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The Concept of Stablecoins and Their Future Prospects

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Abstract: Based on the author's study and research in the virtual currency course at Columbia University's Pre-College Summer Program, combined with discussions with American virtual currency experts, this paper systematically analyzes the definition, operating mechanisms, types, regulatory policies, application scenarios, potential risks, future development, and relationship with the US dollar of stablecoins. The article uses ten core questions as the main thread, comprehensively exploring the position and prospects of stablecoins in the global digital financial landscape, aiming to provide readers with a panoramic understanding from concept to trend.

Keywords: Stablecoin; Digital dollar; Blockchain; Stablecoin types; Genius Act; Cross-border payment; DeFi

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1. Introduction

From July to August 2025, the author participated in the virtual currency course of the Columbia University Summer School program, conducting three weeks of study and research, and engaging in multiple discussions with renowned American virtual currency expert professors, including Prof. Lindsley Medlin. During the course, we discussed the components that make up blockchain and the future of Bitcoin and AI politically and economically. Before the course ended, President Trump signed the "Guiding and Establishing National Innovation for U.S. Stablecoins Act" (commonly known as the "Genius Act")^[1], a landmark piece of legislation with far-reaching impact on the U.S. stablecoin industry.

- (1) What exactly are stablecoins? Why are they called digital dollars? How do they differ from Bitcoin?
- (2) How do they maintain stability? How is the 'dollar peg' achieved? Who guarantees instant cash redemption?
- (3) What are the different types of stablecoins? Which is the most reliable?
- (4) Why are industry giants rushing to issue stablecoins? What is their profit model?

- (5) Under the strictest regulation, can they still maintain high profits?
- (6) Beyond cryptocurrency speculation, what real-world applications do stablecoins have?
- (7) Why have national regulatory attitudes shifted so abruptly?
- (8) Are stablecoins truly safe? Have the risks been completely eliminated?
- (9) Who might emerge as the ultimate winner?
- (10) Will stablecoins replace the US dollar?

2. What exactly is a stablecoin? Why is it called the digital dollar? How does it differ from Bitcoin?

Recently, the global attitude toward stablecoins has shifted almost overnight. Just a few years ago, they were dismissed as a “crypto toy,” a money-laundering tool, and even directly targeted by regulators around the world. Now, the U.S. Congress has passed the Genius Act, bringing stablecoins under the federal regulatory framework—requiring licensing, reserves, and disclosures, with a compliance regime even stricter than that for small banks.

Almost simultaneously, Hong Kong released its Stablecoin Regulatory Ordinance, launched a regulatory sandbox, and prepared to roll out Hong Kong dollar and offshore RMB stablecoins. Singapore, the European Union, Japan, and the Republic of Korea are all rushing to legislate; even Dubai and Abu Dhabi are actively promoting them. Perhaps most surprising, the People’s Bank of China—historically one of the most hardline opponents—has recently discussed the possibility of domestic stablecoin pilots at official meetings ^[2,3].

This is quite a reversal of public perception. What was once widely regarded as an illicit crypto activity is now becoming the new darling of financial reform. It is not just governments—financial and tech giants are piling in as well. Circle (issuer of USDC) successfully went public, with its stock price soaring 750% in a single month. JPMorgan Chase, Citibank, Goldman Sachs, and Bank of America are all moving into stablecoin operations. Even Chinese firms like JD.com, Ant Group, and Xiaomi have registered stablecoin-related companies in Hong Kong.

Naturally, we must ask: What exactly is a stablecoin, and why are countries so eager to embrace it? Is this truly a technological revolution, or just another round of profit-seeking hype?

Let’s start from the simplest point—why is it called a “stable” coin? Its primary selling point is stability. In contrast, what is Bitcoin most famous for? Extreme price volatility. Yesterday it might have been USD 80,000, today USD 100,000, and tomorrow perhaps USD 120,000. Traders may enjoy such roller-coaster movements, but if you want to use it to buy something as mundane as a cup of coffee, that volatility becomes a problem. Imagine you buy a coffee in the morning for 0.001 BTC (worth USD 30 at the time), only to find by afternoon that the same amount of Bitcoin is worth USD 100. Either the buyer or the seller ends up feeling shortchanged—hardly ideal for everyday payments.

Thus, while Bitcoin can function like a stock for investment and speculation, it is ill-suited for daily transactions. The question then arises: Could there be a digital currency that operates on a blockchain, remains outside traditional regulatory bottlenecks, enables fast global transfers, yet has a stable value pegged to the U.S. dollar?

The answer gave birth to stablecoins. In one sentence: a stablecoin is the digital dollar of the blockchain world. Like Bitcoin, it can be transferred across borders and run on decentralized networks, but unlike Bitcoin, its value is pegged—usually at 1 USD—so you can confidently use it for payments, trading, and settlement.

3. Why can stablecoins remain stable? How does the dollar peg work? Who guarantees cash redemption?

The answer can be summed up in one word: peg.

What does that mean? The issuer makes you a promise—one stablecoin equals one U.S. dollar. When you give the issuer one dollar, they issue you one stablecoin. When you return the stablecoin, they destroy (burn) it and give you back one dollar.

This logic is somewhat like topping up Q Coins for Tencent’s online games—except this time, the “Q Coin” is not a virtual token limited to in-game purchases. Instead, it is a globally accepted, price-stable digital dollar that circulates on a decentralized blockchain network, theoretically usable by anyone, anywhere, at any time.

Sounds ideal, right? But here comes the critical question:

Who ensures that this promise is real?

Who guarantees that when you redeem your stablecoin, you will actually get back one U.S. dollar?

This is the core existential question of the stablecoin system. If that promise is broken, the stablecoin’s value could collapse instantly.

In theory, the issuer must hold assets of equivalent value to the total outstanding stablecoins—such as U.S. dollars in bank accounts or short-term U.S. Treasury bills—stored in a regulated bank or trust, ensuring full and immediate redemption at any time.

However, in practice, not all stablecoins use the same method to maintain their peg, and this is why their risk profiles vary significantly. Some rely on real dollar reserves to directly back their coins. Others use cryptocurrency collateral to indirectly stabilize prices. Still others depend solely on algorithmic mechanisms to adjust supply and demand in an attempt to maintain stability.

These three methods form the three major collateral models of stablecoins, and they directly determine each coin’s stability and security. In the following sections, we will analyze each mechanism in detail—its operating logic, advantages, disadvantages, and viability under different regulatory environments ^[4].

4. Types of stablecoins: Which is the most reliable?

Currently, stablecoins on the market can be broadly divided into three categories ^[5]:

- (1) Fiat-backed stablecoins
- (2) Crypto-backed stablecoins
- (3) Algorithmic stablecoins

First, fiat-backed stablecoins are now the primary focus of the latest regulatory frameworks worldwide. This is currently the most mainstream—and also the safest—model. The logic is straightforward: you give an issuer one U.S. dollar, they deposit it into a bank account, and issue you one stablecoin. When you redeem the stablecoin, they destroy it (burn it) and return the dollar to you. This is essentially a 1:1 reserve system.

In essence, it is like a digital version of a U.S. dollar exchange window. Representative examples include USDT ^[6] and USDC. But the key question is: can you fully trust that these issuers actually hold the reserves? Will they misuse the funds? In earlier years, this was indeed the biggest point of distrust in the crypto community. Tether, for example, was criticized for years over its lack of reserve transparency and was even fined.

However, since 2024, the situation has changed dramatically—why? Because the Genius Act was enacted.

The full name of the Genius Act ^[2,3] is the Guiding and Establishing National Innovation for U.S. Stablecoins Act, and it is currently the most important and influential stablecoin regulatory framework in the world. Key

provisions include:

(1) 100% high-quality reserves: reserves must be in cash or short-term U.S. Treasuries, with no investment in high-risk assets.

(2) Real-time reserve disclosure: users can verify the reserve balance at any time.

(3) User redemption priority: in the event of issuer bankruptcy, reserves must be returned to users first.

(4) Licensing requirements: any entity issuing stablecoins must obtain either federal or state licenses.

In short, the U.S. regulates stablecoins more strictly than small banks. The goal is simple: stablecoins can no longer be “wild” financial products; they must become transparent, compliant, state-regulated digital financial instruments.

What about the EU’s MiCA (Markets in Crypto-Assets Regulation)? The EU takes an even more cautious approach. It prohibits interest payments on stablecoins to avoid them becoming “shadow banks” competing with traditional banks. It imposes transaction limits and enforces strict anti-money laundering rules. In essence: you can issue stablecoins, but you cannot undermine the euro’s monetary base.

As for Hong Kong’s Stablecoin Regulatory Ordinance, the approach is strategic. It allows companies to operate under a sandbox trial, with real-time government oversight, and requires licensing, local registration, reserve disclosure, and anti-money laundering compliance. The primary focus is on the Hong Kong dollar and offshore RMB stablecoins for cross-border payments.

Notably, as of August 1, Hong Kong temporarily raised licensing requirements, limiting approvals to traditional banks—HSBC, Standard Chartered, and Bank of China (Hong Kong)—and rejecting applications from companies like JD.com and Ant Group.

From this, one might conclude that fiat-backed stablecoins are now safer than many shadow banks: fully licensed, backed by verifiable reserves, with guaranteed redemption and legal protection. This type has evolved into a digitalized version of national currencies.

Second, crypto-backed stablecoins—such as DAI issued by MakerDAO^[7]—use cryptocurrencies like Ethereum as collateral. For example, a user might deposit USD 150 worth of ETH to generate USD 100 in stablecoins. If ETH’s price falls, the system automatically liquidates the collateral. The advantage of this model is decentralization—there is no single controlling company. The drawback is slower responsiveness and higher volatility, making it unsuitable for large-scale payment systems.

Third, algorithmic stablecoins rely solely on algorithms to adjust supply and demand—without any real asset backing. A notable example is Terra’s UST, which collapsed in 2022, wiping out over USD 40 billion in market value and triggering one of the most infamous crashes in crypto history^[8]. Without tangible reserves, once market confidence evaporates, no algorithm can prevent collapse. This model has effectively been eliminated from the market. According to the Federal Reserve’s 2024 report on the impact of stablecoins, large-scale adoption could affect liquidity in the U.S. Treasury market, raising concerns about financial stability^[9].

In summary, stablecoins are not merely a variant of Bitcoin—they are blockchain-based applications of digital fiat currencies. Under modern regulatory frameworks, they have become more compliant and safer than before—though the costs of issuance and maintenance have also risen. From a global perspective, stablecoins are not limited to being digital U.S. dollars; they could also become digital yuan or digital versions of any national currency.

5. Why are industry giants rushing to issue stablecoins? What is the profit model?

If regulation is now so strict, why are major players still racing to launch stablecoins? How do they make money? The answer is surprisingly simple—and remarkably old-fashioned: interest income.

Imagine this: customers deposit USD 10 billion in fiat currency into your account. They can withdraw it at any time, but for most of the time, that money stays with you. Banks pay you interest on it, but regulations forbid you from paying interest to your customers. If the annual interest rate is 2%, you would earn USD 200 million a year—pure profit.

Now consider the market leader, Tether (issuer of USDT). By the end of 2024, Tether’s circulating supply of stablecoins had exceeded USD 150 billion. What does it do with this money? It invests in U.S. Treasuries, overnight reverse repos, and other low-risk instruments—earning steady interest. At an interest rate of 4%, USD 150 billion in reserves would generate USD 6 billion a year, and with additional returns from short-term securities and repo operations, Tether’s net profit in 2024 reached USD 13 billion.

How many employees does Tether have? Around 150—meaning nearly USD 100 million profit per employee. That’s why some say the most profitable company in the world isn’t Apple or Saudi Aramco, but a small firm registered in the British Virgin Islands—Tether. Its exceptional profitability comes from three factors:

- (1) Zero-cost liabilities: users hand over fiat for USDT, and the company pays no interest in return.
- (2) Low-risk investment income: primarily from U.S. Treasuries, money market funds, and other safe assets.
- (3) Massive scale: earning interest on USD 150 billion in deposits transforms its business model beyond traditional banking logic.

These profits were achieved in an era when Tether still faced constant scrutiny and regulatory penalties. Now, with the Genius Act moving stablecoins from a legal gray zone into a fully regulated framework, the amounts sitting in Tether’s accounts could grow even larger. No wonder traditional financial and tech giants are now launching their own stablecoins.

Another major issuer, Circle (USDC), uses the same model—its core income is also interest. In 2024, Circle’s interest income reached USD 1.68 billion. However, as a latecomer competing with USDT, Circle spent over USD 1 billion of that on exchange partnerships—essentially subsidies—to expand distribution. It’s similar to the early credit card alliance model: the issuer creates the card, the partner recruits users, and the issuer rewards the partner with a fee.

