开源皇冠上的明珠？ 使用大模型辅助扎根理论解释大模型开源的悖论

Releasing the Crown Jewels? Unveiling the Paradox of LLM Open-source Strategy via LLM-Assisted Grounded Theory

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大语言模型的悖论 / The Rise of Open-Source LLMs & A Strategic Paradox

- Large Language Models are no longer just tools; they are core catalysts for digital innovation across all sectors.

大语言模型是高价值的战略资产 / LLMs as High-Value Strategic Assets

- Foundational Technology: LLMs are reshaping digital innovation across all sectors.
- Immense Investment: Frontier models require massive capital, often hundreds of millions of dollars, making them "crown jewel" assets.

其中存在的战略悖论 / The Strategic Paradox

- This creates a central paradox: Why would a firm invest billions in a core technology, only to release it into the public domain?
- This decision challenges traditional proprietary business models and even prior open-source paradigms.

The Research Gap

- Existing theories on **Open-Source Software (OSS)** and **Open Innovation** are insufficient to fully explain the unique, high-stakes calculus in the LLM era.
- There is a clear need for a new, empirically-grounded theory to understand these motivations.

核心研究问题 / Our Research Questions

- To guiding our inquiry, we broke down the problem into three key questions:

RQ1: Motivations

- What are the multifaceted strategic motivations that prompt LLM vendors to engage in open-source innovation for their models?

促使大模型供应商参与开源创新的多方面战略动机是什么?

RQ2: Context

- What key contextual factors (e.g., market position, competitive landscape, regulatory environment) shape these open-sourcing motivations and strategies?

哪些背景（市场地位、竞争格局、监管环境）塑造了这些开源动机和策略?

RQ3: Methodology

- How does a systematically validated LLM-assisted Grounded Theory approach enhance the investigation of complex strategic phenomena like LLM open-sourcing?

LLM辅助的扎根理论方法，如何能增强对此类复杂战略现象的研究?

理论基础与研究缺口 / Theoretical Background & Research Gap

Sensitizing Concepts from Classical Theories

- **Corporate OSS:** Economic logic (commodifying complements, service models), Strategic logic (platform leadership, defense), Signaling (talent, quality). (e.g., Lerner & Tirole, 2002; 2005)
- 以往**企业开源研究**无法揭示巨大投入背后的开源动因
- **Open Innovation:** Leveraging external knowledge (inbound/outbound flows), Community as co-creator. (e.g., Chesbrough, 2003; von Hippel, 2005)
- **开放式创新研究**无法刻画 LLM 社区的高风险与高成本
- **Institutional Theory:** Normative/Mimetic pressures ("AI democratization"), Pursuit of legitimacy (social license). (e.g., DiMaggio & Powell, 1983)
- 以往关于**制度理论的研究**无法具体说明 LLM 独特的社会技术风险如何影响厂商的合法性策略

The Research Gap: The LLM Paradox

Why Give Away Billion-Dollar "Crown Jewels"?
Classical theories struggle to fully explain this.
Unique LLM Dimensions:
- Complex openness spectrum (weights vs. code).
- Unprecedented scale of investment alters ROI.
- Accelerated platform dynamics ("born platforms").
- High sociotechnical risks (misuse, proliferation).

Justification for Methodology

- Existing frameworks are insufficient to explain the complex, emergent strategies.
- Requires an inductive, "bottom-up" Grounded Theory Methodology to build a substantive theory directly from empirical data.

