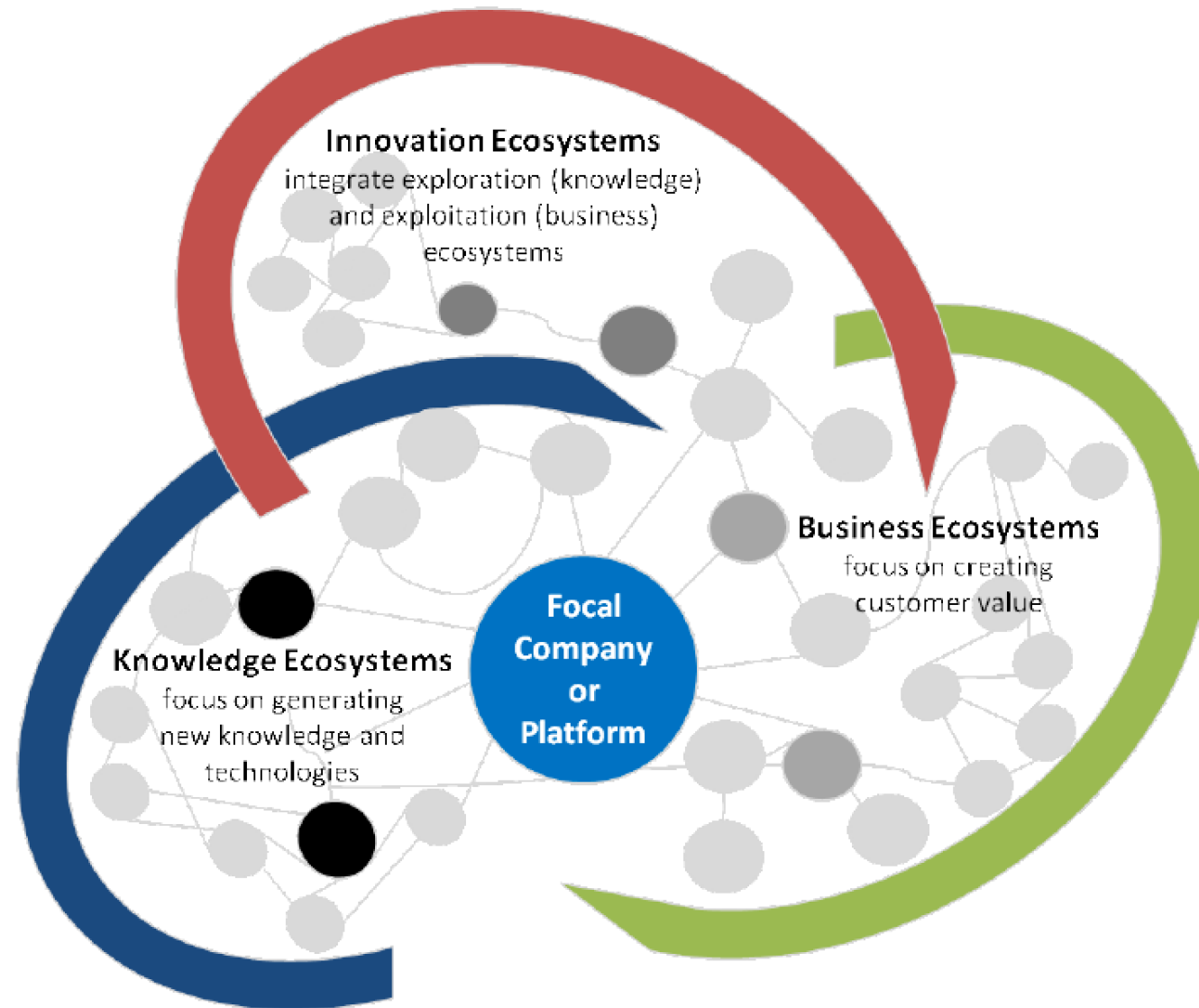
	Stage of process	Level of study	Type of innovation
<i>Economists</i>	Generation Idea generation Project definition	Industry	Product and process Only technical Only radical
<i>Technologists</i>			
Contextual technologists	Generation Commercialization and marketing Diffusion	Innovation (in the industry context)	Product and process Only technical Radical and incremental
Organizational technologists	Generation Idea generation Problem solving adoption Adoption Initiation	Organizational Sub-system	Product and process Only technical Radical and incremental
<i>Sociologists</i>			
Variance sociologists	Adoption Initiation Implementation	Organization	Product and process Technical and administrative Radical and incremental
Process sociologists	Adoption Initiation Implementation	Innovation (at the organizational level)	Product and process Technical and administrative Radical and incremental