Why give money to exchanges? Because stablecoins are built on network effects—the more people use them, the greater their commercial value. Exchanges are the main gateways for user adoption. Circle’s aggressive spending is aimed at getting USDC listed on every exchange and integrated into every wallet—much like the early days of the internet “cash burn” wars: spend heavily, grow users, and increase valuation.

6. With regulation in place, can stablecoins still be hugely profitable?

Now that strict regulation is here, can stablecoin issuers still earn huge profits? One might think the Genius Act, with its requirements for 100% reserves, restrictions on risky investments, licensing obligations, and real-time disclosures, would compress profit margins.

In the short term, yes—costs rise. But in the long run, regulation may actually benefit industry giants and leave profit potential largely intact. Why?

First, the Genius Act’s rules require reserves to be held in low-risk assets—cash and short-term U.S.

Treasuries. With full redemption guarantees, real-time transparency, and no high-risk investment loopholes, profitability is driven almost entirely by the interest rate environment. If the Federal Reserve maintains rates above 4%, stablecoin issuers can generate substantial earnings simply from their reserves. In fact, the current high-rate environment in the U.S. is arguably the single biggest driver of stablecoin profit growth. By contrast, a yen-pegged stablecoin—given Japan’s near-zero interest rates—would have minimal income potential. As Federal Reserve Chair Powell emphasized in his 2023 remarks on digital assets, stablecoins must be subject to strong regulatory frameworks to avoid risks to financial stability ^[10].

Second, regulation creates barriers to entry—effectively a moat for large players. Higher compliance thresholds make it harder for small firms to survive, and licensing will likely be concentrated among established institutions like Circle, PayPal, Visa, and JPMorgan. This could transform the stablecoin market from a “wild west” dominated by crypto-native companies into a sector controlled by tech and financial giants, with profits consolidated in fewer hands.

It is worth noting that while the invention of stablecoins itself is brilliant—some call it the most effortless “money-printing machine” of the century—the Genius Act’s name is a coincidence. The law’s full title is the Guiding and Establishing National Innovation for U.S. Stablecoins Act, and its acronym happens to spell “Genius.”

As for the EU’s MiCA regulation, it bans interest payments and limits transaction volumes, meaning stablecoins in Europe cannot offer high-yield deposit products. There, stablecoins function more as payment tools than investment products. In Hong Kong, regulation focuses on cross-border payments and the issuance of Hong Kong dollars and offshore RMB stablecoins. The goal is to position Hong Kong as the stablecoin financial hub of the Asia-Pacific, attracting compliant issuers. This approach channels stablecoins into payment and financial infrastructure roles rather than speculative assets.

7. Real-world applications of stablecoins

Are stablecoins only useful for crypto traders, with no real connection to our daily lives? Absolutely not. Consider this counterintuitive fact: in 2024, the annual transaction volume of stablecoins reached USD 27.6 trillion—surpassing the total global payments processed by Visa and Mastercard combined. Surprising? That is just the beginning.

The explosion in stablecoin adoption comes from solving some of the most stubborn problems in global payments—slow cross-border transfers, high banking fees, strict foreign exchange controls, inflation-driven currency depreciation, and the lack of a reliable peg in decentralized finance (DeFi). Let’s break down the key use cases:

First: Cross-border payments.

If you want to send USD 100 from China to a friend in the U.S., what are your options?

Bank wire transfer: USD 20 in fees, one to two days to arrive, and a pile of forms to fill out.

PayPal: transaction fees, currency conversion losses, and extra charges for the recipient.

SWIFT: slow, expensive, and opaque.

Now compare that to stablecoins: instant settlement within minutes, fees as low as USD 0.10, and no concept of “cross-border”—it is simply an on-chain transfer. It is essentially a global version of Alipay. This is why giants like Amazon, Walmart, JD.com, and payment providers like Stripe and PayPal are eyeing stablecoins. PayPal has even launched its own—PYUSD—with U.S. regulatory approval ^[11].

Second: A lifeline for high-inflation economies.

If you live in Argentina, where annual inflation is 150% and your local currency loses value daily, what's the first thing you want to do? Get U.S. dollars. But strict foreign exchange controls mean dollars are almost impossible to obtain. The solution? Stablecoins.

In Argentina, Turkey, and Zimbabwe, people use stablecoins like USDT as digital dollars for savings, shopping, and paying rent. In Argentina, landlords now accept USDT rent payments. In Brazil, the central bank integrated stablecoins directly into its national payment system, PIX, enabling on-chain transactions. Here, stablecoins are no longer speculative tools—they are inflation hedges.

Third: The backbone of DeFi.

DeFi—short for decentralized finance—includes lending, asset management, derivatives, and NFT trading, all conducted on-chain. But all these activities require a stable reference asset; without it, volatility would make them unusable. Stablecoins serve as the base currency of DeFi, much like the U.S. dollar in the traditional financial system. Without them, DeFi simply would not work.

Fourth: Grey zones and black markets.

It is a reality that stablecoins first gained explosive adoption not in e-commerce or payment systems, but in black markets—thanks to anonymity, instant global transfer, and difficulty of freezing funds. This made them a preferred medium for dark web transactions, gambling, and illicit fund flows. This is exactly why global regulators have a love-hate relationship with them: they love the financial innovation and competitiveness, but fear the risks of money laundering and terrorist financing. Key laws such as the U.S. Genius Act, the EU's MiCA framework, and Hong Kong's stablecoin regulations all aim to “bring stablecoins into the sunlight,” transforming them from underground tools into legitimate payment infrastructure.

8. Why have governments suddenly changed their attitude?

If stablecoins carry risks of money laundering, why are governments now racing to regulate—and even embrace—them? In one phrase: territory control. Governments have realized that whoever sets the rules first can control the industry's future, attract the best companies, define compliance standards, and collect taxes down the road.

The U.S. has been the most aggressive for a simple reason: the overwhelming majority of stablecoins are pegged to the U.S. dollar, making them a digital upgrade of the dollar's international role. With the Genius Act in place, the U.S. has moved quickly:

- (1) Require licensed issuance and 100% reserve backing.
- (2) Mandate that reserves be held in high-quality, low-risk assets—primarily U.S. Treasuries.
- (3) Enforce real-time reserve disclosures and traceable oversight.

Behind this is a clear geostrategic agenda:

- (1) Strengthen the U.S. dollar's global dominance.
- (2) Boost demand for U.S. Treasuries (Tether alone purchased over USD 30 billion in Treasuries in 2024).
- (3) Secure control over the future of global crypto-finance.

In this sense, the shift from “illegal” to “grey area” to “fully regulated” in just 15 years reflects a grand bargain between technology, markets, and political power. Markets are not democratic elections, but they are a form of silent referendum. The U.S. government has simply decided to embrace the “elephant in the room.”

Mainland China still bans cryptocurrency, but Hong Kong has rolled out its own stablecoin regulations

(effective August) and launched a sandbox program. Why? To protect its role as an international financial center. Singapore is also moving fast, and Hong Kong cannot afford to fall behind. Hong Kong's focus is on HKD- and offshore RMB-pegged stablecoins, potentially serving as a digital RMB internationalization pilot for cross-border payment scenarios.

Elsewhere, Singapore and Dubai have long welcomed Bitcoin and stablecoins. Singapore aims to be Asia's "Web3 capital," while Dubai offers low taxes and easy licensing—becoming a magnet for crypto companies. The EU, Japan, and South Korea are more cautious:

- (1) The EU enforces strict limits, bans stablecoin interest payments, and caps transaction volumes to protect the euro.
- (2) Japan and the Republic of Korea have moved from prohibition to pilot programs to regulated allowance—tightening compliance rules over time.

From a macro perspective, stablecoins are not just a technical innovation—they are part of a currency war. The U.S. uses them to project dollar power; China leverages the digital RMB for defense, using Hong Kong as a forward base; the EU takes a defensive, conservative approach; and Singapore and Dubai are competing to be global crypto-finance hubs. Ultimately, stablecoins could become a foundational layer of the future global payment and monetary system ^[12].

9. Are stablecoins really safe? Have the risks disappeared?

Even with the U.S. Genius Act and Hong Kong's new rules, stablecoins are not entirely risk-free. The risks have changed, but they remain.

Risk 1: Rising compliance costs.

New laws require 100% reserves in highly liquid assets (short-term Treasuries, cash), daily or quarterly disclosures, mandatory licensing, and strict anti-money laundering measures. For smaller issuers, these costs are prohibitive—effectively pushing them out of the market. The result: only giants will remain, and stablecoin issuance will resemble quasi-banking.

Risk 2: Centralization and systemic risk ^[3].

Post-regulation, the market will concentrate heavily on two or three dominant issuers. While this increases safety, it also means that if one fails, the impact will be far greater. Ironically, the original dream of Bitcoin creator Satoshi Nakamoto—financial decentralization—has morphed into a hyper-centralized oligopoly.

Risk 3: Geopolitical vulnerability.

Over 90% of stablecoins are USD-pegged, making their expansion effectively digital dollarization. Emerging economies may ban them outright to protect monetary sovereignty. The U.S. could use stablecoins as a sanctions tool—for example, freezing wallet addresses—though this is harder than controlling SWIFT.

Risk 4: Technology and security threats.

Smart contract vulnerabilities and hacking remain persistent risks. In 2023 alone, cross-chain bridge hacks caused losses exceeding USD 1.2 billion—likely more in unreported cases ^[13]. Compliance does not mean absolute safety.

10. Who might emerge as the ultimate winner?

Who will ultimately dominate the stablecoin market? Will Tether and Circle maintain their reign indefinitely, or

will new challengers rise? There are three main camps entering the arena:

First, the tech and financial giants—Apple, Amazon, PayPal, Visa, and others.

Second, traditional banks such as JPMorgan Chase and Standard Chartered have already begun launching their own stablecoin initiatives.

Third, the established crypto incumbents like USDT and USDC will accelerate their expansion to defend their market share.

The outcome? Stablecoins could evolve into the next-generation payment infrastructure, enabling the U.S. to cement its status as the monetary superpower on the blockchain. Other countries will continue to race to catch up. Within three years, the total market capitalization could exceed USD 1 trillion, with stablecoins used for everything from card payments and cross-border transfers to purchasing NFTs.

In other words, stablecoins are not the endgame—they are merely the opening chapter of a much larger digital finance revolution.

11. Will stablecoins replace the U.S. dollar?

Will stablecoins replace the U.S. dollar? The answer is no. On the contrary, they are poised to become a global expansion tool and lifeline for U.S. dollar hegemony. Today, over 90% of stablecoins are pegged to the dollar, making it easier for USD liquidity to flow into global markets, bypassing capital controls, and functioning as the “oil” of the digital economy.

Of course, the future is far from settled. Currency competition will increasingly be fought in the form of stablecoins, and the eventual “dark horse” is yet to be seen. In truth, money has never been truly stable—what remains constant is humanity’s desire for trust and stability. Stablecoins are simply the newest form of that pursuit.

Let’s imagine: if, within the next five years, the number of stablecoin users exceeds one billion and cross-border payments abandon SWIFT entirely, is that realistic? What if your salary is paid directly in USDT—would the world still look the same?

A final thought: when stablecoins are mandatorily pegged to the U.S. dollar, do anonymity, privacy, and decentralization truly still exist?

12. Conclusion and reflections

Through the exploration of ten core questions, it is evident that stablecoins have evolved from a “grey zone” in the crypto world into a strategic pillar of national financial agendas. They are not merely the product of technological innovation, but also a tool in the geopolitical contest over currency power.

In cross-border payments, as an inflation hedge in high-inflation economies, and as the backbone of DeFi, stablecoins demonstrate disruptive potential. Yet, high regulatory thresholds, market concentration, geopolitical tensions, and persistent technological vulnerabilities remain critical concerns.

The future of stablecoins will depend not only on technological and market momentum but also on regulatory strategies and the shifting landscape of global finance. While unlikely to replace the U.S. dollar, stablecoins may well become the “digital engine” driving dollar internationalization.

For ordinary users, understanding stablecoins is not just about grasping a new form of digital currency—it is about gaining a window into the future of the global financial order.

Disclosure statement

The author declares no conflict of interest.

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A Study on the Rail Transit Economic Field and Its Interactive Development Relationship with Cities from the Temporal-Spatial Perspective

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Abstract: As metropolitan areas expand spatially, they encounter constraints imposed by the fixed daily time budget. Rail transit enhances transport efficiency, reduces costs, and facilitates the formation of a “transit economic field” centered on rail networks, thereby alleviating such temporal-spatial pressures. This paper adopts an integrated temporal-spatial analytical framework. Following a conceptual clarification of the transit economic field, it dissects the mechanisms through which rail transit improves mobility and examines how this field influences urban spatial patterns, temporal dynamics, and their interrelationships. It constructs a theoretical framework to explain the co-development of transit economic fields and cities, supplemented by empirical case studies. The key findings are as follows: Firstly, the transit economic field represents a high-density development model that expands both horizontally and vertically around rail networks. It mitigates temporal-spatial conflicts. Secondly, with rail networks as the core, the field integrates diverse spatial functions, facilitating the establishment of economic connections and stabilizing temporal-spatial relationships. Thirdly, the transit economic field contributes to the preservation of urban natural ecosystems and enhances urban livability. Overall, this research can provide insights for promoting rail transit-oriented development transitions in large cities and urban agglomerations.

