Divergent Pathways of Artificial Intelligence Adoption in E-Commerce: A Multidimensional Comparative Analysis of China, the United States, and the European Union

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Abstract: The transformative impact of Artificial Intelligence (AI) on global e-commerce is shaped by profound regional disparities, yet comparative analyses remain limited. This study introduces a novel Technology-Economics-Society-Regulation (TESR) framework to systematically compare AI adoption pathways in e-commerce across China, the United States, and the European Union. Through a systematic literature review following PRISMA guidelines, analyzing 142 peer-reviewed studies from 2018–2023, we identify distinct regional paradigms. China's platform-centric model leverages integrated ecosystems and vast data scale for operational efficiency and immersive engagement. The United States pursues a market-driven approach, emphasizing Software-as-a-Service solutions and personalization for competitive advantage. The European Union prioritizes a rights-based governance model, focusing on privacy, explainability, and ethical compliance. These divergent trajectories, driven by interdependent technological, economic, socio-cultural, and regulatory dynamics, challenge assumptions of global convergence in AI adoption. This research bridges a critical gap by providing a structured comparative framework, offering actionable insights for policymakers, practitioners, and researchers navigating the heterogeneous evolution of AI-powered e-commerce.
Keywords: Artificial Intelligence; E-Commerce; Comparative Analysis; TESR Framework; China; United States; European Union; Technology Adoption; Regulatory Policy
Published: Oct 12, 2025
DOI: https://doi.org/10.62177/apemr.v2i5.653

1.Introduction

The global e-commerce sector is undergoing a profound transformation, driven by algorithms and powered by Artificial Intelligence (AI). Technologies such as personalized recommendation systems, conversational chatbots, computer vision-enabled search, and predictive logistics are fundamentally reshaping how goods are discovered, purchased, and delivered [1,2]. This technological integration promises unprecedented efficiency, customer satisfaction, and economic growth, heralding a new era of intelligent commerce. By 2025, the global AI in e-commerce market is projected to exceed \$16 billion, with a compound annual growth rate surpassing 40% from 2023 to 2030 [3].

However, the notion of AI as a homogenizing global force is increasingly recognized as inadequate. Closer examination reveals significant variations in how AI is developed, deployed, and governed across different national and regional contexts. China, the United States, and the European Union represent three of the world's largest and most influential e-commerce

markets, each characterized by distinct digital ecosystems, economic philosophies, cultural norms, and regulatory landscapes [4]. For instance, the pervasive, platform-driven AI integration in Chinese "super-apps" like Alibaba's Taobao and JD. com, which command over 80% of the domestic market share [5], contrasts with the decentralized, enterprise software-centric adoption pattern prevalent in the United States. This pattern, in turn, differs markedly from the cautiously innovative approach emerging in the European Union, influenced by stringent data protection laws such as the General Data Protection Regulation (GDPR), which has imposed fines exceeding €3 billion since its implementation [6].

Despite extensive literature documenting AI applications within each market, a significant research gap persists: the absence of a systematic, multidimensional comparative analysis that transcends siloed case studies. Existing reviews often focus solely on technological capabilities, neglecting the intricate interplay of technology, economic models, social structures, and regulatory frameworks that shape AI empowerment trajectories [7].

This study aims to address this gap by exploring the following primary research question: How do the pathways of AI empowerment in e-commerce differ among China, the United States, and the European Union, and what factors explain these divergences?

To answer this, we conducted a systematic literature review and proposed an original analytical framework based on four core dimensions: technological (comparing the focus and integration depth of AI applications), economic (analyzing differing business models and value creation paradigms), socio-cultural (examining varying consumer behaviors and trust levels), and regulatory (contrasting governmental policy approaches).

The contribution of this paper is threefold. First, it synthesizes disparate knowledge into a coherent comparative structure, addressing a critical literature gap. Second, it introduces and validates a novel Technology-Economics-Society-Regulation (TESR) framework for analyzing cross-contextual technology adoption, applicable beyond e-commerce. Third, it provides evidence-based insights into the future trajectory of global e-commerce, suggesting a trend toward divergent regional paradigms rather than a unified global model, with significant implications for strategy and policy.

