

Decoding AI innovation: How R&D alliances drive technological breakthrough

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Introduction

● Background:

In complex AI technologies, firms rarely succeed through internal R&D alone because critical knowledge and complementary assets are dispersed across organizations and are difficult to integrate within a single firm. Consequently, R&D alliances become a necessary strategic pathway for accessing non-redundant expertise and accelerating the recombination required for AI breakthroughs.

● Research Gap:

Collaboration is not merely an avenue for more external knowledge. AI breakthroughs rely on a conversion chain: accessing dispersed knowledge, integrating it across partners, and translating it into scalable outcomes. Two gaps follow. First, alliance heterogeneity: market-oriented alliances contribute commercialization complements, whereas research-oriented alliances contribute frontier knowledge; their effects should therefore diverge. Second, conversion contingencies: whether these inputs yield breakthroughs depends on internal frictions and enablers, notably knowledge path dependence (lock-in) and dynamic capabilities (orchestration, recombination, scaling).

● Contributions:

1. We reposition AI breakthroughs as an outcome of alliance-enabled knowledge access and recombination, not only internal capability accumulation.
2. We theorize and test heterogeneous effects of alliance types (market- vs. research-oriented), clarifying distinct mechanisms rather than treating alliances as uniformly beneficial.
3. We integrate an access – conversion logic by showing how knowledge path dependence can constrain alliance returns while dynamic capabilities help convert alliance inputs into breakthrough AI innovation.

Objectives

- To examine, from a resource dependence perspective, whether R&D alliances help firms overcome internal resource constraints and enhance AI innovation breakthroughs.
- To distinguish the effects of market-oriented versus research-oriented alliances, clarifying how different alliance types shape AI innovation trajectories.
- To test an access–conversion logic by assessing how knowledge path dependence constrains, and how dynamic capabilities enable, the translation of alliance inputs into AI breakthroughs.
- To extend the analysis to generative AI by evaluating whether the proposed alliance mechanisms also explain firms' GenAI innovation outcomes.

Framework

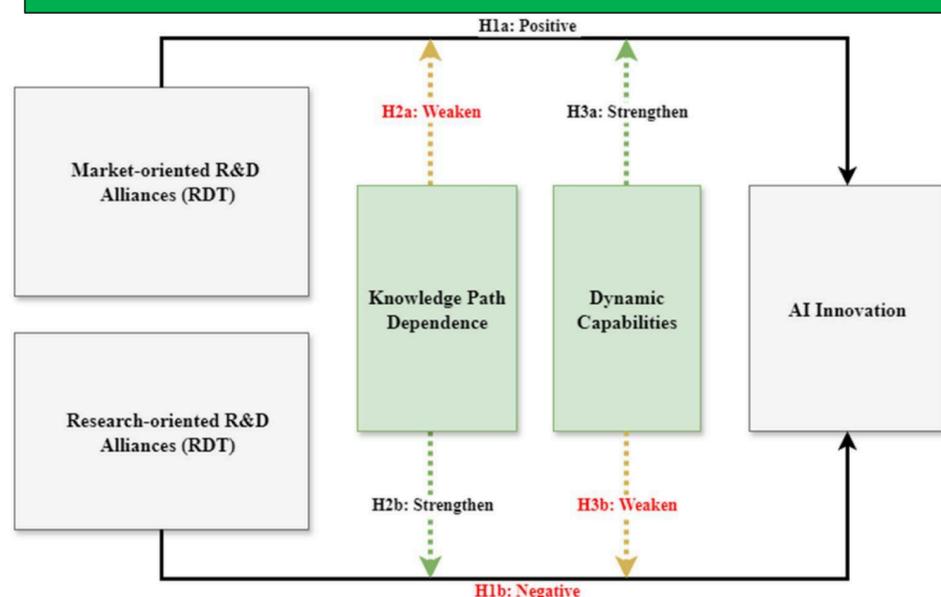


Fig.1 Hypothesis framework.

H1a: Market-oriented R&D alliances strengthen AI innovation.

H1b: Research-oriented R&D alliances weaken AI innovation.

H2a: Knowledge path dependence weakens the positive relationship between market-oriented R&D alliances and AI innovation.