Keywords: Rail transit; Rail transit economic field; Temporal-spatial relationship; Accessibility

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1. Introduction

Transportation serves as the fundamental guarantee for urban operation and a key factor that influences or even determines urban efficiency. Urban rail transit outperforms road-based transport modes in terms of speed, transport capacity, and stability, and has played a significant role in economic development and urbanization. For instance, the Tokyo Metropolitan Area in Japan has formed a high-density rail transit network consisting of JR railways, private railways, and urban subways, which underpins the high-density development of the core area of Tokyo and the radial expansion of peripheral areas around rail lines^[1]. The Grand Paris region has established a rail network

composed of central urban metro and suburban RER (Réseau Express Régional) rapid rail transit, meeting the commuting needs between the core area and peripheral new towns and promoting the development of a polycentric city^[2]. Rail transit has not only become the backbone of transportation in developed metropolitan areas and urban agglomerations such as Tokyo, Hong Kong, China, Paris, and New York, but also a focus of transportation construction in major cities of many developing countries, including Bangkok, Bengaluru, and Curitiba^[3].

Based on the service spatial scope, rail transit can be classified into different types, such as intercity trunk railways, suburban railways, and urban rail transit. Regardless of the type, rail transit features the characteristic of exclusive right-of-way, enabling closed and independent operation that is generally not affected by external environments. Existing development experiences have shown that rail transit is not only an effective transport mode but also exerts a significant impact on urban form, constructing an economic model of efficient development centered around rail networks.

In physics, the interaction between two objects is mediated by a “field.” With one object as the center, a field refers to the spatial scope within which the object exerts influence on other surrounding objects, and the closer the distance, the stronger the influence. The field theory was later extended to fields such as psychology and sociology, which hold that individual or group behavior is not only influenced by preferences but also by the rules of the “field” they are in, thereby generating interactive relationships. Based on the above conceptual connotations, this paper defines the rail transit economic field as a development model and urban form centered on rail transit networks, with rail transit as the dominant travel mode, where population and resources agglomerate around stations and lines, and the agglomeration density gradually decreases from the center to the periphery. Why does the rail transit economic field form? How does it affect urban development? This paper will explore the above questions.

2. Literature review

Economics, geography, and other academic fields all acknowledge transportation as a key factor shaping land location patterns. From agricultural location theory and industrial location theory to transportation location theory, scholars have examined the relationship between transportation infrastructure—including ports and railways—and urban development. The Transportation Revolution explores the role of canals and railways in America’s urbanization process^[4]. Schivelbusch contended that railways not only transformed transportation modes but also reshaped human perceptions of time and space^[5].

As urban spaces expand and populations grow, railways have begun to assume a role in intra-urban transportation, catering to substantial internal transportation demands. To accommodate the need for spatial expansion, regions have leveraged the advantages of railway transportation to guide outward population migration. The concept of Transit-Oriented Development (TOD), first proposed by Calthorpe, is grounded in the principle of coordinating transportation planning with land use to optimize urban form^[6]. Bertolini proposed the Node-Place (N-P) Model, highlighting that areas surrounding rail transit stations possess the dual attributes of being both “nodes” and “places.” Effective utilization of the node function can attract passenger flow to enhance the commercial value of the region, while rational development and utilization of the place function can boost passenger flow for rail transit^[7]. The N-P Model is also frequently employed to assess the development status and potential of rail transit stations.

The TOD model for rail transit has seen numerous successful applications in densely populated metropolitan areas across Asia. In Tokyo’s TOD development, private railway companies have played a pivotal role. Through policies such as land consolidation and floor area ratio incentives, they have implemented the integrated development of stations and their surrounding land, fostering compact urban growth^[8]. Hong Kong, China has adopted the “rail + property” model for integrated transportation and land development, implementing high-

density comprehensive development around each station to form a bead-like urban structure underpinned by rail transit^[9]. With the advancement of urbanization in mainland China, diverse rail transit networks have been constructed and gradually refined. Scholars have initiated research on the significant role of railways in the social economy, particularly in urban development, encompassing areas such as rail transit passenger flow forecasting, network design, station planning, TOD development pathways, and development level evaluation^[10–13].

Most existing research focuses on spatial dimensions. However, a critical consideration is that transit requires time to facilitate spatial transfers, and the efficiency of such temporal-spatial conversion directly influences the operation of the social economy. In discussions of rail transit and urban development, time constitutes an inseparable dimension. This paper will investigate the impact of rail transit on urban development from an integrated temporal-spatial perspective.

3. Framework for the interactive development between the rail transit economic field and cities

As cities expand in scale and evolve into multi-centered structures, commuting distances have lengthened, and travel time to work has increased accordingly. However, the hours in a day are finite, leading to a growing temporal-spatial conflict within cities. Development experiences from cities like Tokyo and Hong Kong, China demonstrate that prioritizing rail transit and integrating transportation with land development is an effective solution to this conflict. In other words, it involves constructing an economic development model centered on rail transit to create a “rail transit economic field.”

3.1. Analysis of temporal-spatial characteristics and accessibility of rail transit systems

From the perspective of temporal-spatial economics, accessibility essentially refers to the ease or difficulty with which people or goods move across time and space. There are differences in the magnitude, efficiency, and scope of time-space transformation achieved by highway, railway, waterway, and air transportation, thus leading to variations in the accessibility of different transportation modes. **Table 1** shows the indicators that measure accessibility from these different angles. Both personal accessibility and regional accessibility are directly affected by how accessible the transportation mode itself is.

Rail transit is a form of public transportation that provides public service-oriented products, featuring mature technology and operation on dedicated networks. Compared to road traffic, rail transit operates in enclosed spaces—like specific “temporal-spatial tunnels”—and is minimally affected by external environments, offering stability, reliability, and high safety. **Figure 1** presents an analysis of the temporal-spatial characteristics and accessibility of rail transit systems.

Table 1. Accessibility analysis from different perspectives

Investigation objects	Main indicators affecting accessibility	Explanation of indicators
User accessibility	Distance between the user and the transportation system	The closer the user is to the transportation system, the more convenient it is to enter the transportation space, and the higher the accessibility.
	Efficiency of usable transport modes	The higher the efficiency of the transport modes available to the user, the higher the accessibility.
	User's travel preference	The higher the efficiency of the user-preferred transport mode, the stronger the accessibility.
	Income status	The better the user's income status, the wider the range of travel options, which may improve accessibility.
Regional accessibility	Land use density	The higher the land use density in the region, the shorter the space-time conversion distance may be, and the higher the accessibility.
	Degree of spatial function integration	The more integrated the regional functions, the shorter the space-time distance between functional areas may be, and the higher the accessibility.
	Dominant transport mode	The faster, larger-capacity, and more reliable the regional dominant transport mode is, the higher the accessibility.
	Traffic network density	The denser the traffic network per unit area in the region, the higher the accessibility.

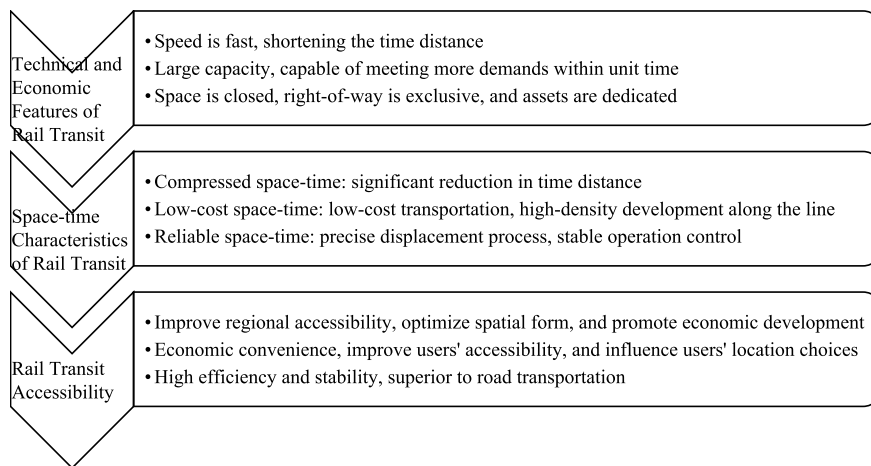


Figure 1. Features and accessibility analysis of rail transit systems

In urban clusters, metropolitan areas, and large cities, travel demand is high and distances are long. The development of a rail transit economic zone benefits both users and the areas along the route. For rail transit users, its advantages in technology and industry enhance mobility capabilities and reduce travel costs. As people perceive rail transit as more convenient, their travel preferences shift: they begin to choose residences or workplaces near rail transit stations and rely on rail as their primary mode of transportation. For regions with a railway network, due to the enhanced transportation capacity brought by railways, high-density development can be implemented, and the integration of functional spaces can be achieved. Its accessibility advantages also attract resources to gather around stations, strengthening the connection between rail transit and urban spaces.

Next, we will explore how rail transit economic fields influence urban temporal-spatial relationships and how rail transit and cities develop in synergy.

3.2. Pathways for interactive development between rail transit economic fields and urban Systems

Rail transit's significant advantage in accessibility greatly improves mobility for the surrounding areas and residents. This enhances the economic attractiveness of spaces around and along rail transit lines, drawing in populations, resources, and various economic activities to form a vibrant "rail transit economic field." Below is an analysis of how this economic field positively impacts spatial utilization, temporal utilization, and temporal-spatial connections in the region.

3.2.1. Impact of rail transit economic fields on spatial utilization

Rail transit is generally recognized as the urban transportation mode with the lowest per capita space consumption. Cities focus development on rail transit spaces, building compact, high-density areas along lines to integrate transportation functions with other urban functions, thereby significantly improving land-use efficiency. Since rail transit can transport far more passengers per hour than buses or private cars, it supports the integrated development of above-ground and underground spaces along lines. This enables cities to expand vertically, meeting the spatial needs of large, crowded metropolitan areas and urban clusters.

Thanks to the speed and reliability of rail transit, more destinations can be reached within the same time frame. This facilitates orderly urban growth along rail lines and supports the development of multi-centered city structures. As resources and functions gather along rail lines, the spaces in these areas become more diversified, comprehensive, and balanced. Many satellite cities can even undertake some non-core functions of the main city through the rail network, optimizing the distribution of urban functional fields to be more balanced and rational.

Improved accessibility and population inflow drive rapid growth in the commercial value of areas along rail lines. In turn, increased commercial development attracts more people and resources, forming a positive cycle. Additionally, compact development around rail transit occupies less surface space, reserving more area for urban green spaces and enhancing urban livability. The spatial utilization of rail transit economic fields is shown in **Figure 2**.

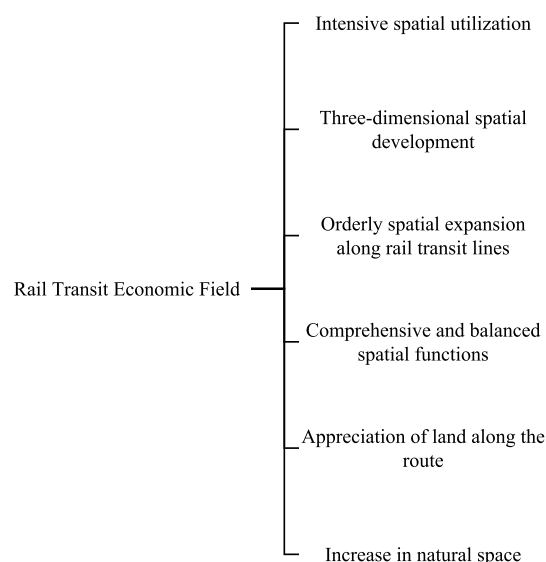


Figure 2. The spatial utilization of rail transit economic fields

3.2.2. Impact of rail transit economic fields on temporal utilization

In terms of optimizing temporal utilization, first, the high-density, mixed-use development along rail lines reduces the distance between different functional spaces, shortening travel distances and time. Second, rail transit's high speed saves travel time. In central areas of large cities, rail transit typically operates at 40–60 km/h—approximately twice the speed of regular road buses. Its speed is comparable to that of private cars, but while cars offer flexibility, increased road traffic leads to worse congestion, making car travel longer and more unpredictable. Thus, rail transit economic fields reduce commuting time and increase leisure time for residents^[14].

Furthermore, rail transit hubs are evolving into multi-functional spaces with extensive surrounding development. This means that during travel, people can simultaneously engage in shopping, leisure activities, cultural visits, or entertainment—achieving “one-stop travel.” Rail transit economic fields enhance the value of travel time.

