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Structural Monopoly Risk and Regulatory Governance of Generative Artificial Intelligence

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Abstract. Generative artificial intelligence, characterized by its high technological barriers and multi-scenario penetration, is accelerating market concentration. Dominant enterprises leverage comprehensive application layouts to establish closed-loop monopoly ecosystems, exerting systemic control over market entry, technological resources, and user choices, thereby manifesting structural monopoly risks. From a horizontal perspective, these enterprises create exclusionary barriers through the hyper-concentration of technological elements—data, computing power, and algorithms—and capital elements—funding and talent. Vertically, they extend their market dominance from the technological layer to the application and terminal layers, transitioning from upstream technological control to downstream market penetration and ultimately binding end-users. To prevent and resolve structural monopoly risks, a balanced framework that harmonizes innovation incentives with competition order must be constructed. Guided by the Inclusive Prudence Principle and the Risk Prevention and Control Principle, this framework should refine data sharing incentives, optimize computing power sharing networks, and build open-source algorithm innovation ecosystems. Collectively, these measures will enable the exploration of antitrust governance strategies better tailored to the early developmental stage of GAI sector.

Keywords: Generative artificial intelligence; Structural monopoly; Monopoly risks; Antitrust governance; AI governance.

1. Introduction

The phenomenal rise of DeepSeek has ignited a global surge in the commercialization of generative artificial intelligence (GAI), which is progressively penetrating and empowering diverse vertical industries. According to incomplete statistics, over 200 enterprises in China—spanning basic telecom operators, cloud computing, semiconductors, finance, automotive, and mobile devices—have announced integration with DeepSeek. Notably, leading cloud platforms including Huawei, Alibaba, Baidu, Tencent, and JD.com have incorporated the DeepSeek large model. Domestically, DeepSeek demonstrates robust productivity capabilities, permeating specialized fields such as medical diagnostics, financial risk management, and smart manufacturing, thereby driving high-quality industrial upgrades and generating substantial economic value.

Notably, the concentration of GAI large-scale models within a handful of tech giants has heightened risks of model collusion, data exploitation, and vertical integration—risks that are not hypothetical but empirically observable [1]. GAI's dual attributes of high technical barriers and multi-scenario penetration are accelerating market consolidation, drawing widespread regulatory scrutiny globally. For instance, the European Union enacted the world's first comprehensive Artificial Intelligence Act in March 2024, while its concurrently implemented Digital Markets Act subjects GAI to "gatekeeper" regulatory frameworks, mandating large platforms to open API interfaces. The U.S. Federal Trade Commission (FTC) has launched a comprehensive investigation into AI enterprises' investments and partnerships, issuing legally binding investigative orders to five industry leaders: Microsoft, OpenAI, Google, Amazon, and Anthropic. The U.K. Competition and Markets Authority (CMA), in its Preliminary Report on AI Foundation Models, explicitly prohibits algorithmic-driven implicit price collusion and requires dominant firms to disclose core training datasets to dismantle data monopolies.

China remains vigilant in monitoring GAI developments. Article 4 of the Interim Measures for the Management of GAI Services, jointly issued by the Cyberspace Administration of China and six other ministries, explicitly prohibits monopolistic and unfair competition practices leveraging algorithmic, data, or platform advantages. A private sector symposium on February 17, 2025, attended by leading AI firms including Alibaba, Huawei, Tencent, and DeepSeek, emphasized the imperative to eliminate institutional barriers to equal access to production factors under the law and fair participation in market competition, while advancing equitable access to infrastructure in competitive sectors for all market entities.

Amid the global race among major economies to secure strategic dominance in artificial intelligence development, a critical priority has emerged: how to foster industrial growth while simultaneously preventing and addressing risk challenges posed by advanced AI systems like ChatGPT. This dual imperative has become a focal concern for nations worldwide [2]. Current theoretical research on GAI-related monopoly risks remains fragmented, with limited targeted studies primarily focusing on data monopolies, algorithmic collusion, and self-preferencing, while systemic analyses remain scarce. Given this context, it is essential to construct a systematic framework that investigates the formation mechanisms of structural monopolies in GAI through dual horizontal and vertical dimensions, while proposing targeted countermeasures informed by practical realities.