分析框架 / Analytical Framework Overview
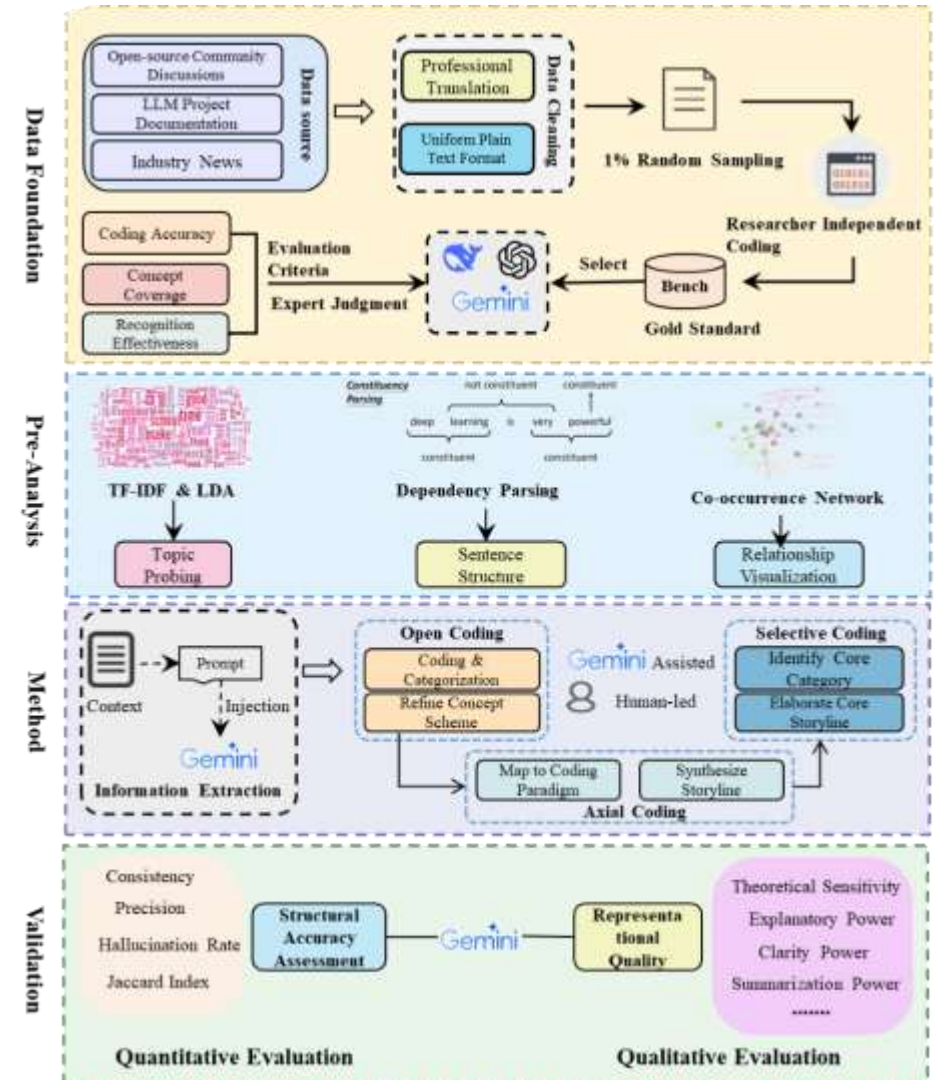
语料库 / Corpus

- A diverse corpus of N = 1,361.

时间范围 / Timeframe

- January 2023 – May 2025
- A period reflecting the significant acceleration and strategic evolution of LLM open-sourcing.

主要数据来源 / Key Data Sources:

- **Vendor Communications:** Official blogs, press releases, white papers (from Llama, Mistral, DeepSeek, Qwen, etc.).
- **Executive Statements:** Public statements, speeches, social media (from key figures like Yann LeCun, Mark Zuckerberg).
- **Community Discourse:** Relevant discussions from GitHub and Hugging Face.
- **Industry Analysis:** In-depth reports from reputable technology journalism.

方法论创新 / An LLM Assisted Straussian GT Beyond the "Chatbox"

- There are many research about LLM-GT now, so why our LLM assisted Straussian GT truly new?

The Problem with Prior "LLM-assisted GT"
以往LLM-GT的论文很多只是简单三级编码

- **Superficial Analysis:** Many attempts are just simple, ad-hoc "chatbox" analyses (e.g., drag-and-drop a file and ask for themes).
- **Superficial Labeling:** They often apply simple three-level coding (Open, Axial, Selective) without capturing the true, complex analytical process.
- **Lacking Fidelity:** Some (e.g., Zhou et al., 2024) claim to use the Straussian paradigm but fail to simulate the actual thought process of a human researcher (e.g., building relationships, constant comparison, paradigm mapping).