Source: Gopalakrishnan, Shanti, and Fariborz Damanpour.

"A review of innovation research in economics, sociology and technology management." *Omega* 25, no. 1 (1997): 15-28.

# Business, Innovation, and Knowledge Ecosystems

# Business, Innovation, and Knowledge Ecosystems



Source: Valkokari, Katri. "Business, innovation, and knowledge ecosystems: how they differ and how to survive and thrive within them." *Technology Innovation Management Review* 5, no. 8 (2015).

# Innovation Ecosystems

## Characteristics

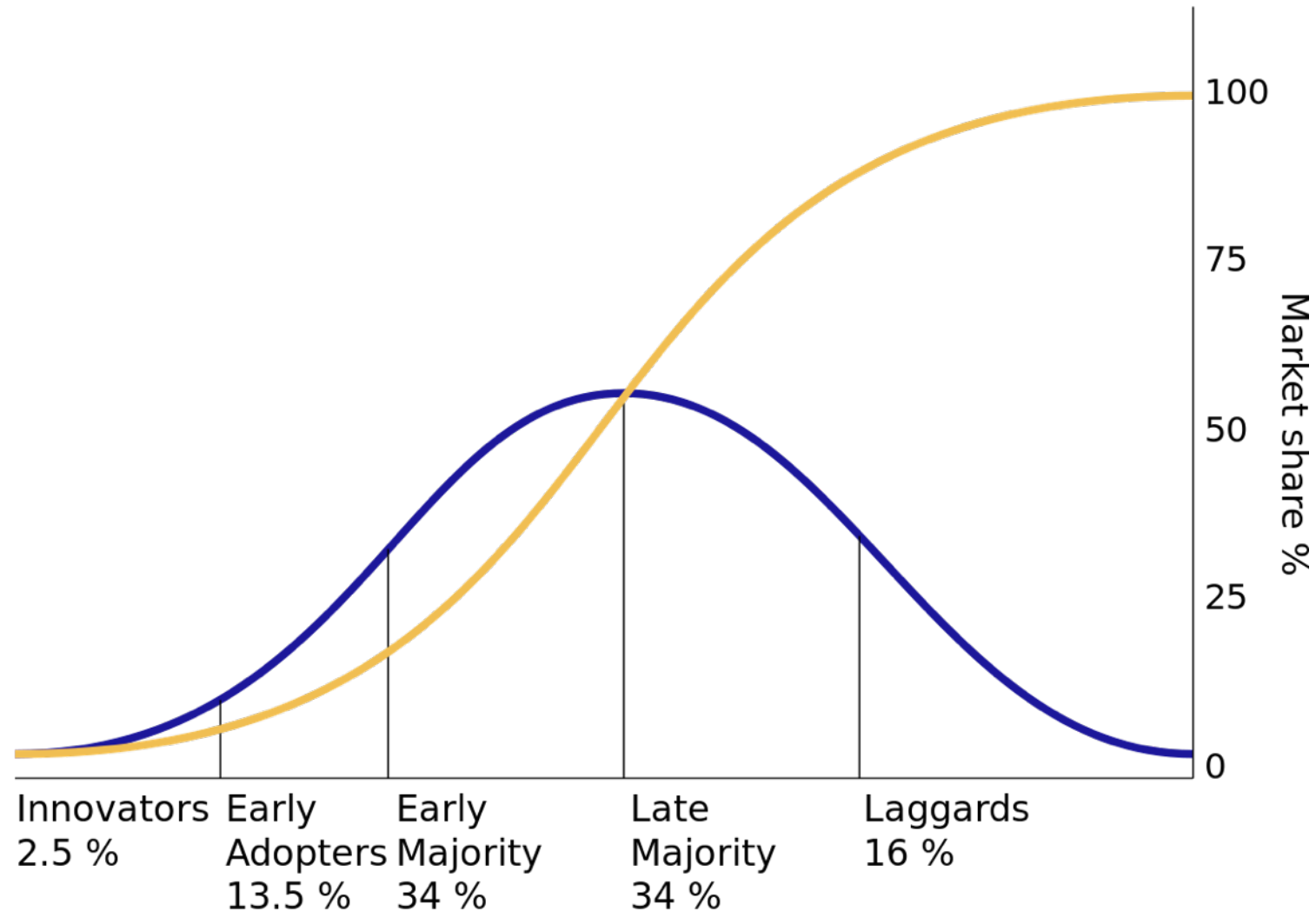
	Business Ecosystems	Innovation Ecosystems	Knowledge Ecosystems
Baseline of Ecosystem	Resource exploitation for customer value	<b>Co-creation of innovation</b>	Knowledge exploration
Relationships and Connectivity	Global business relationships both competitive and co-operative	Geographically clustered actors, different levels of collaboration and openness	Decentralized and disturbed knowledge nodes, synergies through knowledge exchange
Actors and Roles	Suppliers, customers, and focal companies as a core, other actors more loosely involved	<b>Innovation policymakers, local intermediators, innovation brokers, and funding organizations</b>	Research institutes, innovators, and technology entrepreneurs serve as knowledge nodes
Logic of Action	A main actor that operates as a platform sharing resources, assets, and benefits or aggregates other actors together in the networked business operations	Geographically proximate actors interacting around hubs facilitated by intermediating actors	A large number of actors that are grouped around knowledge exchange or a central non-proprietary resource for the benefit of all actors