2. Structural Monopoly in Generative Artificial Intelligence: An Overview

Structural monopoly in GAI refers to dominant enterprises establishing systemic market control through the deep integration of technology, capital, and market dynamics. By leveraging core technical elements—data, algorithms, and computing power—coupled with overwhelming capital advantages, leading firms construct exclusionary barriers in horizontal markets through hyper-concentration of resources, while achieving ecosystem dominance in vertical markets via chain-like control spanning from foundational model development to vertical application scenarios and end-user lock-in. This closed-loop technological ecosystem, built on comprehensive application layouts, enables systemic dominance over market access, technological resources, and consumer choices. Such self-reinforcing monopolistic ecosystems exacerbate the "Matthew Effect" in GAI development, ultimately distorting market competition and eroding public welfare.

3. Horizontal Dimension: Hyper-Concentration of Resources

Horizontal monopoly in GAI manifests as dominant enterprises forming exclusionary barriers within horizontal market layers through concentrated control of technical and capital elements, effectively obstructing market entry and fair competition.

3.1. Technical Elements

From a systems theory perspective, scholars emphasize that data, algorithms, and computing power constitute the recognized tripartite foundation of artificial intelligence. Data serves as the fuel, computing power as the engine, and algorithms as the controller, forming a triangular support system for GAI operations. Within this framework, data-driven optimization fuels algorithmic refinement and stimulates computing power demand, while computational infrastructure provides essential support for data processing and algorithmic execution. Algorithms, in turn, harness data analytics and computational resources to actualize GAI functionalities, completing the technological closed loop. At the core of structural monopoly, leading enterprises perpetuate a self-reinforcing cycle of "data barriers–computing power control–algorithmic supremacy" through monopolization of these critical elements, systematically excluding or restricting market competition.

3.1.1. Data Barriers.

The development of GAI foundation models imposes stringent requirements on the quantity and quality of training data, which fundamentally determine their performance and efficacy. As a critical strategic resource in the information age, data serves as the foundational material for knowledge production within algorithmic power structures and constitutes an essential element for realizing algorithmic dominance [3]. Empirical studies reveal a quasi-linear positive correlation between model scale and performance that when model parameters exceed a critical threshold, capabilities escalate exponentially with size. For instance, GPT-3—with 175 billion parameters—demonstrates emergent contextual learning abilities, starkly contrasting with GPT-2's 1.5 billion parameters. While GPT-4's parameter count remains undisclosed, reasonable estimates suggest a 100-fold increase over GPT-3 [4].

However, beyond established tech giants with preexisting data troves, startups face severe constraints in accessing high-quality data pipelines. Incumbent firms leverage proprietary user data accumulated over decades, directly deploying these resources for research and development. Through exclusive control and cyclical utilization of data assets, they erect insurmountable data barriers. Even when data possesses nominal openness, dominant enterprises employ technical restrictions or contractual blockades to impede competitors' data acquisition. Consequently, startups struggle to overcome technical performance ceilings due to inadequate data parity. This dynamic underscores how GAI perpetuates traditional power asymmetries, reinforcing centralized internet monopolies across all GAI-related industries, with internet tech oligarchs remaining the ultimate arbiters [5].

If dominant firms obstruct data sharing through technical or contractual means, such conduct may constitute exclusionary practices like refusal to deal or discriminatory treatment. In November 2024, Elon Musk alleged that OpenAI engaged in monopolistic behavior by restricting competitors' access to critical data sources through exclusive licensing agreements. Musk's litigation highlighted Microsoft-OpenAI collaboration clauses containing "data-sharing blockade provisions," which barred Microsoft from providing user interaction data on its cloud platforms to rival GAI firms, directly undermining competitors like xAI in model training. Nevertheless, effective identification and regulatory mechanisms for such conduct remain underdeveloped.

3.1.2. Comp utility Control.

From pre-training to application phases, GAI demands massive comp utility (computational capacity) to sustain data processing and algorithmic operations. In the GAI comp utility ecosystem, NVIDIA Corporation dominates the global market, while China's high-performance chips, despite achieving incremental breakthroughs, still lag behind cutting-edge international benchmarks. A comparative analysis of flagship AI accelerators—NVIDIA's H100 (SXM) and Huawei's Ascend 910B—reveals stark disparities: the H100 (SXM) delivers FP16 comp utility of 1,979 TFLOPS, 5.2 times the Ascend 910B's 380 TFLOPS. Under the current paradigm of comp utility hyper-concentration among oligopolistic firms, GAI enterprises face constrained access to independent comp utility provisioning, forcing reliance on dominant cloud service providers for infrastructure leasing. This monopolistic control over comp utility resources systematically distorts market competition, exacerbated by persistent AI chip supply shortages. According to the China Academy of Information and Communications Technology (CAICT), the Americas accounted for 53.75% of global cloud comp utility market share in 2023. Domestically, Alibaba Cloud, Tencent Cloud, and Huawei Cloud collectively command 37.87% of China's market through technological hegemony and brand oligopoly [6].