Our Two Core Innovations
超越对话框且严格重现Straussian范式逻辑

- **A Systematic, Automated Pipeline (Not a Chatbox):** We developed an "out-of-the-box" automated codebase, not a manual chat session. This pipeline runs a sequence of API calls, ensuring a reproducible, auditable, and scalable process across 1,300+ documents.
- **Simulating the Straussian Thought Process:** Our method truly emulates the iterative, cognitive steps of a Straussian expert. Each API call uses a highly specific "expert role" prompt to guide the LLM in performing complex tasks.

模式发现 / Pattern Discovery

目标 / Objective

- To inductively explore the raw data and "sensitize" the researcher before qualitative coding.
- Goal: To create a data-driven "map" of the corpus to guide subsequent LLM-assisted analysis.
- Uses Python package: NLTK, scikit-learn, spaCy, NetworkX

使用主题分析、依存句法分析、词共现网络分析：

- **Thematic Landscape Mapping:** Using TF-IDF & LDA Topic Modeling to identify high-level conceptual clusters and key terms.
- **Strategic Rationale Probing:** Using spaCy Dependency Parsing to find causal and purposive language patterns (e.g., "in order to...", "reason is...").
- **Relational Visualization:** Using NetworkX Co-occurrence Analysis to map relationships between "motive indicators" (e.g., goal, enable, reason) and other concepts.

依存句法分析所识别的语法类型：

- **pattern_reason_causal_conjunction：** 识别因果关系（如 "because of...", "due to..."）。
- **pattern_purpose_to_verb：** 识别目的（如 "...to release..."）。
- **pattern_purpose_in_order_to：** 识别目的（如 "...in order to..."）。
- **pattern_explicit_motive_goal_words：** 识别明确的动机词汇（如 "The goal is to...", "driven by..."）。
- **pattern_outcome_lead_result：** 识别结果（如 "This leads to..."）。
- **pattern_actor_action_opensource：** 识别关键行动者及其开源动作（如 "Meta released..."）。

信息抽取 / Information Extraction

目标 / Objective

- Systematically extract all relevant "motivational incidents" from the 1,361-document corpus.
- Goal: To move from raw text to clean, codable data units.
- Guided by a specific prompt, the LLM acts as a specialist to analyze the raw data.

The "Context-with-Highlight"

- **Scan:** LLM scans the text for any passage indicating a why (motivation, goal, reason).
- **Extract:** It extracts a full, coherent text segment (the "context").
- **Highlight:** It bolds the "conceptual kernel" – the specific phrase containing the core motivation.
- **Annotate:** It generates a brief "note" explaining the highlighted motivation (a proto-memo).
- **Validate:** The researcher reviews and validates all extracted incidents.

Process Showcase


```
{
    "extraction_id": "M00035",
    "case_number": "W5",
    "excerpt_number": 3,
    "source_text_snippet": "Yeah. **DeepSeek is doing fanta
    "notes": "The vendor is motivated to open-source its mo
},
```

开放性编码 / Open Coding

目标 / Objective

- To conceptualize the 3,182 motivational "incidents" into a coherent, emergent theoretical structure.
- Goal: To abstract raw data into meaningful concepts and categories.
- LLM Role: "Grounded Theory Coding Specialist" / "Methodologist"

A Two-Step, Iterative Cycle
（Straussian范式扎根理论"持续比较"理念的体现）

Initial Coding

- The LLM analyzes each incident one-by-one.
- It compares the incident to the existing codebook.
- Rule: It must prioritize reusing an existing Concept and Subcategory if a good fit exists. It only creates a new code if the phenomenon is truly distinct.
- This operationalizes the Constant Comparative Method.