The paper is structured as follows: Section 2 details the methodology of the systematic literature review. Section 3 presents the findings through the four-dimensional framework. Section 4 discusses the implications of these divergent pathways, and Section 5 concludes with limitations and directions for future research.

2.Methodology: A Systematic Review Approach

This study adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure a comprehensive, transparent, and reproducible literature search and selection process [8].

2.1 Literature Search Strategy

A systematic search was conducted across four electronic databases: Web of Science Core Collection, Scopus, IEEE Xplore, and China National Knowledge Infrastructure (CNKI). The search strategy targeted literature published between January 2018 and December 2023. The search string combined keywords related to: (1) Artificial Intelligence (e.g., "AI," "machine learning," "deep learning," "natural language processing," "computer vision"), (2) e-commerce (e.g., "e-commerce," "online retail," "digital commerce"), and (3) specific regions (e.g., "China," "United States," "European Union"). Boolean and proximity operators were tailored to each database's syntax.

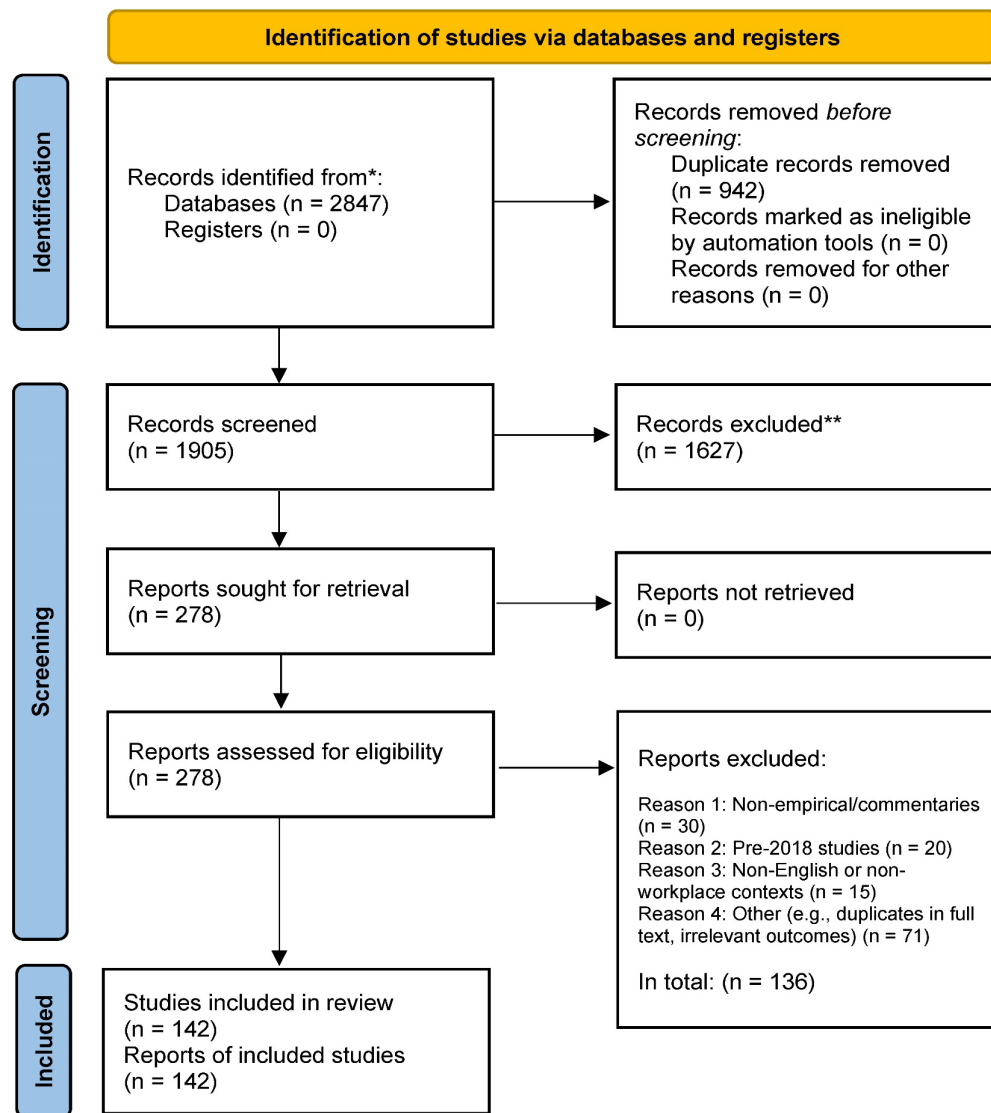## 2.2 Study Selection and Eligibility Criteria