# Innovation

## (Diffusion of Innovation)

- 1. Relative advantage**
- 2. Compatibility**
- 3. Complexity**
- 4. Trialability**
- 5. Observability**

# Diffusion of Innovation



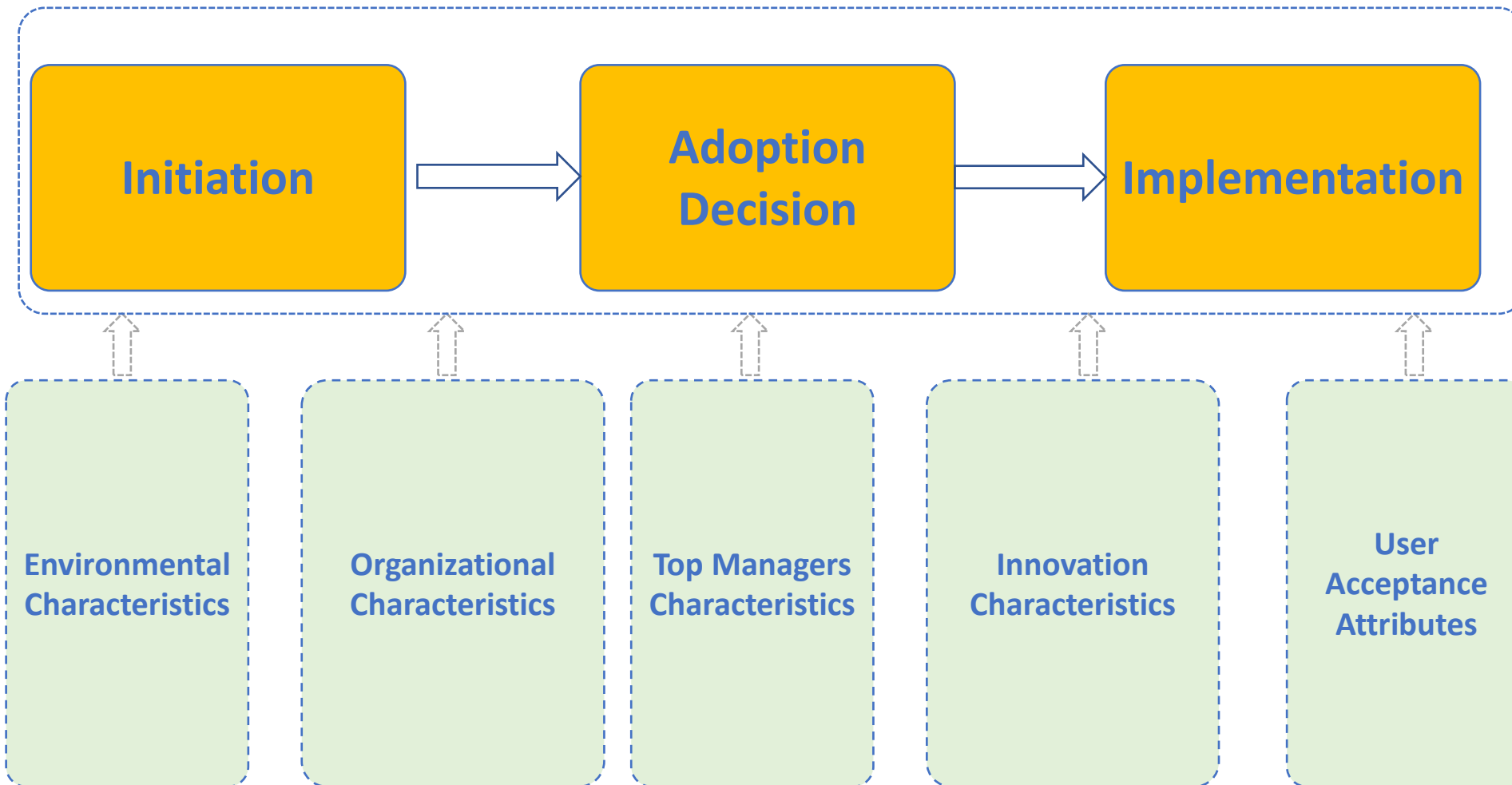
# Innovation Adoption Process



Source: Pichlak, Magdalena.

"The innovation adoption process: A multidimensional approach." Journal of Management and Organization 22, no. 4 (2016): 476.