3.2.3. Impact of rail transit economic fields on temporal-spatial connections

Benefiting from the compressed time-space, low-cost time-space, and reliable time-space enabled by the rail transit system, the circulation of factors within the rail transit economic field becomes more efficient, which can facilitate economic cooperation. More importantly, a stable chain of transportation trips is conducive to solidifying travel patterns, thereby fostering stable socio-economic relationships.

First, rail transit facilitates the establishment of new temporal-spatial connections between elements. High-density vertical development around rail hubs and along lines integrates diverse functional spaces, facilitating economic cooperation. Rail transit also expands the reach of elements, bridging time and space to connect economic factors even in distant regions.

Second, rail transit improves the efficiency of temporal-spatial conversion. Due to features such as dedicated enclosed tracks and high speed, temporal-spatial conversion within rail transit economic fields is generally more efficient than with road traffic.

Third, rail transit stabilizes temporal-spatial connections. Transportation converts physical distance into temporal distance, and limited time can constrain the growth, expansion, and movement of people and goods in large cities. Typically, temporal distance is calculated by dividing physical distance by speed (i.e., travel time). However, when accounting for time spent walking to stations, waiting for trains, or transferring, temporal distance becomes “connection time + travel time.” Adding uncertainties like inclement weather, traffic jams, accidents, or breakdowns further complicates this temporal distance chain. Rail transit, with its reliable and consistent travel, simplifies this chain, reduces uncertainties, and fosters stable, long-term travel routines and economic connections.

3.2.4. Synergistic development of rail transit economic fields and cities

In summary, rail transit—with its technical, economic, and temporal-spatial advantages—alters urban spatial utilization, temporal utilization, and the temporal-spatial connections between elements. It enhances accessibility for regions and users, forming economic fields that transform urban land use in both dimension and density. The construction of rail networks and economic fields enables cities to grow orderly horizontally and develop compactly with high density vertically. Rail transit economic fields alleviate urban temporal-spatial conflicts and reduce unplanned, disorderly expansion. Conversely, as cities develop and their forms evolve, new transportation demands emerge, influencing the planning and construction of rail networks. This cyclical relationship between rail transit and urban development is illustrated in **Figure 3**.

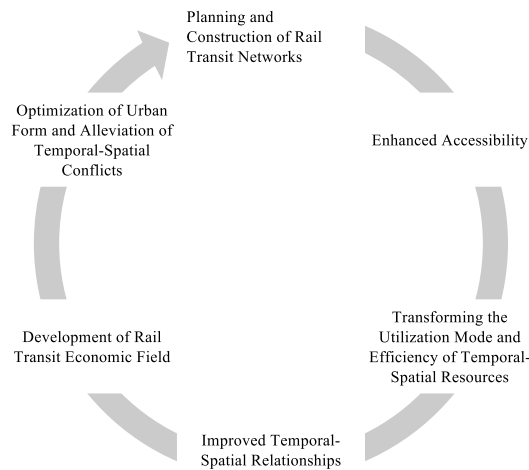


Figure 3. Logic of interactive development between rail transit and cities from a temporal-spatial perspective

3.3. Case study

The Tokyo Metropolitan Area, known as a “city on rails,” has formed an efficient urban morphology through interactive development between rail transit and the city. Japan’s private railway companies were the first to propose and practice the model of synchronizing rail construction with surrounding development. A key proponent was Yataro Kobayashi, founder of Hankyu Railway, giving rise to the “Yataro Kobayashi Model.” This model is a typical example of reshaping urban temporal-spatial relationships through the formation and utilization of rail transit economic fields, with the following construction process: First, while building railways, develop residential areas, introduce department stores, and allocate various living facilities along the lines. Through compact development and spatial integration, improve accessibility and establish reliable temporal-spatial relationships to provide stable passenger flow for rail transit. Second, enhance the commercial value of areas along lines through improved accessibility and engage in diversified operations to generate profits. Third, dynamically and continuously advance the development of areas along rail transit lines to enhance the degree of dependence on rail transit for travel and consolidate temporal-spatial relationships. Ultimately, it forms a multi-centered, sustainable metropolitan area supported by a rail transit network.

The analysis of how rail transit economic fields influence time and space is equally applicable to the interior of urban agglomerations. Nantong City in the Yangtze River Delta is separated from Shanghai by a river, with a straight-line distance of less than 200 kilometers. Before the opening of the Shanghai-Suzhou-Nantong Railway, passenger trains from Nantong to Shanghai had to detour via Nanjing, taking at least 3.5 hours. In July 2020, the first phase of the Shanghai-Suzhou-Nantong Railway began operation, shortening the fastest travel time between Shanghai and Nantong to 1 hour and 6 minutes. Nantong thus entered Shanghai’s 1-hour transportation circle, not only conveniently undertaking non-core functions transferred from Shanghai but also successively signing the “Strategic Cooperation Agreement on Strengthening Suzhou-Nantong Cross-River Integrated Development” with Suzhou and the “Strategic Cooperation Agreement on Strengthening Wuxi-Nantong Cross-River Integrated Development” with Wuxi. Rail transit has reshaped temporal-spatial relationships, thereby promoting economic cooperation within the urban agglomeration and optimizing the functional layout of the agglomeration.

4. Conclusion

There exists an interactive relationship between transportation and urban development, with the underlying logic being as follows: Economic development generates transportation demand, which in turn drives the construction of transportation networks. Conversely, transportation influences regional accessibility, guides the flow and allocation of resources, and shapes new urban morphologies. Owing to their distinct technical and economic attributes, different transportation modes exert varying impacts on regional accessibility. Rail transit, characterized by large capacity, high speed, stability, and reliability, is capable of meeting large-scale concentrated transportation needs, enhancing accessibility in areas along the lines, and forming a rail transit economic field centered on the rail network. The advantages of the rail transit economic field in urban development are summarized as follows:

- (1) Through horizontal axial development and vertical three-dimensional high-density development, the rail transit economic field can satisfy the spatial demands of modern megacities.
- (2) The rail transit economic field is conducive to establishing economic linkages, improving the efficiency of temporal-spatial conversion, and facilitating the consolidation of temporal-spatial relationships, thereby breaking through the temporal constraints in the process of megacity expansion.
- (3) The rail transit economic field promotes the coexistence of urban spaces and natural environments through intensive land use.

The research framework of this paper also contributes to exploring the relationship between railways and economic development on a larger scale. It should be noted that this study only provides a qualitative explanation of the impact of the rail transit economic field on spatial, temporal, and temporal-spatial relationships. The efficiency of the rail transit economic field and its specific impacts on urban development require further verification through quantitative analysis.

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From Homo Economicus to the Rational Practitioner: Reconstructing Rational Choice Through Inner Cultivation in *Journey to the West*

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Abstract: This paper examines the classic Chinese novel *Journey to the West* through the lens of rational choice theory, with a particular focus on the logic of cultivation and behavioral decision-making. By incorporating the notion of “inner cultivation” (*xin xing xiulian*) into the analytical framework, we introduce the concept of the “cultivating economic agent,” aiming to explore how rationality is generated, evolved, and transcended throughout the spiritual journey. The study argues that, in the context of Eastern culture, rationality is not merely an innate or static faculty but one that can be cultivated and transformed. Through textual analysis of the behavioral trajectories of Sun Wukong, Zhu Bajie, and Tang Sanzang, we uncover a structured behavioral logic of “goal orientation–institutional discipline–purification of the mind.” The findings suggest that although cultivation behaviors are not utilitarian decisions per se, they exhibit rational characteristics such as goal stability, autonomous will, and embedded incentives.

Keywords: Inner cultivation; Rational choice; Homo economicus; Behavioral economics; *Journey to the West*

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1. Introduction

The homo economicus model assumes individuals are rational, informed, and utility-maximizing. While foundational to economics, it struggles to explain behaviors driven by faith, morality, and spiritual goals. Recent advances in behavioral and institutional economics highlight the limits of this assumption, recognizing that real-world choices are often bounded and shaped by values.

The Chinese classic *Journey to the West* offers an alternative view of rationality through its depiction of cultivation. Characters like Tang Sanzang, Sun Wukong, and Zhu Bajie embody different paths of inner transformation. By interpreting their actions through rational choice theory and the concept of *xin xing xiulian* (heart-mind cultivation), this paper proposes a new behavioral type: the “cultivating economic agent.”

This approach expands rational choice theory into spiritual domains and grounds it in Eastern views of self,

choice, and human development. Rather than rejecting rationality, it reframes it through discipline, belief, and structured cultivation—bridging classical economic models with Eastern cultivation traditions.

2. Theoretical foundations

2.1. Rational choice and the homo economicus assumption

The homo economicus model assumes that individuals are rational agents with stable preferences, complete information, and the cognitive capacity to choose optimal outcomes in pursuit of utility maximization ^[1]. On this basis, rational choice theory has constructed a mature analytical framework widely used in modeling consumer behavior, investment decisions, institutional arrangements, and strategic interactions.

However, since the mid-20th century, the limitations of this model have become increasingly evident. Herbert Simon's theory of bounded rationality emphasized that individuals face cognitive, informational, and computational constraints, leading them to make “satisficing” rather than optimal decisions ^[2]. Institutional economics further contends that rational behavior is shaped by the institutional environment, which not only defines the space of available actions but also influences choices through incentives and constraints ^[3,4].

More recently, behavioral economics has drawn on psychology and neuroscience to account for seemingly “irrational” behaviors. Time inconsistency, loss aversion, cognitive dissonance, and belief perseverance all suggest that rationality is structured in nonlinear and context-dependent ways ^[5,6]. While these theories have enhanced our understanding of suboptimal or boundedly rational behaviors, they still struggle to explain decisions oriented toward “spiritual value”—those characterized by abstract goals, delayed returns, and high immediate costs.

2.2. Philosophical foundations of cultivation in Daoism and Buddhism

In Chinese thought, cultivation (*xiuxing*) is more than a religious act—it is a deep inquiry into human nature, self-transcendence, and existence. Unlike the Western model that sees rationality as calculation and control, Eastern traditions view rationality as something cultivated through *neiguan* (inner observation) and *zijing* (self-purification), centered on the refinement of the heart-mind (*xin xing*).

In Daoism, the aim is to “attain the Dao” through the dual cultivation of essence and life (*xing ming shuang xiu*) and alignment with nature (*shun qi ziran*). Desire is not suppressed but gently transformed. Rationality here emerges from attunement, timing, and non-intervention (*wu wei*), resembling adaptive, context-sensitive judgment rather than optimization.

Buddhism begins with the insight that all things are impermanent and the self is illusory. Through ethical conduct, meditation, and wisdom, practitioners eliminate attachment and realize *śūnyatā* (emptiness). This form of rationality is ontological, grounded in direct insight into reality. It transcends instrumental reasoning, allowing action rooted in compassion even after recognizing the emptiness of worldly goals.

3. From homo economicus to the cultivating agent

3.1. The economic logic of cultivation and the “anomaly” of rationality

At first glance, cultivation behavior appears incompatible with the rational choice paradigm. It involves substantial immediate costs—physical austerity, emotional suppression, and intensive willpower training—while its rewards are abstract, non-material, and often indefinitely deferred. According to conventional economic reasoning, such behavior would be classified as irrational.

However, if viewed through a dynamic and longitudinal lens, and if spiritual utility is factored into the agent's utility function, cultivation may be interpreted as a form of long-term, high-latency investment. In *Journey to the West*, Sun Wukong endures five centuries of confinement, repeatedly battles demons, and shoulders the burden of guardianship. The short-term costs he incurs far exceed any immediate gains, yet these actions are directed toward the ultimate spiritual return of becoming a Buddha. Once “inner purity” and “fulfilled aspiration” are treated as components of personal utility, the logic of cultivation can be reabsorbed into the domain of rational choice.

This logic aligns with insights from the economics of religion, which interprets religious behavior as a form of consumption of “transcendent goods”—valuable precisely because of their scarcity and symbolic significance^[7]. Yet unlike traditional religious economics, which assumes stable preferences and fixed rationality, *Journey to the West* portrays rationality itself as the product of cultivation, not its precondition.

3.2. *Xin xing* as the generative mechanism of rational evolution

The proverb “the mind is both mountain and cave” captures the dual nature of *xin xing*—the heart-mind is at once stable and chaotic. Cultivation seeks to “restrain the mind and refine the nature,” transforming erratic impulses into consistent, goal-aligned actions. This process can be understood as the endogenization of rationality through inner training.

In behavioral economics, agents often struggle with cognitive biases and time-inconsistent preferences, such as hyperbolic discounting or impulsive decision-making. In *Journey to the West*, Sun Wukong's “monkey mind,” Zhu Bajie's sensuality, and Tang Sanzang's moral rigidity symbolize different destabilizing forces. As the journey progresses through 81 tribulations, these characters gradually develop internal mechanisms of discipline and restraint, reducing impulsiveness and aligning short-term behavior with long-term purpose^[8].