The initial search yielded 2,847 records. After removing duplicates, 1,905 titles and abstracts were screened against predefined eligibility criteria. Inclusion criteria encompassed:

(a) empirical studies, conceptual papers, or review articles;

(b) focus on AI applications in e-commerce;

(c) explicit analysis of China, the United States, or the European Union;

(d) publication in English or Chinese in peer-reviewed journals or conference proceedings.

Exclusion criteria included: (a) papers focused solely on AI technical development without e-commerce application; (b) papers lacking a clear regional focus; (c) editorials, prefaces, or short commentaries without original analysis; and (d) papers not accessible in full text.

Following initial screening, 278 full-text articles were assessed for eligibility, resulting in a final corpus of 142 studies for in-depth analysis. The selection process is summarized in Figure 1.

Figure 1. PRISMA Flow Diagram of Literature Selection Process

Identification of studies via databases and registers

Identification

Records identified from*:
Databases (n = 2847)
Registers (n = 0)

Records removed *before screening*:
Duplicate records removed (n = 942)
Records marked as ineligible by automation tools (n = 0)
Records removed for other reasons (n = 0)

Screening

Records screened (n = 1905)

Records excluded** (n = 1627)

Reports sought for retrieval (n = 278)

Reports not retrieved (n = 0)

Reports assessed for eligibility (n = 278)

Reports excluded:

Reason 1: Non-empirical/commentaries (n = 30)
Reason 2: Pre-2018 studies (n = 20)
Reason 3: Non-English or non-workplace contexts (n = 15)
Reason 4: Other (e.g., duplicates in full text, irrelevant outcomes) (n = 71)

In total: (n = 136)

Included

Studies included in review (n = 142)
Reports of included studies (n = 142)

2.3 Data Extraction and Analytical Framework

Data from included studies were extracted into a standardized matrix, capturing author(s), publication year, region of focus, AI technology, e-commerce function, key findings, and challenges.

The data were analyzed using a multidimensional comparative framework, categorizing findings into four dimensions: technological (AI application types, e.g., recommendation systems, computer vision, NLP/chatbots, logistics, dynamic pricing); economic (business models, market concentration, investment patterns, key performance indicators like conversion rates); socio-cultural (consumer acceptance, trust, privacy concerns, societal impacts); and regulatory (data protection laws, AI ethics guidelines, platform governance). This framework enabled structured within-region and cross-region thematic analysis, identifying patterns, convergences, and divergences in AI empowerment pathways.

The analytical process was guided by a conceptual model expressing aggregate AI empowerment (AAE) for a region as a function of its scores across the four dimensions:

$$AAEr = f\ (Tech\_r, Econ\_r, Soc\_r, Reg\_r)$$

This qualitative model underscores the combined effect of dimensions on empowerment pathways. Figure 2 visually depicts how these dimensions interact to shape regional AI adoption.