Dominant firms exploit technical barriers, capital intensity, and market power to establish exclusionary comp utility governance within the GAI value chain. Such structural dominance erects prohibitive entry barriers for new participants in accessing high-performance comp utility assets, contravening principles of competitive neutrality. Antitrust risks emerge when incumbents engage in refusal to deal (e.g., withholding AI training chips), exclusive dealing (restricting third-party access), monopoly pricing, or discriminatory provisioning. A paradigmatic case involves NVIDIA's alleged abuse of dominance through its denial of A800 GPU sales to selected GAI developers, a strategic comp utility blockade that impaired competitors' model training capabilities and constitutes refusal to deal under antitrust law.

3.1.3. Algorithmic Dominance.

The formidable capabilities in data acquisition, extraction, analysis, and processing are constituted by interconnected algorithmic systems [7]. The research and development of GAI algorithmic models inherently imposes high market entry barriers on startups due to the complexity of technological innovation and substantial investment costs during the initial phase. Patent systems, by granting dominant enterprises technological exclusivity rights, further entrench these competitive thresholds. This dynamic makes it highly unlikely for new formidable competitors to emerge in the relevant market within the foreseeable future. Most enterprises opt against developing algorithmic models de novo, instead leveraging existing frameworks for iterative innovation. Consequently, advanced algorithmic models of dominant firm's secure market hegemony, while small and medium-sized innovators become dependent on the algorithmic infrastructures controlled by a few incumbents. This dependency enables dominant players to transmute algorithmic superiority into algorithmic power, securing control over technical standardization. Dominant firms further entrench their monopolistic positions through continuous model iteration, fueled by access to premium user data and research and development investments. Their leading models undergo perpetual optimization, creating self-reinforcing cycles of technological and market dominance.

Simultaneously, dominant enterprises consolidate algorithmic advantages through open-source framework binding and proprietary service monetization strategies. During early-stage competition, GAI firms incentivize third-party integration by open-sourcing application programming interfaces (APIs) to attract users and build ecosystems. However, as market positions solidify, the strategic calculus shifts: when the benefits of third-party application integration are outweighed by the advantages of restricting competitor access, firms transition open-source models to closed-source architectures [8]. In the initial phase of technological ecosystem construction, dominant players adopt open-source technical standardization strategies, releasing base model source code to attract developers and subtly establish de facto technical protocols. Once dependency on their ecosystems is entrenched among users and competitors, they execute closed-source pivots, coercing ecosystem participants into accepting premium-priced products or services to maintain algorithmic functionality. This open-source attraction–closed-source monetization paradigm not only maximizes commercial returns but also secures unilateral control over technological roadmaps and standardization. A representative case is OpenAI's strategic release of the GPT-2 model under open-source licenses to cultivate developer engagement and accumulate research data, followed by its shift to closed-source licensing for GPT-3 and subsequent versions. By exclusively deploying these models via Microsoft Azure cloud services while restricting third-party API functionalities, OpenAI fortified algorithmic monopolies and suppressed competitive innovation.

3.2. Capital Elements

In addition to technological factors, capital elements constitute a critical driver for dominant enterprises to reinforce their competitive advantages and establish structural monopolies. By leveraging capital to control foundational technical resources such as data and computing power, and attracting top-tier talent in GAI through high compensation packages, dominant firms amplify technological barriers and consolidate market dominance. This creates a self-reinforcing cycle of capital aggregation, talent acquisition, and market control.

3.2.1. Capital Aggregation.

Competing in the GAI domain necessitates substantial capital investments in data resources, computing infrastructure, algorithmic development, and talent acquisition. Establishing a mature general-purpose search engine demands significant upfront expenditures, particularly for algorithm development, including research and development costs, equipment procurement, and human resource expenses [9]. Post-deployment operational costs remain exorbitant. As is reported, OpenAI reportedly spends $700,000 daily to operate ChatGPT for processing user queries [10] Dominant enterprises accelerate technological iteration through accumulated capital and external financing, reinforcing their market positions and attracting further investments to perpetuate this cyclical advantage.