Refinement & Consolidation

- The researcher and LLM review the entire list of coded pairs.
- Merge Concepts: Semantically similar concepts are merged to reduce redundancy.
- Split/Refine Subcategories: Overly broad subcategories are split to preserve meaningful distinctions and enhance conceptual clarity.

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轴心编码 / Axial Coding

目标 / Objective

- To systematically connect the 75 Subcategories from Stage 2 and assemble them into a coherent theoretical model.
- Goal: To move from "what" (concepts) to "how" and "why" (relationships).

A Multi-Dialogue Approach

Preliminary Aggregation
对分散构念进行初步聚合

The LLM sifts through all 75 subcategories, groups related themes, and proposes preliminary roles

- (e.g., "This looks like a Causal Condition," "This looks like an Action").

Paradigm Mapping 映射到Straussian范式

The LLM systematically maps all core subcategories into the Straussian Coding Paradigm:

- Causal Conditions (致因)
- Phenomenon (核心现象)
- Context (脉络)
- Intervening Conditions (中介条件)
- Action/Interaction Strategies (行动策略)
- Consequences (结果)

Narrative Generation
生成初步叙事

The LLM generates the first narrative summary (the "storyline") that logically connects all six paradigm components.

- Output the first draft of the theoretical storyline.

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选择性编码 / Selective Coding

目标 / Objective

- To integrate the entire paradigm model from Stage 3 into a single, cohesive substantive theory.
- Goal: To move from a "model" of relationships to a "theory" with full explanatory power.
- LLM Role: "Distinguished Professor" & "Qualitative Theorist"

A Multi-Dialogue Approach

Identify Core Category	Refine Storyline	Dimensionalize & Build Typology	Final Assessment
识别核心范畴	**精炼故事线**	**维度化与类型构建**	**最终评估**
The LLM analyzes the entire Stage 3 paradigm and proposes a single, abstract "Core Category" (e.g., Strategic Orchestration...) that unifies all other components.	The LLM rewrites the narrative from Stage 3 to revolve entirely around this new Core Category, explaining the full process.	• The LLM identifies key dimensions of variation (e.g., "Primary Driver," "Scope of Openness"). • It then proposes a typology of "Faction Types" to explain how different vendors enact the core theory.	The LLM assesses the final theory's conceptual density, coherence, and (conceptual) saturation, identifying any remaining gaps.

理论饱和度测试 / Theoretical Saturation Test

目标 / Objective

- To test the explanatory power and resilience of the final theory (from Stage 4).
- Goal: To validate if the theory is "saturated" or if it has significant conceptual gaps.
- LLM Role: "Critical Methodologist"

[Final Theory] + [📄 Data Excerpt] → [LLM "Critic" 🧑‍⚖️] → ["Does it fit?"]

Provide Theory	**Provide Data**	**Evaluate Fit**	**Assign Status**
提供核心类别和故事线	**提供先前的数据摘录**	**评估理论是否解释数据**	**分配评估状态**
The LLM is given the final Core Category and Storyline.	The LLM is fed a sample of previously coded data excerpts from Stage 1 & 2.	The LLM is prompted to evaluate: "Does our final theory fully explain this specific data excerpt?"	LLM assigns one of three statuses: Confirms Saturation, Suggests Further Refinement, Points to New Theoretical Development.

方法论验证 / Validation: High Reliability of the LLM-Assisted Method

Quantitative Evaluation: Human Gold Standard

Rigorous comparison of LLM output vs. human consensus coding.

Key Metrics (F1-Scores):