Figure 2. The Technology-Economics-Society-Regulation (TESR) Analytical Framework
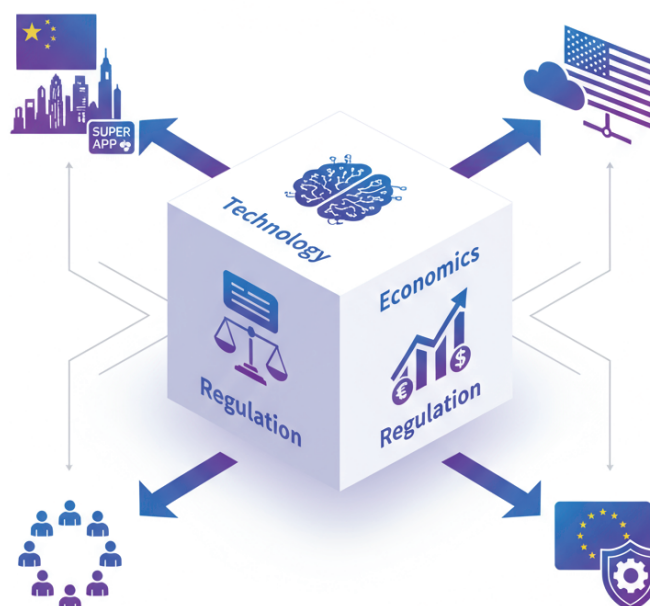
3.Findings

This systematic analysis reveals distinct divergences in AI empowerment in e-commerce across China, the United States, and the European Union, best understood through the Technology-Economics-Society-Regulation (TESR) framework. Each dimension's unique configuration forms self-reinforcing systems, culminating in fundamentally different pathways.

3.1 Technological Dimension: Divergent Integration Patterns

AI applications are advanced across all three regions, yet their architectural philosophies and primary focuses differ, reflecting contextual drivers.

In China, e-commerce is characterized by deeply embedded, platform-centric AI integration. Leveraging vast, multi-modal data streams—spanning social interactions, payment behaviors, and location data—within "super-app" ecosystems creates immersive user experiences. AI serves as the core operational engine for platforms like Alibaba's Taobao and JD.com. For instance, recommendation algorithms integrated with live-streaming features enable seamless product discovery and purchase conversion, contributing to China's live-streaming e-commerce market reaching $480 billion in 2023, accounting for approximately 20% of online retail sales [9]. Computer vision applications, such as augmented reality for virtual try-ons in cosmetics and apparel, reduce return rates by 25–40% and increase conversion rates by 15–30% [10]. This end-to-end control optimizes the entire value chain, exemplified by AI-driven logistics networks that dynamically reroute packages based on real-time conditions.

The United States exhibits a specialized, disaggregated Software-as-a-Service (SaaS) model. While tech giants like Amazon develop proprietary AI systems, the defining feature is specialized B2B providers offering cloud-based solutions, creating a "best-of-breed" landscape where retailers assemble customized tech stacks. SaaS penetration in e-commerce grew from 35% in 2018 to 68% in 2023 among medium and large retailers [11]. This ecosystem drives innovation in hyper-personalized recommendation engines using advanced neural networks for precise consumer preference prediction. The focus is on scalable solutions delivering measurable return on investment, particularly through enhanced customer acquisition and retention. Venture capital investment in AI-enabled retail technologies reached $12.3 billion in 2022 [12].

The European Union's technological trajectory prioritizes pragmatic, compliance-oriented approaches, emphasizing explainability, transparency, and privacy preservation. Significant efforts focus on Explainable AI (XAI) methodologies aligned with GDPR's right to explanation, such as counterfactual explanations for automated decisions [13]. Linguistic and cultural diversity drives innovation in multilingual AI solutions for cross-border complexities. Applications emphasize supply chain optimization and customer service automation, prioritizing reliability over immersive engagement. The Digital Europe Programme allocated over €2.1 billion for ethical and trustworthy AI development in 2022 [14].