Dominant firms exert resource control through long-term capital reserves. For instance, DeepSeek's parent company, Huanfang Quantitative (a leading Chinese quantitative hedge fund managing assets exceeding 100 billion CNY), preemptively acquired over 10,000 high-end NVIDIA GPUs and constructed proprietary computing centers as early as 2021. This strategic hardware investment bypassed traditional startups' reliance on external financing, enabling uninterrupted long-term research and development. Concurrently, global GAI investments remain hyper-concentrated among a few technologically dominant incumbents. OpenAI has raised over $30 billion in cumulative financing, with its latest valuation soaring to $340 billion. Through a $40 billion funding led by SoftBank, it supports the Stargate data center project, which costs $500 billion. This strategic initiative further entrenches ecosystem barriers, solidifying its monopolistic positioning. Dominant firms leverage their high valuations to attract additional financing for research and development, accelerating technological upgrades and solidifying market positions. This enhances industrial valuations and establishes a positive feedback loop for capital inflow. For most market entrants, the prohibitive costs of developing competitive high-performance algorithms create insurmountable barriers [11] ccording to Flexera's 2024 State of the Cloud Report, over 84% of enterprises face challenges in cloud cost management, marking it the top cloud adoption hurdle for two consecutive years. Massive capital requirements and upfront sunk costs force numerous startups to exit markets due to funding shortages and financing difficulties, cementing the oligopolistic dominance of capital-endowed incumbents.

3.2.2. Talent Concentration.

The technological competition in the GAI domain fundamentally revolves around the acquisition of top-tier talent, with structural imbalances in human capital accelerating the formation of monopolistic market structures. Due to the specialized nature, technical complexity, and rapid iteration cycles inherent to GAI technologies, practitioners in this field face exceptionally high professional competency requirements, resulting in acute talent scarcity. Dominant enterprises consolidate core competitiveness by attracting, cultivating, or monopolizing elite technical personnel through competitive compensation packages.

On one front, dominant firm deploy substantial financial resources to secure talent advantages, offering industry-leading remuneration to assemble world-class research teams. According to March 2025 data from Levels. fyi, a U.S. tech compensation benchmarking platform, OpenAI's salary offerings for software engineers range from 143,000 annually for junior roles to approximately 1.332 million for senior positions. Notably, OpenAI pioneered a novel compensation structure in the tech sector: the Profit Participation Units (PPU) system, which combines base salaries with equity incentives. PPU holders gain profit-sharing rights, enabling employees to benefit from future corporate earnings—a strategy designed to enhance appeal to high-end technical talent.

On another front, dominant enterprises provide superior research and development environments and cutting-edge infrastructure, offering robust support and expansive developmental opportunities for recruited experts. Furthermore, talent mobility remains subject to control by incumbents. When professionals with substantial practical expertise cannot freely transition across organizations, technological innovation becomes constrained by the strategic preferences of dominant players, while competitors struggle to develop disruptive technological threats [12] Dominant firms further orchestrate talent flow through industry-academia collaborations (e.g., DeepSeek's joint laboratory with Tsinghua University) and ecosystem lock-in mechanisms (e.g., NVIDIA's CUDA certification system).

Consequently, talent aggregation within dominant enterprises systematically marginalizes small and medium-sized firms in recruitment battles due to compensation disparities and resource deficiencies. This structural monopoly arising from imbalanced talent distribution exacerbates technological gaps between incumbents and startups. As GAI technologies continue evolving, persistent talent concentration will entrench monopolistic market architectures, perpetuating long-term competitive asymmetries.

4. Vertical Dimension: Chain-like Ecosystem Control

Vertical monopoly in the GAI domain refers to dominant enterprises leveraging their hegemony in technical standard-setting to extend market power from the technological layer to application and terminal layers. By constructing a closed and exclusionary ecosystem across vertical market hierarchies, these firms achieve upstream technological control, downstream market penetration, and end-user lock-in, thereby excluding competitors and consolidating monopolistic dominance.