Rationality is no longer a pre-given faculty but a structural outcome generated and refined through *xin xing* cultivation. Behavioral consistency and goal alignment are not products of external incentive design but the result of internal rational development.

3.3. From economic man to cultivating agent: A structural model

Building on the analysis above, we propose a structural model of the “Cultivating Economic Agent” as a theoretical refinement of the classical homo economicus (**Table 1**). This model captures the unique logic of long-term, spiritually motivated, and institutionally embedded behavior.

Table 1. Comparison between traditional economic man and cultivating agent

Model dimension	Traditional economic man	Cultivating economic agent
Rationality basis	A priori, stable and fixed	Emergent through cultivation, adaptive, and plastic
Behavioral goals	Utility maximization (mostly material)	Spiritual fulfillment, self-transcendence (non-material, delayed)
Temporal structure	Short- to mid-term orientation	High delay tolerance, long-term consistency
Decision drivers	Preferences and external incentives	Aspiration (<i>yuanli</i>), belief, internal moral order
Cost tolerance	Low (seeks to avoid high costs)	High (accepts long-term suffering and discipline)
Choice consistency	Context-sensitive, volatility-prone	Stable, autonomous, marked by <i>dingli</i> (mental firmness)

This model suggests that in specific cultural and institutional settings, rationality is not only modifiable but

also upgradable through deliberate cultivation. Cultivation-oriented behavior is not irrational; rather, it represents a higher-dimensional rationality—a systemic response to life choices grounded in willpower, belief systems, and spiritual clarity.

4. The logic of cultivation and rational pathways

4.1. Sun Wukong: From gifted economic agent to self-disciplined cultivator

Sun Wukong begins as a figure of exceptional natural talent and rare resource endowment. Born from stone and trained by the Patriarch Bodhi, he quickly acquires powerful abilities, fitting the profile of a “gifted economic agent.” Yet his early behavior—marked by defiance and ego—leads to his rebellion against Heaven and eventual punishment under the Five Elements Mountain. This institutional constraint marks the shift from innate ability to disciplined cultivation. As the journey progresses, Sun faces repeated trials—such as recognizing deception, resisting pride, and demonstrating loyalty. These challenges refine his self-control and align his actions with long-term goals. His behavior shifts from impulsive to deliberate, reflecting an evolution from raw power to internalized rationality, grounded in *dingli*—the cultivated steadiness to endure adversity.

4.2. Zhu Bajie: Marginal rationality and cultivation under constraint

Zhu Bajie exemplifies a weak self-regulator. Once the Marshal of the Heavenly Canopy, he is exiled for indulgence in lust and excess. His actions align with the present-biased agent in behavioral economics—seeking immediate rewards and prone to impulsivity. His path, known as *dai ye xiuxing* (cultivating with karmic burden), is marked by moral lapses, yet he never quits the pilgrimage or loses sight of its goal. This suggests a “bounded correction” model: though flawed, he stays on course through institutional pressures and residual aspiration. Bajie’s behavior reflects a dynamic between external discipline and internal inertia. His case shows that rationality can be cultivated even in agents with limited self-control, so long as supportive institutional structures are in place.

4.3. Tang Sanzang: Faith-driven rationality and the embodiment of teleological commitment

Tang Sanzang embodies faith-based rationality. His choices consistently serve the ultimate goal of retrieving the scriptures, guided by his unchanging original intention (*chuxin bu gai*), even amid deception, suffering, and doubt. His steadiness stems not from calculation but from value rationality rooted in religious conviction. From an institutional perspective, his behavior is anchored by three forces: religious doctrine, belief commitment, and emotional stability. Together, these form an internal framework that sustains action without immediate reward. Though lacking in flexibility or strategy, Tang’s moral clarity unifies the group and offers direction. His example shows that belief systems can provide enduring behavioral consistency, where rationality is covenantal rather than instrumental. This case illustrates that spiritual rationality is not fixed, but shaped by disposition, institutional context, and belief structure—ultimately oriented toward transformation and transcendence.

5. Modeling the cultivating economic agent

5.1. Core elements of the model

This section introduces the Cultivating Economic Agent as a refinement of the classical homo economicus, designed to explain long-term, high-cost, and non-material decision-making. The model incorporates spiritual goals, internal discipline, and institutional context into a unified behavioral logic. It rests on three key dimensions:

- (1) Behavioral goals:
 - Immaterial: Oriented toward symbolic or transcendental aims.
 - Delayed: Outcomes emerge only after sustained effort.
 - Hard to measure: Benefits are not easily quantified or compared.
- (2) Motivational sources:
 - Aspiration (*yuanli*): A conscious spiritual vow.
 - Faith structure: A stable belief system guiding long-term behavior.
 - Institutional scaffolding: External mechanisms—rules, roles, trials—that reinforce internal goals.
 - Together, these form a durable incentive structure that sustains action in the absence of immediate reward.
- (3) Type of rationality: Focused attention and goal stability; tolerance for delay and discomfort; coherence over time in thought and behavior.
 - This higher-order rationality emerges through self-cultivation, not innate traits. It evolves through iterative feedback between intention, action, and outcome.

5.2. Comparative structure: Traditional vs. cultivating agent

To clearly demarcate the distinctions between the traditional and cultivating models of the economic agent, we present a comparative framework across six analytical dimensions (**Table 2**):

Table 2. Behavioral structure of traditional vs. cultivating economic agent

Analytical dimension	Traditional economic agent	Cultivating economic agent
Rationality type	Fixed, instrumental, calculative	Evolving, moralized, introspective
Temporal orientation	Prioritizes short- to mid-term gains	Oriented toward delayed fulfillment and ultimate goals
Utility structure	Material, quantifiable, consumption-focused	Spiritual, symbolic, non-quantifiable
Motivational drivers	Self-interest, external incentives	Faith, aspiration, and institutional coordination
Cost tolerance	Low (avoids pain and defers cost)	High (accepts hardship and long-term sacrifice)
Rational adjustment mechanism	External signals and punitive feedback	Internal reflection and self-monitoring

This model reveals that the cultivating agent corresponds more closely to the realistic agent explored in behavioral economics, while extending the framework to include cultural, spiritual, and institutional dimensions. It transcends the limits of rational choice theory without abandoning its structural strengths—by repositioning rationality as an emergent property of long-term inner cultivation.

6. Conclusion and theoretical implications

Our findings show that cultivation behavior in *Journey to the West* follows a coherent triadic logic: purpose orientation, willful discipline, and institutional feedback. While these behaviors exceed the scope of utilitarian calculation, they are by no means irrational or arbitrary. Instead, they are grounded in a form of evolved rationality that integrates internal volition, external structure, and spiritual coherence.

The study challenges the mainstream assumption that rationality is a fixed cognitive endowment. Instead, it proposes that rationality can be cultivated through repeated moral practice, intentional reflection,

and institutionalized constraint. The characters in *Journey to the West* demonstrate how inner obstacles—impulsiveness, desire, egoism—can be overcome not through suppression but through transformation. This highlights a developmental trajectory in which agents transition from desire-driven action to goal-aligned rational conduct.

More broadly, this research responds to the contemporary challenge of rational reconstruction in an era of fragmented belief and unstable values. In modern societies, individuals are often torn between external institutional demands and internal emotional impulses, leading to a fractured sense of rational agency. The Cultivating Economic Agent offers a model for reintegrating purpose, belief, and discipline—showing that rationality is not merely a matter of efficient choice, but a product of spiritual alignment and ethical commitment.

Disclosure statement

The authors declare no conflict of interest.

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Cultural Homogenization in Ethnic Minority Heritage Tourism: Responses from Xijiang Qianhu Miao Village

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Abstract: In recent years, the rapid expansion of heritage tourism within China's ethnic minority regions has been accompanied by a significant challenge: the homogenization of cultural tourism imagery and experiences. This phenomenon adversely affects the sustainable development of local tourism industries. To foster the effective integration, preservation, and development of heritage tourism and ethnic cultures, this study presents a case analysis of Xijiang Qianhu Miao Village in Guizhou Province. Drawing upon field research and systematic analysis, the paper critically examines manifestations of homogenization across four key dimensions: cultural image representation, commercial operational models, experiential tourism methodologies, and the depth of cultural engagement. Based on these findings, the study proposes targeted strategies to optimize the cultural tourism experience within this specific context.

Keywords: Heritage tourism; Ancient town tourism; Cultural homogenization; Xijiang Qianhu Miao Village

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1. Introduction

Guizhou Province possesses a wealth of well-preserved ancient ethnic settlements, establishing a foundational basis for high-quality integration of cultural tourism. Notable examples include Zhenyuan Ancient Town, Xijiang Qianhu Miao Village, and Zhaoxing Dong Village—each distinguished by unique cultural attributes that annually attract substantial domestic and international visitation. Since 2019, the Department of Culture and Tourism of Guizhou Province and the Provincial Development and Reform Commission have sequentially designated five batches of key rural tourism villages, aiming to establish “flagship destinations” for provincial rural tourism development. In 2021, the Guizhou Province 14th Five-Year Plan for Cultural and Tourism Development was promulgated, advocating for the strategic development of world-class mountain tourism destinations to facilitate Guizhou's transition from a major tourism province to a globally competitive tourism powerhouse. Furthermore, consecutive “Attracting Visitors to Guizhou” incentive programs were implemented in 2023 and

2024, leveraging preferential policies and subsidy mechanisms to effectively stimulate inbound tourism demand. However, the accelerated expansion of ancient town tourism has precipitated multifaceted challenges, most conspicuously the homogenization of cultural tourism imagery and experiences. This phenomenon poses a latent threat to the sustainable development of local cultural tourism industries. Homogenization is defined as the progressive standardization of cultural products and services within a specific domain, resulting in the erosion of distinctiveness. Such convergence diminishes the unique historical characteristics and cultural identity of ancient towns, leading to standardized visitor experiences. Consequently, the historical value and cultural diversity of these settlements are compromised, thereby undermining the intrinsic appeal and long-term viability of traditional heritage destinations.

Scholars have examined the homogenization challenges in tourism-focused towns^[1] and ancient towns^[2] across Yunnan, Guizhou, and Sichuan provinces. Others have explored strategies and methods to address homogenization through digital technologies^[3–5]. Taking the Xijiang Qianhu Miao Village as a case study, this paper examines its homogenization issues from four perspectives: cultural image presentation, commercial formats, cultural tourism experiences, and depth of cultural excavation. It proposes pathways to overcome homogenization, aiming to provide references for ethnic minority traditional ancient towns to break free from homogenization challenges.

2. Homogenization phenomenon in Xijiang Qianhu Miao Village

Xijiang Qianhu Miao Village, China's largest Miao settlement and a 4A-rated scenic area, spans 5.5 square kilometers and stands as a cultural treasure of Leishan County in Qiandongnan, Guizhou. Hailed as an open-air museum of Miao culture, it showcases rich history and customs, particularly renowned for festivals like the Gucang Festival and Miao New Year. Its distinctive wooden stilt houses, arranged in a picturesque pattern, are listed on the National Intangible Cultural Heritage Register. Renowned writer Qiuyu Yu once praised this Miao village as “answering everything with beauty.” Since 2008, substantial government investment in infrastructure upgrades has spurred rapid economic growth and tourism development in the ancient town. However, accompanying homogenization issues have gradually emerged. Xijiang Qianhu Miao Village urgently needs to explore pathways to reduce homogenization to preserve its cultural distinctiveness and tourism competitiveness.

2.1. Homogenization in cultural image presentation

The homogenization of cultural image presentation in Xijiang Qianhu Miao Village manifests primarily in two aspects.

The first one is the similarity in the design styles and planning concepts of streets and buildings. The planning and design philosophy for streets and buildings is relatively outdated, assuming that fulfilling basic functional requirements completes the task without considering integration with local natural and cultural characteristics. Without unified, organized, and distinctive planning and design, many new shops and restaurants began imitating the styles of other popular tourist ancient towns, causing the originally distinctive Miao-style street architecture to gradually lose its individuality.

Second, cultural symbols have become superficial. To cater to tourist preferences, traditional Miao handicrafts and souvenirs in the village have increasingly been replaced by mass-produced goods. This not only diminishes the uniqueness of Miao culture but also impacts the livelihoods of local artisans. Merchants now prioritize short-term commercial value over deepening the cultural significance of intangible heritage. The market is flooded with

poorly crafted imitations, gradually diluting the cultural essence of Xijiang Qianhu Miao Village.