Table 1: Technological Dimension Comparison

Feature	China	United States	European Union
Primary Driver	Ecosystem Integration & Data Scale	Innovation & Market Competition	Efficiency & Regulatory Compliance
Key Strength	Computer Vision, Integrated Recommenders	Foundational Models, SaaS Solutions	Supply Chain Logistics, XAI
Integration Model	Vertical, Platform-Centric	Horizontal, SaaS-Centric	Fragmented, Enterprise-Centric
Data Utilization	Holistic, Multi-modal	Targeted, Behavioral	Segmented, Privacy-conscious
Innovation Focus	Immersive Engagement	Personalization Accuracy	Explainability & Transparency

3.2 Economic Dimension: Contrasting Value Creation Models

Economic structures and incentives shape distinct value creation logics and business models across the regions.

China's model is dominated by vertically integrated platforms using AI as a competitive moat. These platforms create self-reinforcing ecosystem flywheels, where superior AI attracts users and merchants, generating diverse data to refine systems. The focus is on maximizing user engagement and Gross Merchandise Volume (GMV) within walled gardens, monetized through internal advertising, transaction fees, and cloud services. Alibaba invested $6.8 billion in AI research in 2022 [15], driving market concentration with the top three platforms controlling over 78% of e-commerce market share [5]. Small and medium enterprises (SMEs) participate as merchants within these platforms, aligning AI development with platform goals.

The United States features a hybrid model combining platform dominance with independent AI solutions. Specialized AI vendors offer subscription-based SaaS, enabling retailers to access sophisticated capabilities without large upfront costs, though creating third-party dependency. The economic focus is on measurable return on investment, emphasizing Customer Lifetime Value (CLV) and customer acquisition cost (CAC). Venture capital investment reached $12.3 billion in AI retail technologies in 2022 [12]. This competitive landscape drives innovation but results in fragmentation, as retailers integrate multiple solutions.

The European Union's economic structure, marked by numerous SMEs and strong antitrust enforcement, emphasizes operational efficiency within the Digital Single Market. AI optimizes cross-border logistics, inventory management, and multilingual tools, enabling smaller retailers to compete. Venture funding for AI retail technologies was €3.2 billion in 2022, supplemented by €4.7 billion in public funds from the Digital Europe Programme for SME-focused AI [14]. The Digital Markets Act discourages market concentration, promoting a distributed model where AI serves as an equalizing tool.

Table 2: Economic Dimension Comparison

Feature	China	United States	European Union
Dominant Model	Integrated Platform Economy	Hybrid (Platform + SaaS)	SME & Efficiency-Led
Investment Driver	Strategic Ecosystem Control	Venture Capital & ROI	Operational Efficiency & Grants
Key Metric	GMV, Engagement	CLV, CAC	Cost Savings, Cross-Border Efficiency
SME Role	Merchants within Platforms	Customers of SaaS Solutions	Primary Beneficiaries
Market Concentration	High (Top 3: 78%+)	Moderate (Top 3: 55%)	Low (Top 3: 42%)

3.3 Socio-Cultural Dimension: Varieties of Trust and Acceptance

Consumer attitudes and societal values create distinct cultural contexts, influencing AI deployment and forming feedback loops.

Chinese consumers exhibit utilitarian trust, prioritizing AI-powered convenience over privacy concerns. Research shows 68% are willing to share personal data for personalized experiences, compared to 42% in the United States and 28% in Germany

[16]. Social commerce and group buying, facilitated by AI, are cultural differentiators, with live-stream shopping generating $480 billion in 2023 [9]. AI-powered payment platforms like Alipay and WeChat Pay are used by 92% of mobile internet users [5]. Privacy concerns, though present, are secondary to hyper-convenience and engagement. American consumers show conditional, individualistic acceptance, expecting personalized experiences while remaining skeptical of data practices. Studies indicate 65% appreciate AI recommendations but express concerns about algorithmic bias and data misuse [11]. The Federal Trade Commission reported a 300% increase in algorithmic decision-making complaints from 2019 to 2023 [17]. This drives demand for transparency and ethical AI, with 45% of major retailers publishing AI ethics statements by 2023, up from 12% in 2018 [12]. European consumers adopt a rights-based cautious approach, viewing privacy and autonomy as fundamental. Research shows 72% are uncomfortable with AI-driven decisions without human oversight [14], and 64% seek information on data usage, compared to 38% in the United States and 29% in China [18]. Trust is earned through compliance and transparency, with 57% willing to switch platforms for better privacy protections [19].