4.1. Technological Layer: Upstream Technological Control

At the technological layer, dominant enterprises establish monopolistic control over critical technologies through data acquisition barriers, computing power resource control, and algorithmic model monopolization. Combined with hyper-concentrated capital advantages, they engineer technical standards and ecosystem barriers to secure exclusive dominance in upstream industrial chains. The innovative nature of GAI inherently creates substantial entry barriers, leading to extreme concentration of technologies and markets among incumbent tech giants, which systematically suppresses the growth of small and medium-sized innovators [13]. This market dominance exhibits dynamic iterativity. The technological superiority is perpetually reinforced through the "data barriers–computing power control–algorithmic supremacy" triad, while capital advantages intensify via the "capital aggregation–talent acquisition–market dominance" cycle. Such mechanisms render it practically insurmountable for competitors in vertical markets to bridge technological gaps at the foundational layer.

4.2. Application Layer: Downstream Market Penetration

In the vertical integration process of structural monopoly in GAI, market penetration at the application layer exhibits systemic characteristics of technological superiority transforming into technological power. Dominant enterprises leverage foundational technological advantages to extend monopolistic influence from basic research and development layers to vertical application scenarios through industry-customized models and ecosystem closure strategies, forming a transmission chain of technical standardization–scenario adaptation–ecosystem lock-in. Take DeepSeek as an example: leveraging its formidable technological prowess and domestic innovation credentials, it has catalyzed a large-scale "GAI integration wave" in China's downstream markets. According to incomplete statistics, over 20 central state-owned enterprises, 12 provincial-level regions, and more than 10 leading internet firms—including Alibaba, Tencent, Baidu, and JD.com—have integrated DeepSeek. Over 100 listed companies on the A-share market have adopted DeepSeek, accelerating AI commercialization. This radial expansion pattern not only reconfigures industrial chain value distribution but also establishes self-reinforcing monopolistic closed loops through data flywheel effects, where increased user interaction data feeds model optimization. Ultimately, first-mover technological advantages are converted into insurmountable market entry barriers.

In this process, monopolistic conduct by dominant firms manifests dual characteristics of opaqueness and Eco systemization. Dominant enterprises implement structural self-preferencing through technical protocols, preferentially allocating technological resources to their proprietary ecosystems in downstream markets. While the EU's Competition Policy for the Digital Era report posited that preferential treatment for self-operated products/services could be justified as returns on platform development, such rationalization becomes invalid in GAI contexts [14]. Scholar Jiao Haitao argues that the illegality of self-preferencing stems not merely from differential treatment but from platforms' dual roles—as both market participants and infrastructure controllers [15]. In GAI vertical markets, dominant firms abuse their dual identities as technology providers and market competitors. As technology providers, they control core resources, forcing downstream firms to depend on their technical protocols for industry solutions. As market competitors, they vertically integrate to directly contest downstream market share. This duality enables them to restrict access through technological supply while harvesting benefits through market competition, profoundly distorting downstream competitive landscapes. In addition, dominant firms further enforce ecosystem lock-in by coercing users into accepting closed-loop services through bundling strategies. By integrating GAI technologies with proprietary products/services, they directly influence competition across segmented markets. Microsoft exemplifies this through integrating ChatGPT with its operating systems and search products, transferring traditional software market power into GAI application markets. Such practices elevate user switching costs, amplify lock-in effects, and entrench incumbents' business advantages [16].

4.3. Terminal Layer: End-User Lock-in

At the terminal layer, dominant GAI enterprises establish high-switching-cost user loyalty through data flywheel effects and cognitive dependency loops, achieving systemic control over end-users.

On one front, these firms leverage data flywheel mechanisms to harvest real-time interaction data between users and GAI models, which feeds back into model optimization. This continuous improvement cycle enhances user satisfaction with algorithmic performance, incentivizing increased usage frequency and generating more interaction data. For instance, approximately 30% of GPT-4's training data originates from real-time user dialogues. Underpinned by such technological capabilities, the convergence of algorithmic manipulation and data exploitation enables the algorithmic "enclosure" of users, wherein social relationships are commodified and users subjected to unbounded data extraction [17].