# Innovation Adoption Process



RBV=  
Resource-Based View

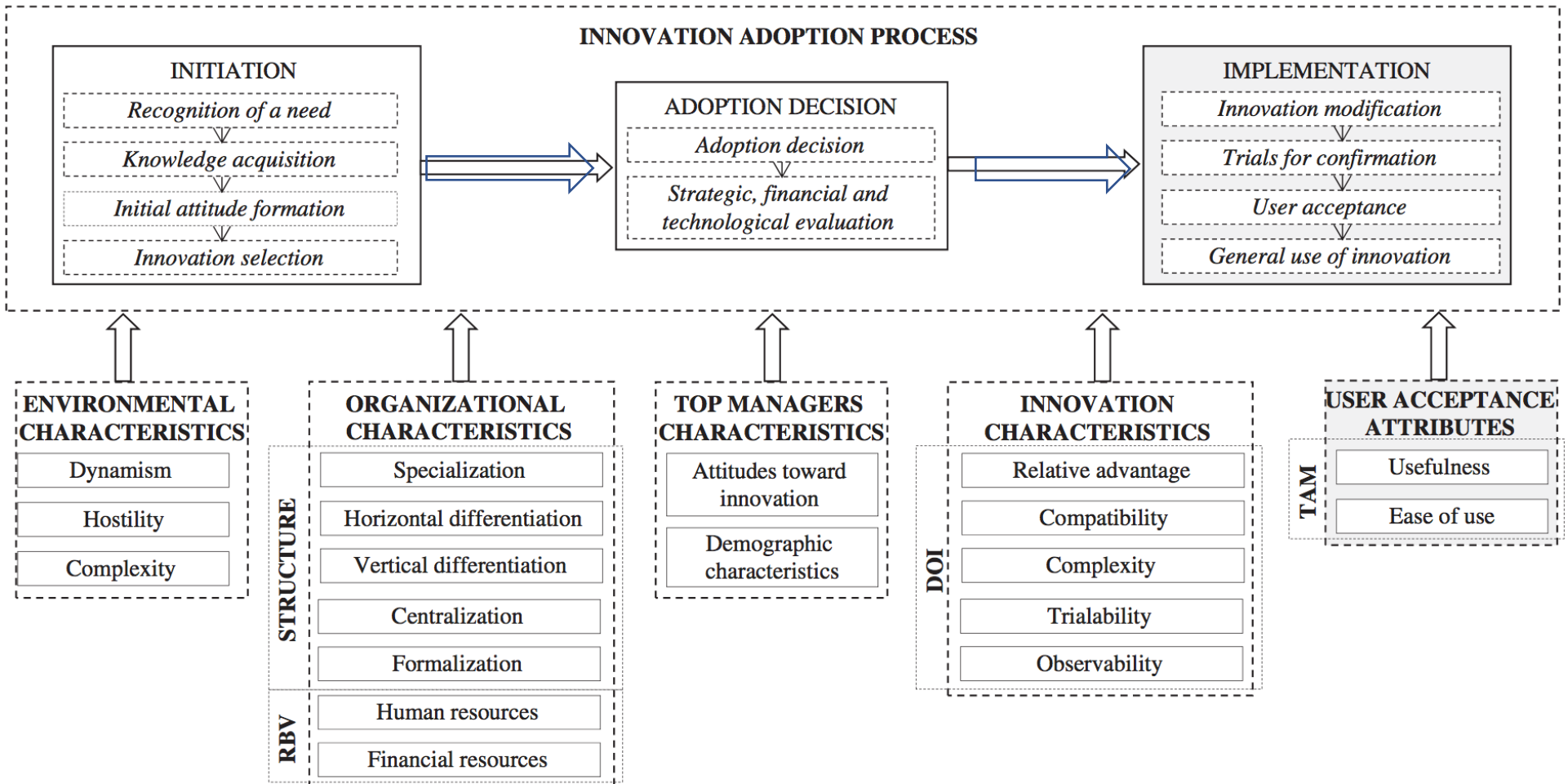
DOI =  
Diffusion of Innovation Theory

TAM=  
Technology  
Acceptance  
Model

Source: Pichlak, Magdalena.

"The innovation adoption process: A multidimensional approach." Journal of Management and Organization 22, no. 4 (2016): 476.