Table 3: Socio-Cultural Dimension Comparison

Feature	China	United States	European Union
Consumer Priority	Convenience & Social Engagement	Personalization & Choice	Privacy & Rights
Attitude to Data	Generally Accepting	Ambivalent & Conditional	Cautious & Rights-Based
Key Catalyst	Social Commerce & Mobile Payments	Expectation of Customization	Value-Driven Digital Citizenship
Primary Concern	Service Quality	Bias & Manipulation	Surveillance & Autonomy
Trust Mechanism	Utilitarian Exchange	Conditional Value Delivery	Rights Protection

3.4 Regulatory Dimension: Governance Paradigms and Their Consequences

The regulatory environment significantly shapes AI empowerment pathways.

China's state-led strategic governance aligns AI with national economic objectives. The Personal Information Protection Law (PIPL) of 2021 balances data protection with technological sovereignty [20]. The "China Standards 2035" initiative aims to shape global AI standards [20]. This "guided innovation" allows rapid commercial AI scaling within strict data and content parameters. The United States employs a sectoral, pro-innovation approach with decentralized regulation. The absence of comprehensive federal AI legislation results in state-level and sector-specific rules. The Federal Trade Commission addressed AI-related harms with 23 enforcement actions from 2020 to 2023 [17]. By 2023, 12 states enacted consumer privacy laws and seven implemented AI regulations [21]. The European Union's precautionary, rights-based approach prioritizes fundamental rights. The GDPR (2018) and AI Act (2024) establish global benchmarks, with the latter introducing risk-based AI regulation [22]. This "Brussels Effect" influences global standards [6], driving focus on explainable, privacy-preserving AI.

Table 4: Regulatory Dimension Comparison

Feature	China	United States	European Union
Philosophy	State-Led Strategic Governance	Pro-Innovation, Sectoral Approach	Precautionary, Rights-Based
Key Legislation	Personal Information Protection Law (PIPL)	Sectoral Laws (FTC Act, State Laws)	GDPR, AI Act
Primary Goal	National Sovereignty, Social Stability	Market Competition, Innovation	Protection of Fundamental Rights
Enforcement Approach	Strategic, Adaptive	Reactive, Case-by-Case	Systematic, Risk-Based
Global Influence	Domestic Market Control	Corporate Power	Brussels Effect (Standard Setting)

In summary, systematic differences in AI empowerment pathways are evident. Figure 3 visualizes these through radar charts, highlighting distinct regional priorities.

Figure 3. Radar Chart Comparison of Key Metrics Across the TESR Dimensions
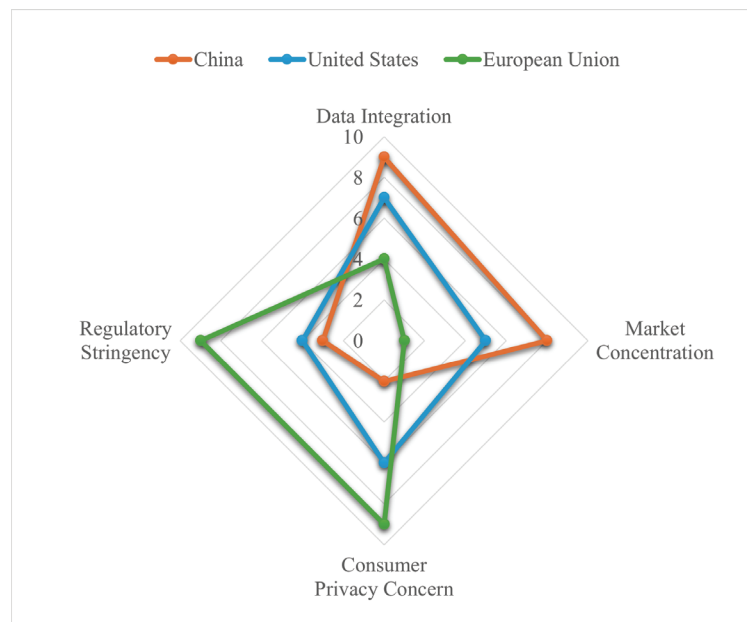