On another front, prolonged immersion in GAI ecosystems erodes users' autonomous thinking capacities and self-driven exploration, fostering gradual dependency on GAI technologies and forming high-switching-cost loyalty loops. The growing user stickiness of GAI consumer products fundamentally reflects the progressive alienation of human cognitive agency. Consequently, GAI's technological power subtly establishes control over users across physical and psychological dimensions. Through self-learning, iterative upgrades, and service optimization, these systems amplify user satisfaction while cultivating emotional alignment with GAI technologies, thereby desensitizing users to the erosion of their cognitive sovereignty [18]. A February 10, 2025 studies by Microsoft and Carnegie Mellon University researchers revealed that increased reliance on AI tools correlates with diminished critical thinking, impairing individuals' ability to reactivate these skills when necessary. The issue lies not in AI surpassing human capabilities but in humans becoming overly dependent on imperfect tools, leading to the atrophy of intrinsic competencies [19]. By embedding personalized services deeply into daily routines, dominant enterprises reduce users' cognitive labor costs while systematically degrading their capacity for independent learning and reasoning. This cultivates "AI dependency syndrome" characterized by prohibitive switching costs.

Therefore, end-user lock-in represents an evolution of technological monopoly from resource control to cognitive permeation. Through dual mechanisms of data flywheels and cognitive dependency, dominant firms extend their influence from technological dominance to the reshaping of user cognition, seeking not only market monopolization but also the control of human thought patterns.

5. Fundamental Principles for Governing Structural Monopolies in Generative Artificial Intelligence

The establishment of fundamental principles for a governance framework not only constitutes the value benchmark for legal application but also determines the design direction and operational efficacy of specific rules. To formulate the core principles for governing structural monopolies in GAI, it is imperative to anchor these principles in the intrinsic characteristics of market competition. Within the dynamic equilibrium between incentivizing technological innovation and safeguarding market order, a forward-looking and adaptive value coordination system must be constructed.

5.1. Inclusive Prudence Principle

The Inclusive Prudence Principle refers to a governance approach that, during the nascent stage of GAI technology development, dynamically balances regulatory intensity with technological attributes through categorized and tiered supervision and flexible regulation. This principle aims to maximize the preservation of an innovation-friendly environment while ensuring fair market competition. At present, most GAI technologies and their derivative markets remain in early developmental phases, necessitating a regulatory environment that prioritizes openness over constraint to foster innovation among market participants. Antitrust enforcement authorities should also reserve sufficient developmental space for the advancement and application of GAI, appropriately balancing the relationship between innovation encouragement and antitrust oversight to amplify the societal benefits of it [20].

China's Interim Measures for the Management of Generative Artificial Intelligence Services explicitly states: "The state shall adopt effective measures to encourage innovative development of GAI, implementing inclusive, prudent, categorized, and tiered regulation over GAI services." From a domestic perspective, China's GAI sector is still in its infancy. While a few dominant firms have begun to exhibit monopolistic tendencies, market entities and industrial structures remain fluid, with no solidified market hierarchy yet established. Any enterprise that breaks through technological bottlenecks to launch advanced products could significantly reshape the competitive landscape. Consequently, policy solutions grounded in the Antimonopoly Law should be pursued under the guidance of the Inclusive Prudence Principle, clarifying the pathways and frameworks for applying antitrust regulations to the GAI industry to foster its healthy growth [21]. From an international standpoint, cutting-edge GAI technologies have emerged as a new battleground for global competition. The United States, China's primary rival in this domain, prioritizes building first-mover technological advantages and maintaining hegemony by promoting innovation-centric policies. It relies predominantly on non-binding guidelines, market-driven regulatory approaches, and ex post responses such as corporate self-regulation, public oversight, and judicial or administrative interventions. Similarly, Japan adopts a technology-first regulatory philosophy, emphasizing non-mandatory guidelines, industry self-discipline, and ethical norms as part of a soft law governance model. Given pivotal role in the international GAI arena, overly stringent governance measures risk stifling technological research and development and societal adoption. It is crucial to emphasize that the Inclusive Prudence Principle does not entail diluted regulatory rigor. Rather, it seeks to institutionalize a dynamic equilibrium between technological innovation incentives and market order maintenance, ultimately cultivating a competitive ecosystem where innovation and market stability coalesce.