- Stage 1 (Information Extraction): 0.896 (Initially 0.824, improved after human review found LLM identified more relevant incidents).
- Stage 2 (Open Coding): 1.0 (Perfect alignment on concepts).
- Stage 3 (Axial Coding): 0.875 (High precision, slightly lower recall as expected when focusing theory).
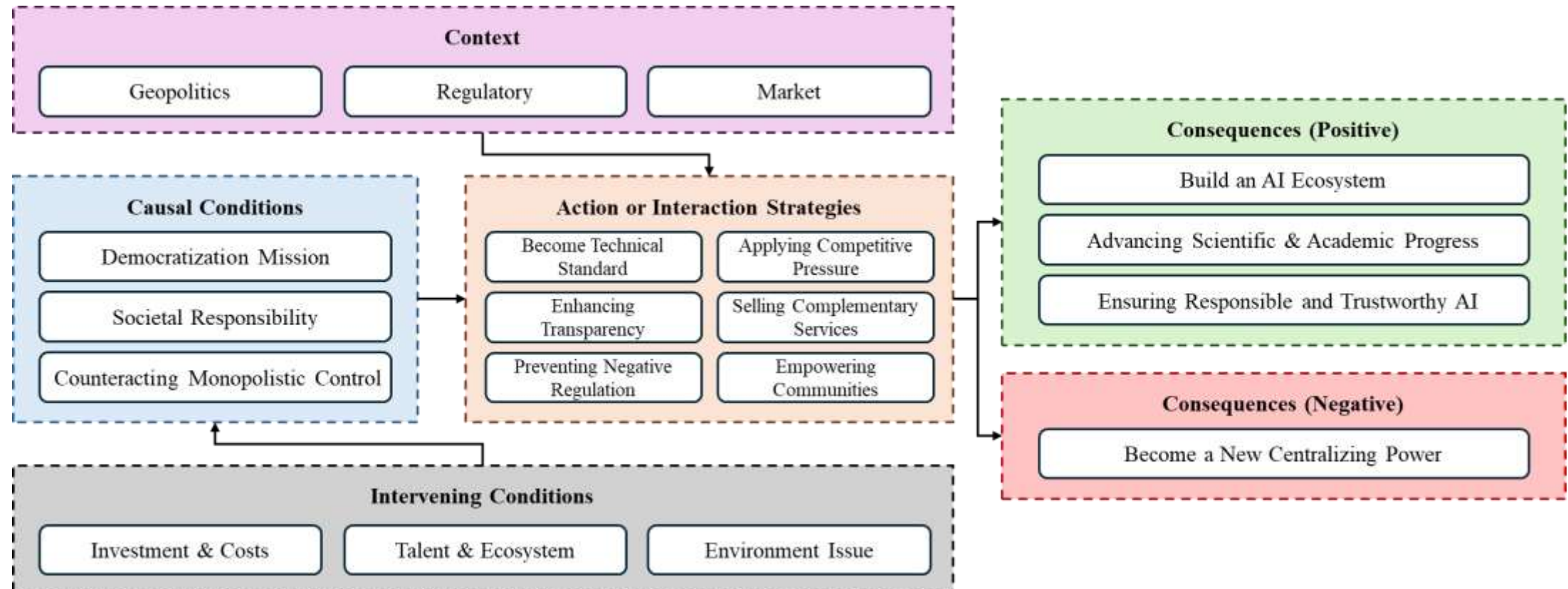
Qualitative Evaluation: Representational Quality

- LLM generated concise, appropriate, and theoretically sensitive concepts (Stage 2).
- LLM constructed a coherent, parsimonious, and insightful core storyline (Stage 3 & 4).
- **Key Insight:** Successfully identified and articulated the central paradox: using "openness" for "centralization."
- It serves as a valuable tool, **enhancing efficiency while preserving researcher** control over interpretation.

Stage	TP	FP	FN	Precision	Recall	F1-Score
Information Extraction	392	90	77	0.8133	0.8358	0.8244
Information Extraction (fixed)	392	14	77	0.9655	0.8358	0.896
Open Coding	469	0	0	1	1	1
Axial Coding	42	0	12	1	0.7778	0.875