H2b: Knowledge path dependence strengthens the negative relationship between research-oriented R&D alliances and AI innovation.

H3a: Dynamic capabilities strengthen the positive relationship between market-oriented R&D alliances and AI innovation.

H3b: Dynamic capabilities weaken the negative relationship between research-oriented R&D alliances and AI innovation.

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Method

● **Data:** Firm-year panel of Chinese A-share listed companies (2007–2021), merged with CNIPA patent data to track AI innovation.

● **Variables:** The key independent variables are R&D alliance types—market-oriented alliances (firm–firm / firm–individual expert co-patenting) versus research-oriented alliances (firm–university / research-institute co-patenting); the moderators are knowledge path dependence and dynamic capabilities; controls include standard firm characteristics (e.g., Size, Lev)

● **Machine learning to measure AI innovation:**

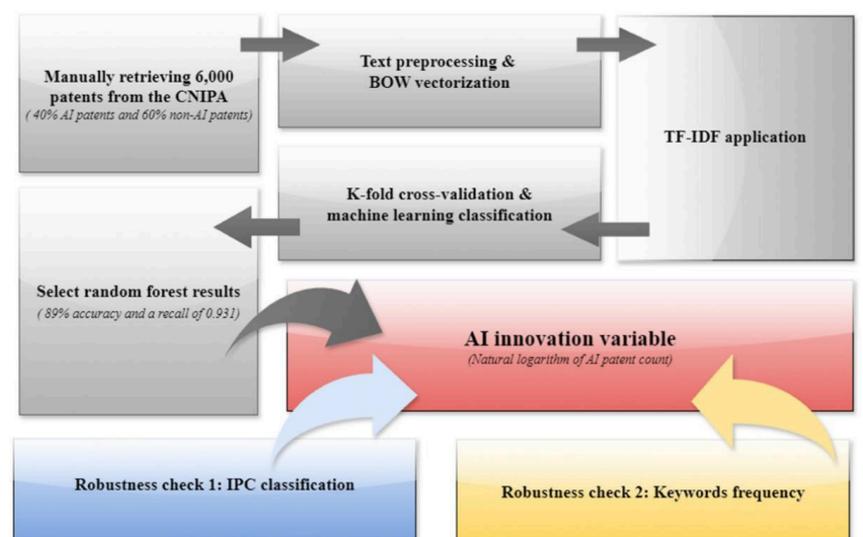


Fig.2 AI computational process

Discussion

● Theoretical contributions:

1. RDT: We extend resource dependence theory by showing that alliances matter in AI not only for resource access, but for converting external dependence into breakthrough innovation—market-oriented alliances ease conversion, while research-oriented alliances may increase translation costs.
2. Alliance/KBV: We demonstrate alliance heterogeneity in complex technologies by distinguishing market- vs. research-oriented alliances, showing they deliver different knowledge/complement bundles and thus different innovation effects.
3. Contingency (path dependence & dynamic capabilities): We build an access – conversion framework where path dependence weakens alliance returns via lock-in, while dynamic capabilities enable orchestration and scaling into breakthrough (including GenAI) outcomes.

● Practical contributions:

1. Managers should treat alliance strategy as a portfolio choice: prioritize market-oriented partners when the bottleneck is application, deployment, and speed-to-market, and use research-oriented partners when frontier exploration is the goal—then design governance accordingly.
2. To avoid “collaboration without conversion,” firms need integration routines (joint problem framing, data/interface standards, milestone-based co-development) that reduce translation costs across partners.
3. Firms with strong path dependence should deliberately widen search (cross-domain partners, rotating teams) to prevent alliances from reinforcing lock-in, while investing in dynamic capabilities (sensing, coordination, reconfiguration) to turn external inputs into scalable AI outcomes.

Conclusion

Our findings show that market-oriented R&D alliances boost AI innovation, including generative AI, whereas research-oriented alliances depress overall AI innovation and exhibit no significant effect on GenAI. Knowledge path dependence exacerbates these patterns by constraining absorption and commercialization. Conversely, strong dynamic capabilities mitigate these downsides, enhancing integration, orchestration, and scaling to convert external inputs into breakthrough, scalable AI outcomes.

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