5.2. Risk Prevention and Control Principle

The Risk Prevention and Control Principle refers to a governance approach grounded in the Holistic National Security Perspective, which establishes bottom-line and worst-case scenario thinking. Through ex ante intervention mechanisms, it proactively identifies, assesses, and mitigates systemic and overarching risks potentially triggered by GAI technologies. Security and stability serve as critical safeguards for advancing high-quality development and are essential metrics for evaluating its success. Systemic and framework-oriented laws and regulations governing the effective, scalable, secure, and controllable utilization of GAI must be developed and refined from the vantage point of national security [22]. Consequently, it is imperative to reinforce bottom-line and worst-case scenario thinking, constructing a regulatory framework centered on ex ante intervention. This framework should prioritize addressing structural monopoly risks posed by dominant enterprises, effectively preventing and resolving systemic risks arising from the large-scale application of GAI, and overcoming the shortcomings of reliance on ex post penalties. By shifting from passive defense to proactive evolution, systemic crises can be resolved at their source.

Drawing on prior governance experiences with leading large-scale platform enterprises, these principal advocates establishing ex ante intervention mechanisms and implementing targeted preemptive supervision. For dominant firms that control core technological resources and exhibit strong monopolistic inclinations, regulators should closely monitor their developmental trajectories during the technology's nascent stages and conduct preemptive investigations. By collecting and analyzing transactional behaviors and technological measures of these enterprises, authorities can forecast their future conduct trends. Should monopolistic intent or actions be detected, timely measures—such as stringent monitoring, evidence preservation, formal warnings, or administrative interviews—must be enacted. Simultaneously, the government can organize forums for corporate leaders to actively encourage and steer dominant enterprises toward aligning their development trajectories with societal public interests. This ensures that technological innovation progresses in tandem with the fulfillment of social responsibilities.

6. Specific Measures for Governing Structural Monopolies in Generative Artificial Intelligence

Building upon the foundational principles, it is essential to integrate the formation mechanisms of structural monopolies and adopt a dual horizontal-vertical perspective. This approach must target the three core horizontal elements—data, computing power, and algorithms—and the vertical logic of market penetration to address practical challenges in regulating structural monopolies within GAI at the operational level.

6.1. Refining Data Sharing Incentive Mechanisms

Improving data sharing incentives is critical for dismantling data silos, promoting the effective utilization of high-quality data resources, and providing robust support for core technological advancements. As a foundational resource for GAI, data is pivotal to achieving breakthroughs in technological research and development, while data barriers constitute a fundamental driver of horizontal structural monopolies.

On one hand, policies should incentivize enterprises to share data in compliance with legal frameworks. A significant portion of core high-quality data is concentrated in dominant firms, creating data silos that restrict market entry. To prevent monopolistic markets stemming from data barriers and advance the sustainable development of GAI sector, policies must be designed to systematically encourage data openness. For instance, China's Data Elements × Three-Year Action Plan (2024–2026), released on December 31, 2023, emphasizes guiding enterprises to open data, encouraging market-driven exploration of commercial data value, and supporting innovative applications through societal data integration. The plan also calls for enhanced public data openness and utilization, optimized data governance, and strengthened public-private collaboration to maximize the development and application of data resources.

On the other hand, efforts must intensify to elevate the accessibility and utility of public data. Government agencies and public institutions possess vast, high-quality datasets spanning demographics, finance, healthcare, and other domains. These authoritative and comprehensive public datasets are vital for enabling GAI technologies to excel in specialized fields. Thus, we should progressively explore market-oriented mechanisms such as public data authorization or licensed development. Under the premise of safeguarding national security and personal privacy, priority should be given to opening high-quality data closely tied to public interests and technological innovation, ensuring that public data openness gradually evolves into a key engine for driving technological advancement within a secure framework. For example, in the healthcare sector, the scarcity of high-quality medical data and the lack of interoperability between hospital systems have emerged as critical bottlenecks for deploying GAI applications. Addressing these challenges through structured data sharing frameworks could unlock transformative potential in medical innovation and service delivery [23].

6.2. Optimizing the Computing Power Sharing Service Network

Optimizing the computing power sharing service network can effectively alleviate computational bottlenecks faced by small and medium-sized innovative enterprises, enhance the efficiency of existing computing resource utilization, and drive the high-quality development of GAI technologies through the high-quality advancement of computing power. Currently, China is progressively advancing the systematic construction of its computing power sharing service network. On January 3, 2025, China launched the world's first photoelectric-integrated deterministic computing network infrastructure, a milestone that lays a solid foundation for transitioning from technological breakthroughs to industrial leadership in next-generation network infrastructure and ultimately achieving global preeminence. On January 14, the China Quality Certification Center announced the inauguration of evaluation services for computing power and efficiency in data centers.