2.2. Homogenization of commercial formats

Field investigations reveal that Xijiang Qianhu Miao Village shares commercial similarities with numerous other ancient towns. Snack stalls, ethnic makeup and costume photography studios, and various chain stores line the streets, creating a modern commercial atmosphere that inevitably dilutes the original traditional Miao village lifestyle. Vivid scenes—such as farm women singing while washing clothes, elderly women embroidering and chatting on bridges, and Miao youth singing and dancing—have gradually faded from visitors' view, making it harder to uncover the village's deeper cultural essence. Furthermore, to meet tourists' growing consumption demands and boost the town's economy, modern entertainment venues like bars have proliferated in Xijiang. Particularly along the Baishui River, the second floors of numerous stilt houses have been converted into bars. While these nighttime entertainment venues inject new vitality into the town's evenings, they also bring considerable noise and commotion, disturbing visitors' rest and compromising the quality of their immersive cultural experience. Excessive modern commercialization risks distorting and altering the town's traditional culture.

2.3. Homogenization of cultural tourism experiences

The homogenization of cultural representation and commercial operations has resulted in increasingly standardized visitor experiences at Xijiang Qianhu Miao Village. To empirically assess this phenomenon, a quantitative survey was conducted during the summer peak season, involving 100 randomly selected visitors within the scenic area. Findings revealed significant perceptual convergence: 50% of respondents expressed reluctance to engage with ethnic performances due to perceived redundancy with similar offerings at other destinations; 40% declined participation in ethnic costume and makeup services, citing indistinguishability from comparable attractions; and 90% perceived local handicrafts and streetscapes as replicating those found in alternative heritage sites. These data substantiate a critical homogenization crisis in the village's cultural tourism product delivery.

Three primary dimensions of this homogenization were identified:

(1) Commercial product standardization: Miao cuisine serves as a fundamental medium for cultural transmission. However, escalating tourist demand has prompted many food establishments to introduce non-traditional, mass-market menu items. This adaptation has progressively eroded the culinary distinctiveness of authentic Miao gastronomy, thereby compromising the experiential authenticity sought by cultural tourists.

(2) Tourist activity conformity: To accommodate mass tourism preferences, certain Miao performing arts have been reduced to formulaic productions, sacrificing the cultural heterogeneity and artistic uniqueness inherent to Miao traditions. Concurrently, the proliferation of commercial photography services has generated standardized visual scenarios and costuming options, diminishing both the individuality of visitor documentation and the destination's distinctive cultural imagery.

(3) Service delivery homogeneity: Operational efficiencies achieved through standardized service protocols—including uniform tour narratives and fixed itineraries—ensure baseline quality control but simultaneously engender monotonous visitor experiences. This systemic standardization impedes nuanced appreciation of Miao cultural complexity and diversity, ultimately constraining the depth of cultural engagement achievable within the destination.

2.4. Homogenization in cultural depth exploration

Homogeneity in cultural excavation depth manifests in two aspects. The one is the shallow capacity for cultural element excavation. For ancient towns, insufficient cultural elements significantly diminish visitor appeal, while a simple accumulation of numerous but poorly refined elements blurs the town's cultural identity and direction. Xijiang Qianhu Miao Village possesses diverse cultural expressions—culinary traditions, costume culture, architectural heritage, and festival celebrations—yet its excavation remains insufficient. While visitors can sense the unique charm of Miao culture, their engagement often remains superficial, limited to observation and fleeting experiences. This phenomenon is often dubbed “sightseeing tourism,” lacking deeper cultural exchange and understanding. The other aspect is the low value of tourism products. Miao silverware, embroidery, and batik crafts are key tourism products in Xijiang, yet as the tourism market expands, these goods have lost their original cultural distinctiveness and artisanal value. They now resemble products from other ancient towns and even lack uniqueness within the Miao village itself, with most being replicas. Truly dedicated artisans crafting authentic pieces are increasingly rare.

The crux of these issues lies in insufficient cultural excavation, preventing the full expression of Miao culture's essence and depth. The village prioritizes superficial forms over substance in cultural promotion, neglecting the exploration and preservation of deeper layers like Miao history, religion, and customs. This not only diminishes the cultural influence of the Miao people but also hinders visitors' ability to genuinely comprehend and experience the unique charm of Miao culture.

3. Solutions to homogenization

3.1. Strengthening ethnic cultural exploration, promoting intangible heritage protection and digital resource development

Firstly, establish collaborative partnerships with academic institutions to undertake systematic ethnographic research on Miao cultural heritage. Implement digital archiving and repository systems for cultural preservation, supplemented by academic symposia to facilitate cultural exchange. Develop intangible cultural heritage (ICH) transmission bases featuring skill demonstration workshops and certification programs. Define strategic positioning for Miao villages through culturally authentic carriers to enable sustainable tourism. Construct a digital ethnic tourism framework integrating distinctive cultural elements (as illustrated in **Figure 1**).



Figure 1. Silverware crafting scene at Xijiang Qianhu Miao Village

Secondly, foster innovation through talent recruitment and technology transfer to develop immersive cultural products. Formulate incentive policies targeting local entrepreneurs to revitalize ICH skills through community participation. This facilitates visitor transition from passive observers to active participants in authentic cultural experiences. Integrate traditional crafts with culinary heritage via digital platforms (e.g., augmented reality-based craft design, interactive Miao cuisine workshops) to enhance experiential engagement.

3.2. Promoting industrial integration to develop a diversified industrial ecosystem

Xijiang Qianhu Miao Village can counter homogenization by capitalizing on its unique ethnic culture and natural landscape to develop distinctive tourism products. By cultivating region-specific crops such as Miao-style terraced rice and medicinal herbs, and expanding their sales via e-commerce, the village effectively integrates agriculture with cultural tourism. This approach facilitates the transformation from a traditional agrarian economy toward a diversified industrial structure, driven by a “primary industry leading tertiary industries” model. Furthermore, promoting convergence with sectors like wellness and educational tourism extends industrial chains and generates regional synergies. Such strategies not only create a multi-dimensional industrial ecosystem but also reinforce the foundation of rural revitalization through tourism.

3.3. Building traditional Miao Village cultural IP through new media

Adhering to the principle of IP uniqueness, Xijiang Qianhu Miao Village should prioritize establishing a distinctive heritage tourism brand. This requires strengthening support for agricultural product processing and developing regionally specific souvenir products that align with tourists’ demand for high-quality rural goods. Concurrently, collaboration with tourism platforms and sites should be enhanced to promote Miao cultural offerings through live streaming, short videos, and official social media accounts, thereby expanding the brand’s market reach beyond niche audiences.

The village must also leverage new media platforms to foster dynamic visitor engagement. By disseminating high-quality visual content (images, videos, and narratives) showcasing the site’s scenic and cultural assets, and actively responding to visitor feedback, the destination can cultivate interactive relationships. Transforming smart tourism platforms from static information portals into conversational hubs will enhance visitors’ emotional connection to the site. Such engagement not only strengthens cultural identification but also stimulates sustained interest in Miao heritage.

3.4. Enhancing visitor service quality through digital technology

Xijiang Qianhu Miao Village can enhance digital innovation through marker-based augmented reality (AR) systems. Complementing existing virtual reality experiences and digital tours, AR modules would enable visitors to access layered cultural content—including historical narratives, architectural analyses, and ethnographic demonstrations—via smartphone scanning of designated site markers. This approach facilitates deeper cultural immersion while enhancing experiential engagement.

To optimize these innovations, the site should implement systematic visitor feedback mechanisms. Digital analytics platforms can collect and evaluate satisfaction metrics across multiple touch points (e.g., social media, online surveys, integrated review systems), enabling data-driven service refinements. Such iterative improvements, responsive to visitor expectations, may effectively mitigate cultural homogenization by tailoring experiences to authentic cultural engagement.

4. Conclusion

This paper analyzes the homogeneity of Xijiang Qianhu Miao Village. It proposes pathways to overcome homogenization through four strategies: enhancing the exploration of ethnic cultural resources, fostering industrial convergence, establishing a distinctive Miao Village cultural IP, and utilizing digitalization to improve visitor services. These approaches offer scientific and practical references for the preservation and development of traditional ancient towns. Through collaborative efforts among local government, tourism enterprises, and residents, ethnic tourism destinations can effectively address homogenization and advance toward sustainable development.

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An Analysis of the Bidirectional Shaping Mechanism Between Short-Video Algorithms and Film Narrative Driven by the Attention Economy

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Abstract: This study examines the bidirectional shaping mechanism between short-video algorithms and film narratives within the attention economy. It investigates how algorithmic logic influences cinematic storytelling and how films, in turn, contribute to the aesthetic enhancement of short-video content. Drawing on Communication Accommodation Theory and Berry's Acculturation Theory, along with case analyses and industry data, this research demonstrates that algorithms push films toward high-stimulus, fast-paced narrative patterns—characterized by increased shot density and structural fragmentation—to capture and retain viewer attention. Conversely, films counter this influence by supplying narratively deep and artistically refined content that elevates short-video aesthetics and encourages critical audience engagement. This dynamic reflects a process of mutual adaptation rather than one-sided dominance. The study concludes that such interaction signifies a broader restructuring of cultural production logic, facilitating cross-media convergence while simultaneously posing risks to cultural diversity due to the prioritization of high-traffic content. Balancing this relationship will require policy support, algorithmic transparency, and strengthened industry self-regulation to preserve artistic integrity and cultural ecosystem diversity.

Keywords: Short-video algorithm; Film narrative; Bidirectional shaping; Cultural production logic; Attention economy

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1. Introduction

The contemporary media landscape is characterized by complex interactions between traditional and digital forms, with the relationship between short video platforms and the film industry representing a particularly significant site of negotiation. The rapid proliferation of short video content, governed by algorithmic systems prioritizing immediate engagement, has fundamentally altered attention economies and consumption patterns worldwide. Concurrently, the film industry, with its established traditions of narrative depth and aesthetic immersion, faces both unprecedented challenges and opportunities within this new digital ecosystem.

This research investigates the hypothesis that the interaction between these two media forms constitutes a process of “bidirectional domestication”—a mutual adaptation wherein short video algorithms domestically shape film narratives toward faster pacing and higher stimulation, while films, leveraging their cultural capital, reverse domesticate the short video landscape toward greater aesthetic depth and quality content. This dynamic represents nothing less than a reconstruction of cultural production logic, with profound implications for artistic expression, industry structures, and cultural diversity.

The theoretical significance of this study lies in its integration of Communication Accommodation Theory (CAT) and Cultural Adaptation Theory to explain media convergence phenomena. While previous research has examined technological impacts on cinema or platform economics separately, this study provides a synthesized framework for understanding their reciprocal relationship. Practically, this research offers valuable insights for content creators, industry stakeholders, and policymakers navigating the evolving media landscape.

This paper is structured according to conventional academic formatting, presenting materials and methods, comprehensive results, detailed discussion, and substantive conclusions. Through systematic analysis of industry reports, academic literature, and empirical data, this study aims to provide a nuanced understanding of how bidirectional domestication operates, its impacts, and its implications for the future of cinematic art in the digital age.

2. Materials and methods

2.1. Research design

This study employs a mixed-methods approach combining qualitative theoretical analysis with quantitative data examination. The research design incorporates document analysis of industry reports, academic literature review, and case study examination to develop a comprehensive understanding of the bidirectional domestication phenomenon. This triangulation method ensures robust findings through methodological complementarity.

2.2. Data sources

Primary data were extracted from multiple authoritative sources:

The China Film Association’s “Nearly 500 Popular Film Images Analysis Report” (2025) provided quantitative data on shot duration, frequency, and narrative patterns across a significant sample of films from 2010–2025.

The “2023 Short Video Attention Report” by Second Hand System offered crucial metrics regarding attention span changes and consumption patterns.

The National Film Administration’s “Film Industry Report 2024” supplied industry-wide data on production trends, distribution patterns, and economic impacts.

Douban platform data (2024) provided audience evaluation metrics and criticism patterns for comparative analysis.

2.3. Theoretical framework

The analysis is grounded in two primary theoretical frameworks:

Communication Accommodation Theory (CAT) provides a mechanism for understanding convergence and divergence strategies in media interaction, illustrating how short videos accelerate narrative rhythm through highly stimulating content (convergence), while movies counter with aesthetic upgrading through artistic depth (divergence)^[1].

In John Berry's acculturation theory, strategies such as "integration" and "separation" can be further analogized to the response modes within the film industry: commercial films actively incorporate the logic of short videos to broaden their audience (integration), while art films adhere to their own style to preserve artistic independence (separation) ^[2]. Such differentiated responses transcend the binary opposition of "technology eroding art" and instead foster a symbiotic relationship between media.

At the narrative level, traditional films rely on long shots to create immersion, while contemporary films tend to use short shots to assemble information, which is essentially a response to the "high information density" characteristics of short videos ^[3].

Supplementary theoretical perspectives include:

- (1) David Bordwell's film narratology concepts for analyzing changes in cinematic language.
- (2) Stuart Hall's encoding-decoding model for understanding audience interpretation.
- (3) Dallas Smythe's audience commodity theory for contextualizing attention economies.