4.Discussion

The TESR framework reveals that AI empowerment in e-commerce follows divergent pathways shaped by the interplay of technological, economic, socio-cultural, and regulatory dimensions. These elements form self-reinforcing systems, creating distinct regional paradigms.

4.1 The Interdependent Nature of the Four Dimensions

The key insight is the interdependence of the TESR dimensions, resisting technological determinism and creating coherent regional patterns. As shown in the previous analysis, the four dimensions do not exist in isolation, but constitute a self-consistent complex feedback system, ultimately driving China, the United States, and Europe towards completely different development paths. Figure 4 reveals the mechanism of path differentiation caused by differences in initial institutional environments.

Figure 4. Schematic Diagram of Divergent AI Empowerment Pathways Driven by Institutional Context
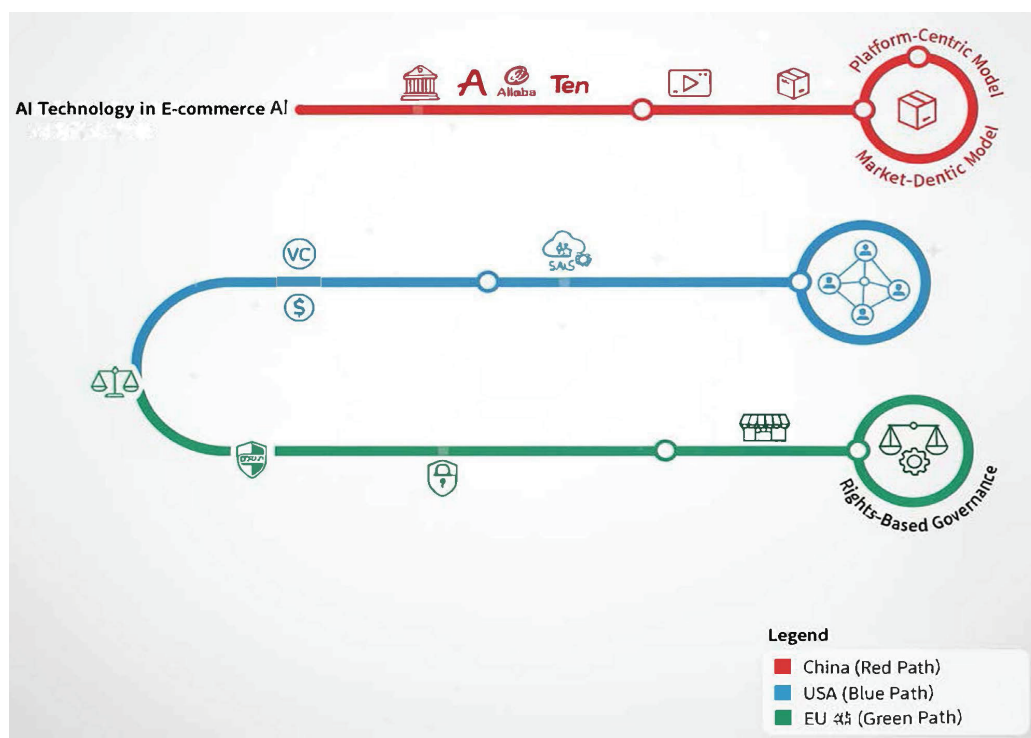
In China, strategic regulation fosters large platforms, shaping economic structures around ecosystem control. These platforms leverage comprehensive data for integrated AI, delivering convenience valued by consumers, reinforcing social acceptance and creating a "platform-dominated AI integration" paradigm [15,20].