# Innovation Adoption Process



RBV=  
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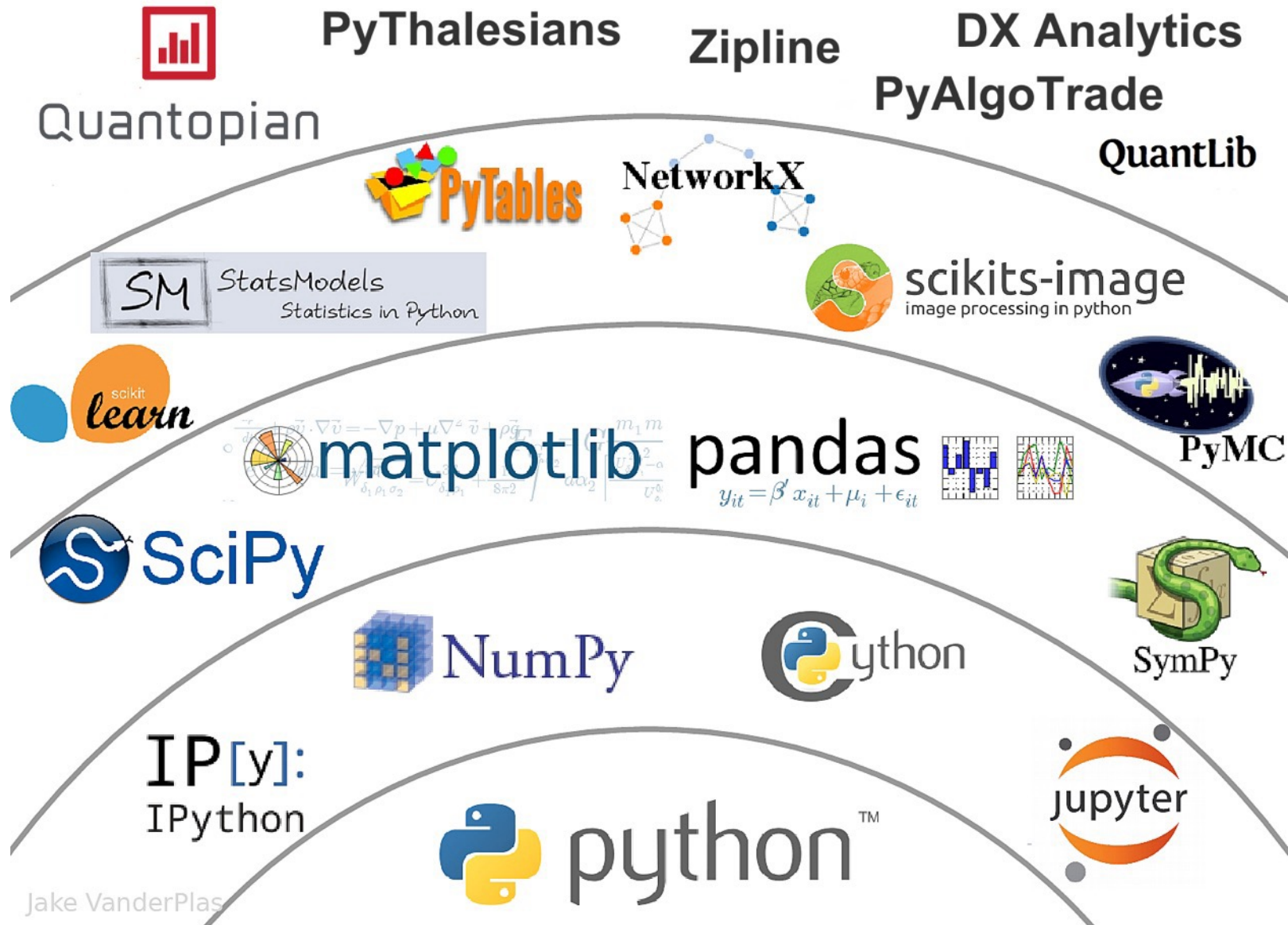
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Source: Pichlak, Magdalena.

"The innovation adoption process: A multidimensional approach." Journal of Management and Organization 22, no. 4 (2016): 476.

# The Quant Finance PyData Stack



Jake VanderPlas

Source: [http://nbviewer.jupyter.org/format/slides/github/quantopian/pyfolio/blob/master/pyfolio/examples/overview\\_slides.ipynb#/5](http://nbviewer.jupyter.org/format/slides/github/quantopian/pyfolio/blob/master/pyfolio/examples/overview_slides.ipynb#/5)

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