2.4. Analytical approach

Content analysis was conducted on the extracted data with a specific focus on:

Quantitative metrics: Shot duration frequency, attention span data, box office figures, viewership statistics.

Qualitative patterns: Narrative structures, aesthetic approaches, critical reception trends.

Case studies: Deep analysis of specific films (e.g., "Fast & Furious 10," "Silent Village," "The Last Night on Earth") demonstrating particular adaptation patterns.

Ethical considerations were maintained through the exclusive use of publicly available data and proper citation of all sources. Limitations include potential regional specificity of data and the rapidly evolving nature of the phenomena under study.

3. Results

3.1. Attention economy metrics

The data reveals dramatic changes in audience attention patterns directly attributable to short video consumption. The average user attention span decreased from 8 seconds in 2018 to 3 seconds in 2023 ^[4], representing a 62.5% reduction over five years. This shift has created substantial pressure on film narratives to deliver core content more rapidly.

Commercial films demonstrated direct responsiveness to these changes. Analysis of "Fast & Furious 10" revealed a shot switching frequency of 1.2 times per second in its opening five minutes, nearly double the rate of comparable films from the early 2010s. Conversely, films maintaining traditional pacing faced significant challenges: "Silent Village," utilizing extended long takes exceeding 30 seconds, achieved only 1 million yuan in first-week box office revenue, with over 60% of Douban comments criticizing its slow pace.

Statistical analysis of Douban data (2024) showed a strong correlation between pacing and reception: 72% of films rated below 6/10 received criticism for "slow pacing," while all top-rated commercial films were characterized by "immediate conflict introduction" ^[5].

3.2. Narrative structure transformation

The China Film Association's analysis of nearly 500 popular films revealed significant technical evolution:

The average number of shots increased by 40% in 2020–2025 compared to 2010–2015.

The average shot duration decreased by 30% over the same period ^[6]. This change points to the narrative gene of “high information density” in short videos ^[7].

Films increasingly incorporated “highlight moments” specifically designed for platform sharing.

Case studies demonstrated adaptive narrative strategies:

“Cloud Atlas” employed segmented narrative blocks averaging under 2 minutes each, mirroring short video multi-segment patterning.

“The Wandering Earth 2” generated specific high-impact sequences (space elevator explosion, lunar nuclear detonation) that accumulated over 8 billion views on Douyin while maintaining feature narrative integrity.

3.3. Production process evolution

Data indicates fundamental shifts in creative processes:

65% of film promotion budgets were allocated to short video platforms in 2024.

Platforms increasingly influence production through data-sharing arrangements.

Netflix’s algorithmically-derived creative metrics (pre-conflict positioning, emotional peaks, visual symbols) have been integrated into development processes.

The “cross-media compatibility” model has emerged, where productions are consciously designed for “one creation, multiple distribution” across theatrical and platform environments.

3.4. Counter-domestication patterns

Despite adaptation pressures, significant resistance patterns emerged:

Art films like “Sons and Daughters of the Jianghu” maintained aesthetic integrity while achieving high Douban scores (7.6/10) through community support.

Analysis of the content of artistic films (“The Last Night on Earth” 70-minute long take analysis) garnered over 50 million views, demonstrating an appetite for sophisticated content.

Audience criticism mechanisms effectively penalized algorithmically-optimized but artistically-deficient productions (one fantasy film’s rating dropped from 6.5 to 4.2 following fan community criticism).

3.5. Industrial restructuring

Substantial industry transformation is evident:

Art cinema numbers decreased by 20% between 2019–2024 ^[8].

Action and comedy films dominated production (60% of output) while documentaries and experimental films diminished (10% share).

Platform-producer revenue-sharing ratios reached 6:4 for derivative advertising income.

Short video platforms directly influence theatrical scheduling through viewership metrics.

4. Discussion

4.1. Theoretical integration

The findings substantially support the application of Communication Accommodation Theory to media convergence phenomena. The observed patterns of cinematic narrative acceleration represent clear convergence strategies toward short video logic, while the maintenance of artistic integrity in certain films demonstrates divergence strategies preserving medium-specific values. This dynamic aligns with CAT’s prediction that

communication systems adjust their behavior to enhance interaction effectiveness.

Berry's Cultural Adaptation Theory similarly provides explanatory power for the differential industrial response^[9]. The commercial film sector's embrace of short video characteristics exemplifies an integration strategy, while art cinema's adherence to traditional forms demonstrates a separation strategy. This theoretical framework successfully transcends simplistic "technology versus art" dichotomies by recognizing the strategic nature of adaptation decisions.

The research findings further validate Smythe's audience commodity theory within contemporary digital capitalism^[10]. Attention metrics directly influence production decisions, and algorithmic systems effectively transform viewer attention into quantifiable, tradable commodities. However, the counter-domestication patterns observed complicate this framework by demonstrating how cultural capital can create alternative value systems partially independent of immediate attention metrics.

4.2. Power dynamics and agency

The bidirectional domestication model reveals complex power negotiations within media ecosystems.

While algorithmic systems exert substantial influence through attention economies, the research demonstrates that agency persists at multiple levels:

- Producers exercise strategic choice in adaptation approach (integration vs. separation).

- Creators leverage cultural capital to resist homogenization.

- Audiences utilize critical capacity to reward/punish artistic decisions.

This multi-layered agency suggests that technological determinism provides insufficient explanation for media evolution. Rather, the findings support a structuration perspective wherein technological systems establish constraints and opportunities while human agency operates within and against these structures.

4.3. Cultural diversity implications

The documented 20% decrease in art cinemas and dominance of action/comedy genres (60% of production) raise significant concerns about cultural diversity. Algorithmic preference for highly shareable content creates substantial pressure toward homogenization, potentially marginalizing nuanced or challenging content.

However, the substantial viewership (50+ million) for sophisticated analysis content suggests alternative distribution pathways for complex material. This indicates that while algorithmic systems prioritize certain content types, they don't eliminate demand for diverse material—rather, they reshape how such content must be packaged and distributed.

4.4. Future evolution trajectories

The research suggests several probable development pathways:

- Continued evolution toward "cross-media native" production designed from inception for multiple distribution formats.

- Emerging counter-movements leveraging algorithmic systems to promote diverse content (as demonstrated by Bilibili's 30% exposure increase for niche content through algorithm adjustment).

- Potential regulatory response to preserve cultural diversity as market mechanisms prove insufficient for maintaining varied cultural production.

The integration of AI technologies will likely accelerate these trends, creating both new opportunities for

content creation and new challenges for artistic preservation.

5. Conclusion

5.1. Summary of findings

This research demonstrates that the relationship between short video platforms and the film industry constitutes a process of bidirectional domestication characterized by mutual adaptation rather than unilateral determination.

Key findings include:

- Significant transformation of attention patterns, with average span decreasing to 3 seconds.

- Fundamental narrative restructuring toward increased shot frequency (40% increase) and decreased shot duration (30% decrease).

- Emergence of data-driven production processes prioritizing cross-media compatibility.

- Substantial counter-domestication through cultural capital leveraging and audience critical activity.

- Major industry restructuring favors algorithmically favored content types.

These changes represent neither the eradication of cinematic art nor the simple triumph of technology, but rather a complex renegotiation of cultural production within new technological conditions.

5.2. Theoretical contribution

This study makes significant theoretical contributions by:

- Successfully applying Communication Accommodation Theory and Cultural Adaptation Theory to media convergence phenomena.

- Demonstrating the coexistence of technological influence and artistic agency.

- Providing empirical support for updated versions of audience commodity theory within digital capitalism.

- Developing the bidirectional domestication model as a framework for understanding contemporary media relationships.

5.3. Practical implications

The findings offer valuable insights for various stakeholders:

- Content creators can leverage an understanding of adaptation mechanisms to navigate artistic-commercial tensions.

- Platforms might develop more nuanced algorithmic systems that better balance engagement with diversity.

- Policymakers should consider support mechanisms for preserving cultural diversity within algorithmically-driven environments.

- Educators should emphasize critical media literacy skills enabling audiences to navigate increasingly complex media environments.

5.4. Limitations and future research

This study has several limitations that suggest productive future research directions:

- Regional focus primarily on Chinese market data necessitates comparative international research.

- The rapidly evolving technological environment requires ongoing study.

- Longer-term cultural impacts warrant longitudinal investigation.

- Future research should particularly examine:

AI integration impacts on content creation and distribution.
Emerging models for preserving cultural diversity within algorithmic systems.
Evolutionary patterns in audience critical capacity and media literacy.
Cross-cultural variations in adaptation patterns and outcomes.

The bidirectional domestication model provides a robust framework for continuing investigation into the evolving relationship between technological systems and cultural production, offering both analytical precision and practical relevance for understanding media in the digital age.

Disclosure statement

The authors declare no conflict of interest.

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Construction of a Marketing System for Leveled Mathematics Readers from a User-Oriented Perspective: A Strategy Optimization Study Based on the 4V Marketing Model

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Abstract: In the context of the continuous deepening of the “Double Reduction” policy and the growing demand for quality education, leveled mathematics readers, as an emerging form of publishing that integrates subject education and reading experience, face challenges such as unclear leveling logic, insufficient functional support, and weak user engagement. This paper introduces the 4V marketing theory and constructs an analytical framework from four dimensions: differentiation, functionality, added value, and resonance. Two representative products, “Climbing Mathematics” and “Spark Mathematics,” are selected for a typical case comparison to identify their strengths and weaknesses in content design, service systems, and brand operation, and to extract transferable strategic elements. The study finds that the user-value-oriented strategy based on the 4V model can effectively address the core issues in the market promotion and user relationship building of leveled mathematics readers, providing practical paths and theoretical support for educational publishing institutions to achieve product innovation and brand upgrading in this niche field.

Keywords: 4V marketing theory; Leveled mathematics readers; Educational publishing; Typical case analysis; Marketing strategy

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1. Introduction

Since the implementation of the “Double Reduction” policy, China’s basic education ecosystem has undergone a profound transformation from an exam-oriented to a quality-oriented approach. The service model in the publishing industry has also evolved from a single content supply to a more integrated and experience-based development. In the context of the gradual maturation of leveled language reading, leveled mathematics readers, as an important extension, have gradually entered both home and school environments. Compared to language

products such as Chinese and English, mathematics books not only bear the function of knowledge transfer but also need to play a role in fostering logical thinking and improving mathematical literacy. This raises higher requirements for content design, expression methods, and supporting services.

Although a diverse product system labeled with terms like “logical thinking” and “fun mathematics” has emerged in the market, problems such as vague leveling criteria, single functional forms, and limited brand recognition still persist. These shortcomings result in high-quality content struggling to efficiently reach target users and failing to create a sustainable usage ecosystem, which in turn hinders publishing institutions from upgrading toward service-oriented and brand-oriented models. Traditional marketing approaches have proven ineffective in addressing the diversified and personalized needs of users.

To break through this predicament, this paper introduces the 4V marketing theory, systematically analyzing the content logic and marketing strategies of leveled mathematics readers from a user-value perspective. By comparing two typical cases, “Climbing Mathematics” and “Spark Mathematics,” which follow different publishing logic, the paper identifies common issues and differentiated advantages, extracts replicable successful strategies, and aims to provide a theoretical basis and feasible paths for educational publishing institutions to optimize products and build brands in the leveled reading niche market.

2. Analysis of the current market for leveled mathematics readers

In recent years, driven by the dual forces of the national “Double Reduction” policy and the focus on quality education, the educational publishing industry has accelerated its transition from a “knowledge-transmission” model to a “literacy-oriented” model. Leveled mathematics readers, as a typical category within this transformation, have attracted increasing attention from parents, teachers, and students. Their main value lies in expressing abstract mathematical concepts through storytelling, imagery, and task-driven approaches, balancing both subject knowledge transmission and the stimulation of reading interest, thus establishing an introductory path for mathematics learning^[1-3].

However, the overall market is still in its early stages of development. Issues such as structural imbalance, weak service functionality, and lagging brand development persist, restricting the sustained growth of this category and hindering the formation of user engagement and loyalty.

2.1. Lack of scientifically systematic leveling logic in content structure

Currently, most leveled mathematics books on the market are categorized mainly by “age groups” or “preschool/primary school grades,” lacking a refined tiered design based on cognitive development levels and mathematical learning pathways. Most books present content in the form of “fun questions + simple stories,” which lacks systematization and a progressive hierarchy. This approach fails to support students’ gradual learning goals at different stages and limits both the educational functionality and the usage cycle of the books.

2.2. Limited support for supporting functions and adaptability to usage scenarios

Most leveled mathematics books remain in a single printed book format, lacking integration with digital resources and online platforms. As a result, they fail to meet parents’ practical needs for “read-along, tutoring, and feedback” and struggle to provide effective teaching support for educators. While some products offer QR code-linked courses, the content is fragmented and resources are scattered, making it difficult to establish a stable and cohesive

learning service system.