To further universalize the empowerment of computing power sharing service network and enable more efficient resource sharing across broader domains, it is imperative to clarify the legal attributes of computing power and refine the legal mechanisms governing computing power property rights. For scarce resources, a proven method to enhance utilization efficiency is to formalize them as rights [24]. Once computing power is propertied, it acquires distinct property attributes, enabling safer and more convenient transactions. Innovations such as securitization and fractionalization of computing power can enhance market liquidity and optimize the utilization efficiency of these resources. China has already seen practical advancements in computing power trading. For example, the Guiyang Big Data Exchange introduced a listed trading system for computing power resources, while the Yangtze River Delta Computing Power Interconnection Platform established a multi-tiered service architecture. These initiatives validate the feasibility of market-driven allocation of computing power resources. However, the corresponding legal mechanisms and policy frameworks for computing power transactions remain underdeveloped. Key issues include ambiguous legal definitions of computing power rights and the absence of standardized pricing mechanisms.

Therefore, legislation must provide clear and robust legal foundations for computing power resource sharing. This includes defining the rights and obligations of stakeholders, regulating transaction mechanisms, and constructing a computing power sharing service network that balances market vitality with systemic risk mitigation. Such measures will ensure the network not only invigorates the computing power market but also safeguards against transactional risks, fostering a sustainable ecosystem for GAI innovation.

6.3. Building an Open-Source Algorithm Innovation Ecosystem

Constructing an open-source innovation ecosystem facilitates resource aggregation and collaborative innovation, dismantling algorithmic monopolistic closed loops to establish a virtuous cycle of "technology sharing–ecosystem prosperity–innovation reinforcement." From the intrinsic nature of artificial intelligence (AI) technologies, open-source practices align more closely with AI's technical essence. Existing consensus holds that AI and open-source principles exhibit strong synergies [25]. China has introduced numerous policies to advance the development of open-source innovation ecosystems. The 2017 Next-Generation Artificial Intelligence Development Plan enshrined "openness and collaboration" as a foundational principle. The 2023 Global AI Governance Initiative further emphasized the importance of open-source cooperation, while the 2024 National Next-Generation AI Standardization System Construction Guidelines explicitly called for the formulation of safety standards for AI open-source frameworks. Scholars note that GAI sector harbors immense untapped innovative potential. Faced with unprecedented opportunities brought by open-source paradigms, the nation must seize these prospects while ensuring effective risk management and actively championing the development of open-source AI models [26].

Recently, DeepSeek has implemented a series of open-source initiatives, which not only contribute to fostering a healthy AI industrial ecosystem but also enhance the societal efficiency of generative AI productivity, creating new opportunities and growth avenues for related industries. Therefore, it is imperative to steadfastly adopt an open and inclusive stance by positioning open-source practices as a critical engine for advancing GAI innovation, while intensifying efforts to construct shared platforms for open-source innovation ecosystems. Concurrently, safety standards and operational guidelines specific to GAI open-source initiatives must be established to ensure secure and efficient algorithmic openness.

7. Conclusion

GAI is a foundational and cutting-edge technology spearheading the new wave of scientific revolution and industrial transformation. It has successfully integrated into global political, economic, cultural, and military domains, unlocking unprecedented developmental opportunities and emerging as a vital engine for cultivating new quality productive forces. GAI is reshaping the global industrial landscape at an unprecedented pace. While unleashing innovative potential, it also catalyzes structural monopoly risks arising from the conversion of technological advantages into technological power. the core challenge of structural monopoly lies in dominant enterprises constructing self-reinforcing mechanisms through the horizontal hyper-concentration of technological and capital elements (e.g., data, computing power, algorithms) and vertical deep penetration across the technological, application, and terminal layers. This entrenches their market dominance into a rigid, self-perpetuating trajectory. To prevent and resolve structural monopoly risks, a balanced framework must be established to harmonize innovation incentives with competition order. Guided by the Inclusive Prudence Principle and the Risk Prevention and Control Principle, this framework should prioritize open-sharing mechanisms for foundational technological resources such as data, algorithms, and computing power. By integrating global governance experiences, antitrust regulatory strategies better suited to GAI's early developmental stage can be explored. Through proactive and effective antitrust oversight, the innovative vitality of the GAI sector can be unleashed, fostering a fair and competitive market environment for technological advancements. This approach will propel the high-quality development of GAI technologies, enabling them to navigate the waves of global competition with stability and long-term vision.

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