In the United States, a pro-innovation regulatory approach enables platform growth and independent AI solutions, driving economic structures focused on personalization and efficiency. These meet consumer demands for customization while addressing privacy concerns, forming a "market-driven AI innovation" system [11,17].

In the European Union, socio-cultural emphasis on rights shapes precautionary regulation, prioritizing explainable, transparent AI. This supports economic structures empowering SMEs, creating a "rights-based AI governance" paradigm [14,22].

4.2 Theoretical and Practical Implications

The findings have significant implications for both theoretical understanding and practical application in AI and e-commerce. Theoretically, the development and validation of the TESR framework offer a nuanced approach to understanding technology adoption, surpassing existing models like the Technology-Organization-Environment (TOE) framework. The TESR framework provides greater granularity by examining how economic, socio-cultural, and regulatory dimensions interact with technological capabilities, explaining why similar technologies yield different outcomes across contexts [11,15]. This framework is adaptable for analyzing technology adoption in diverse institutional environments beyond e-commerce.

Practically, the analysis underscores the need for region-specific strategies for multinational enterprises. Success in China requires integration with platform ecosystems, while effectiveness in the United States demands participation in the SaaS market, and operations in the European Union necessitate compliance with rights-based regulations [5,14,22]. For policymakers, the study highlights trade-offs in regulatory approaches, influencing innovation, market structures, and social outcomes [17,20,22]. For researchers, it identifies avenues for further investigation, particularly the long-term impacts of divergent pathways on competition, innovation, and consumer welfare.

4.3 Limitations and Future Research Directions

This study provides a comprehensive analysis but has limitations. The rapid evolution of AI, particularly generative AI, may challenge identified patterns. The focus on three major economic blocs excludes emerging economies in Southeast Asia, Africa, and Latin America, which may exhibit unique AI adoption trajectories. Reliance on published literature introduces potential biases, as proprietary AI systems within private corporations are often undisclosed.

Future research should address these limitations. Investigating how generative AI and large language models reshape regional patterns could reveal whether they drive convergence or reinforce divergence. Longitudinal studies are needed to assess socioeconomic impacts on market competition, consumer welfare, labor markets, and technological sovereignty. Applying the TESR framework to regions like Southeast Asia, India, and Latin America could evaluate its generalizability. Sector-specific analyses in industries such as fashion, groceries, and digital services would clarify how these pathways manifest. Finally, policy effectiveness analyses could compare the EU's comprehensive framework, the United States' sectoral model, and China's strategic governance to evaluate unintended consequences [17,20,22].

5.Conclusion

This systematic review synthesizes 142 studies to demonstrate that AI adoption in e-commerce follows divergent pathways across China, the United States, and the European Union. These divergences reflect systemic variations in economic structures, societal values, and regulatory philosophies, necessitating a contextualized understanding beyond a purely technological lens.

The novel Technology-Economics-Society-Regulation (TESR) framework provides a comprehensive tool for analyzing these pathways, identifying three paradigms: China's platform-centric model, emphasizing integration and ecosystem control; the United States' market-driven model, focusing on innovation and personalization; and the European Union's rights-based model, prioritizing ethical governance and fundamental rights [5,11,14,15,22]. These paradigms form self-reinforcing systems where technological, economic, socio-cultural, and regulatory dimensions interact.

A key finding is the absence of convergence toward a universal AI adoption model. Instead, evidence suggests deepening divergence, with each region developing AI applications that reinforce institutional characteristics, challenging technological

determinist perspectives [4,6]. This has significant implications for stakeholders. Multinational enterprises must adopt region-specific strategies, policymakers can learn from comparative regulatory impacts, and researchers gain a structured framework for further exploration.

Limitations include the rapid pace of AI development, particularly generative AI, which may alter patterns, and the focus on three regions, excluding emerging economies. Reliance on published literature may introduce biases regarding proprietary systems. Despite these, the TESR framework and empirical insights advance theoretical and practical understanding of AI's

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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