战略编排 / Strategic Orchestration of Competitive Openness

Our analysis reveals a central process: **"Strategic Orchestration of Competitive Openness"**. The deliberate management of 'openness' as a dynamic tool to navigate the complex interplay of ideology, competition, and market demands in the LLM landscape..
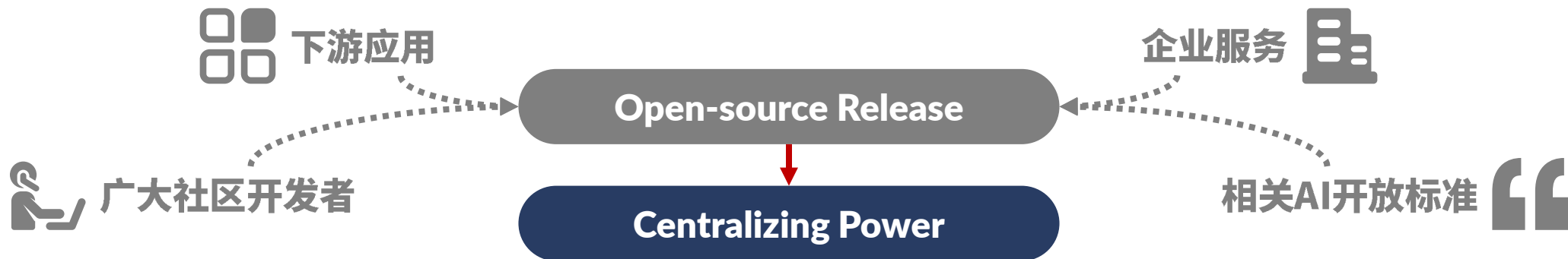
以开放促集中 / Openness Leading to Centralization

Highlighting the Key Consequence

- **Referencing the Paradigm Model:** The strategic orchestration often leads to a paradoxical negative outcome.
- **The Paradox:** While promoting openness, collaboration, and democratization, a primary consequence for the orchestrating vendor is often "Becoming a New Centralizing Power."

Explaining the Mechanism

- **Ecosystem Dependency:** By making their LLM the de facto standard through open release, vendors cultivate a vast ecosystem (developers, startups, applications) that becomes reliant on their foundational technology.
- **Strategic Control:** This dependency grants the vendor significant influence over the ecosystem's direction, standards, and value capture, effectively centralizing power despite the "open" nature of the core asset.

下游应用

企业服务

广大社区开发者

相关AI开放标准

Open-source Release

Centralizing Power

派系衍生 / The Three Factions of Openness

The Open Evangelists
开放布道者

- Driver: Primarily Value-driven (democratization, anti-monopoly).

- Scope: Lean towards Comprehensive & Permissive openness.

- Philosophy: Focus on Community Empowerment.

🌸 理想主义和社区精神

The Pragmatic Cultivators
生态培育者

- Driver: Balanced (mix of values and commercial/competitive goals).

- Scope: Often Hybrid / Open-core, adaptive openness.

- Philosophy: Blend of Empowerment & Platform Consolidation.

🔵 战略平衡和市场适应

The Strategic Accelerators
战略加速者

- Driver: Primarily Utility-driven (market share, competitive advantage).

- Scope: Often Selective & Restricted, tactically chosen openness.

- Philosophy: Focus on Platform Consolidation.

♟ 企业目标与市场竞争

贡献与启示 / Advancing Theory and Informing Practice

Theoretical Contributions

- **Extends Platform & Strategy Theory:** Shows extreme openness can be a strategy for ecosystem control and act as a disruptive tool in the high-cost AI context.

- **Enriches Open Innovation Theory:** Details strategic orchestration of community input for R&D/safety, highlighting co-creation dynamics.

- **Advances IS Research Methodology:** Offers a validated framework for human-AI collaboration in qualitative research, boosting efficiency.

Practical Implications

- **For Industry (LLM Vendors & Adopters):** Provides an actionable strategic framework to assist organizations in formulating, evaluating, and refining their open-source strategies for complex AI systems. It highlights the critical need to assess the potential long-term risks associated with ecosystem dependency and vendor lock-in, even when engaging with open-source models, guiding more informed adoption and partnership decisions.

- **For Policy (Regulators & Policymakers):** Crucial insight – "Open" ≠ Democratizing.

Thanks for your attention !

Speaker | Mingfeng Hong

Code is available at: https://github.com/MingfengHong/llm_assisted_gt

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