2.3. Uneven user coverage with market focus overly concentrated on younger age groups

Currently, the majority of leveled mathematics books on the market are focused on children aged 3–8, while there is insufficient response to the reading needs of upper primary school students. This structural gap results in a shorter user lifecycle, lower repurchase rates, and hinders the establishment of long-term user relationships and brand loyalty. At the same time, teachers' awareness and acceptance of these books are low, and the products have not effectively entered school teaching environments. As a result, the distribution and usage of these books heavily rely on family decision-making chains.

2.4. Traditional brand operation models, lacking mechanisms for long-term user relationship building

Publishers generally adopt a channel-oriented traditional distribution path, relying mainly on online platform promotions, book rankings, and recommendations for sales. There is a lack of systematic brand image development and emotional communication strategies. The exposure of books on social platforms such as Xiaohongshu and Douyin tends to remain at superficial levels like “unboxing” or “promotional recommendations,” making it difficult for users to form deep interactions or a sense of brand belonging.

3. Typical case analysis and problem extraction

3.1. Typical case analysis

In order to identify the advantages and structural dilemmas in the actual publishing and operation process of leveled mathematics readers, this paper selects two typical cases for comparative analysis: the “Climbing Mathematics Reading Series” (Beijing Normal University Press) and the “Spark Mathematics Readers Series” (Spark Education). These two cases represent the “research-based publishing logic” and the “platform-based operation logic” respectively, and exhibit significant differences in content construction, functional expansion, user engagement, and brand operation, making them suitable for verifying the 4V strategy model.

The “Climbing Mathematics” series relies on an authoritative research-based system to construct a complete curriculum content system, emphasizing systematicity and teaching adaptability. The books are suitable for use in both classroom teaching and after-school extensions, with high knowledge coverage and academic rigor. However, its expression style is more rational, lacking interactivity between text and images, and providing weak support for family scenarios, resulting in low user engagement.

In contrast, the “Spark Mathematics” series is user-experience-oriented, building a family reading and interactive learning environment through storytelling, interesting task design, and digital platform support. Its strengths lie in strong user engagement and rich dissemination paths, but it faces challenges such as insufficient depth in the curriculum system, lack of standards, and weak teaching adaptability, which limit the usage cycle for upper-grade users and adoption by teachers.

To more clearly present the key characteristics of both cases under the four dimensions of the 4V theory, **Table 1** has been organized.

Table 1. Comparison of typical cases under the 4V strategy dimensions

4V strategy dimensions	Climbing Mathematics (research-based model)	Spark Mathematics (platform-based model)	Comparison conclusion and problem focus
Differentiation	Layered according to curriculum standards, systematic structure	Contextual storytelling introduction, diverse reading scenarios	Significant differences in content expression style, both lack fine-grained leveling based on cognitive models
Functionality	Rich teacher resources, strong teaching integration	App interaction, gamified challenges, high digital integration	Each function has its advantages, but fails to form a complete loop, user chain is inconsistent
Added value	Focus on mathematics culture and literacy extension	Achievement system, growth check-ins, parent-child tasks	Neither has established long-term usage incentives or a learning outcome visualization loop
Resonance	Professional authority, high trust among teachers	IP-based operation, active parent-child community	Lack of unified brand image and personalized strategy, weak emotional connection with users

3.2. Case problem summary

Through the analysis of typical cases, there are three main issues with the current mathematical leveled readers. First, there is a lack of a scientific content construction mechanism based on children's cognitive development patterns, leading to a lack of systematic structure and gradient in the book content, which fails to effectively promote the gradual improvement of students' abilities. Second, the design of functional services is fragmented, lacking organic integration with digital resources and adaptation to different usage scenarios, which limits the product's extensibility and user experience. Third, the brand communication approach is overly simplistic, neglecting the long-term development of user relationships and emotional interaction, resulting in a vague brand image, low user loyalty, and difficulty in achieving long-term market penetration.

4. Marketing strategy construction based on the 4V theory

In response to the core issues revealed in the typical case analysis, such as chaotic leveling logic, lack of functional support, and weak brand connection, this paper combines the 4V marketing theory to construct a systematic marketing strategy framework for leveled mathematics readers. The framework is developed from four dimensions: "differentiation, functionality, added value, and resonance." The aim is to help educational publishing institutions achieve a holistic leap in content design, service integration, and brand development.

4.1. Constructing a cognitively-driven content layering system

Currently, leveled mathematics readers generally lack scientific grading criteria and cognitive model support, with unclear product differentiation and market homogenization. Therefore, publishers should develop a cognition-driven content layering system based on children's mathematical cognitive development stages. In addition to age-based divisions, the system should incorporate dimensions such as "cognitive difficulty," "problem-solving paths," and "cognitive types" as standards for content grading. Furthermore, integrating the STEAM (Science, Technology, Engineering, Arts, and Mathematics) concept, publishers can develop interdisciplinary fusion books, such as "Geometry in Stories" and "Data in Daily Life," to enhance product recognition and usage value. This

would truly achieve thematic differentiation and diversify expression methods^[4-6].

4.2. Creating a paper-digital integrated service loop system

Functionality is not only about the usability of the product, but also determines the depth of interaction and usage cycle between the book and the user. Publishers should create a product ecosystem that integrates physical books, digital resources, and learning services, enabling multi-scenario adaptation and resource collaboration. For example, an app can be developed to provide learning feedback mechanisms, error collection features, and dynamic path recommendations, which can be linked with guidance tasks and QR codes in the physical books to form a complete learning loop: “Reading—Practice—Feedback—Consolidation.” For the teacher’s side, teaching resources such as courseware templates and classroom interaction packages can be developed. For parents, functions like “reading prompts,” “difficulty indicators,” and “learning suggestions” should be strengthened to enhance family engagement.

4.3. Focusing on the integration of learning incentive mechanisms and literacy extension content

Currently, leveled mathematics books in the market face issues such as vague additional value design and ineffective incentives. Therefore, a dual-value system combining learning incentives and content depth should be prioritized. The product content should incorporate layered incentive mechanisms, such as “challenge tasks,” “stage check-ins,” and “badge systems,” and use designs like growth record books and achievement-sharing pages to make the learning process visual and achievable. Additionally, the inclusion of “mathematics culture” modules, such as stories of mathematicians, the history of mathematics, and the connection between mathematics and daily life, will enhance the books’ literacy depth and spiritual value. This shift encourages users to move from “finishing a book” to “completing a growth experience”^[7].

4.4. Building a personalized brand and community operation mechanism

Brand communication should not rely solely on the book content itself, but also on continuous user communication mechanisms. Publishers should strengthen emotional connections and user engagement by building a personalized brand image and a user community ecosystem. On one hand, this can be achieved by creating exclusive IP characters for the book series, forming a unified visual system and value expression, thus enhancing brand recognition and approachability. On the other hand, by operating a reader community platform, interactive activities such as “parent sharing sessions,” “teacher-student reading days,” and “book challenge competitions” can be organized to increase user stickiness and brand loyalty, transforming the relationship from “product purchase” to “brand following”^[8,9].

5. Retrospect and prospect

With the deepening implementation of the “Double Reduction” policy and the ongoing promotion of quality education, leveled mathematics readers, as a bridge between educational needs and family reading, are increasingly showing their unique market value and educational potential. However, the current category still faces many shortcomings in areas such as content logic, functional expansion, and user relationship building, making it difficult to support long-term user engagement and brand establishment. Traditional publishing marketing thinking is no longer sufficient to address the diversified, multi-scenario, and multi-layered value demands of users in the new era.

This paper uses the 4V marketing theory as an analytical framework, combining the two typical cases of “Climbing Mathematics” and “Spark Mathematics” to identify the main issues in differentiation expression, functional integration, added value, and user resonance in leveled mathematics readers. It proposes a four-dimensional strategy model based on user-value orientation. The study shows that the 4V theory is highly adaptable and valuable for guiding the systematic optimization of product design, service layout, and brand operation, providing a path for the transformation of educational books from “content publishing” to “user operation.”

However, this study still has some limitations. On one hand, the research primarily relies on typical case analysis, lacking large-scale quantitative data to verify the model’s dimensions. On the other hand, the practical effectiveness of the 4V strategy system has yet to be evaluated through long-term tracking in real markets. Future research could further combine empirical research, user behavior data, and publishing institutions’ operational practices to systematically validate the implementation effects of different strategy dimensions. Additionally, the research scope could be expanded to include other literacy-related books, such as those in science, logic, and programming, to test the model’s cross-category transferability.

Disclosure statement

The authors declare no conflict of interest.

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Surpassing the Silence of the DSM: Discussion on the Digital Trade Dispute Resolution Path for China and the Global South Countries under the Paralysis of the WTO Appellate Body

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Abstract: Since the appointment of new appellate judges by the World Trade Organization (WTO) was banned in 2019, the paralysis of the appellate body has seriously damaged the Dispute Settlement Mechanism (DSM), leaving a gap in resolving the escalating digital services trade disputes involving complex issues such as data flow and algorithm governance, and the existing WTO rules have failed to fully address these problems. Although MPIA offers a temporary alternative, its limited membership, uncertain executability, and untested applicability to new types of digital disputes make it inadequate. Meanwhile, the rising technological nationalism and fragmented regulations (such as the GDPR and the CLOUD Act) have exacerbated the global digital governance divide, marginalizing China and the countries in the Global South. This article analyzes the decline of DSM, highlighting the eroded rule predictability and legal fragmentation, and critically assesses the limitations of MPIA and the deficiencies of the traditional WTO framework in disputes such as data localization. A series of cases has revealed the trends of “pre-dispute governance” and unilateralism. In the face of this dual crisis, this article holds that China and the Global South must embark on a path of transformation from “system participants” to “system shapers,” rather than merely conforming. The strategies it explores include leveraging domestic regulations (such as data outbound security assessment), promoting regional cooperation (such as the mediation mechanism of RCEP), and advancing initiatives like the Global Data Security Initiative. This dual approach of maintaining “policy sovereignty” and establishing “compliance sovereignty” aims to ensure institutional autonomy, enhance rule-making capabilities, and establish a fairer, rule-based digital trade order in the context of DSM paralysis and regulatory fragmentation.

Keywords: DSM; MPIA; Digital services trade; China-Global South rule-shaping

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1. Introduction

As the global economy undergoes digital transformation, digital services trade has increasingly become a new

focal point in international economic governance. As a key component of the digital economy, digital services trade encompasses not only the cross-border transmission, storage, and processing of data but also multiple fields such as algorithm services, cloud computing, platform economy, and digital platform governance^[1]. Its legal attributes and institutional norms are far more complex than those of traditional goods or services trade. Under this situation, the major theoretical and practical issues facing global data service governance are how to effectively resolve international disputes involving digital services trade and improve the dispute resolution mechanisms for digital services trade.

However, at a time when such disputes are rapidly increasing, the global multilateral trading system is experiencing unprecedented institutional dysfunction. Since its establishment, the WTO's Dispute Settlement Mechanism (DSM) has been regarded as the cornerstone of global economic rule of law. Although it is difficult to accept, the WTO is indeed in decline. Since 2019, the WTO's Appellate Body has been paralyzed due to the United States' prolonged obstruction of new judge appointments, rendering the DSM's three-tiered mechanism system effectively unable to function properly^[2]. This has left trade disputes among members without final, binding rulings^[3]. Such institutional paralysis not only undermines the WTO's authority and credibility but also poses a fundamental challenge to the rules-based multilateral trade system.

Against the failure of the DSM, some members have attempted to fill the institutional void by establishing the Multi-party Interim Appeal Arbitration Arrangement (MPIA)^[4]. On April 27, 2020, China, along with the European Union and more than ten other WTO members, jointly released a ministerial declaration announcing the establishment of the MPIA within the WTO framework. Under this mechanism, disputes among participating members during the temporary suspension of the Appellate Body will be resolved through arbitration procedures outlined in Article 25 of the WTO's Understanding on Rules and Procedures Governing the Settlement of Disputes. China expressed its commitment to collaborating with other WTO members to actively advance efforts to resolve the impasse in the appointment process of Appellate Body members through the MPIA. The goal is to restore the normal functioning of the Appellate Body at the earliest opportunity, thereby upholding the rules-based multilateral trading system^[5]. However, as a temporary arrangement, the MPIA has a limited scope of participating members, insufficient binding force, and lacks predictability, and thus cannot fully replace the original DSM system^[6]. What's more? There are no disputes involving digital services trade that have been addressed through the MPIA mechanism, and its applicability and effectiveness in addressing complex issues such as data flows, digital regulation, and platform rules remain to be tested^[7].

Meanwhile, a new wave of global conservatism is profoundly reshaping the international environment for digital services trade. As Lin *et al.* discussed, major developed countries are increasingly linking data flows and data service trade to national security and technological competition^[8], strengthening control over domestic and foreign platforms through the CLOUD Act, export controls, and investment reviews^[9]. The European Union (EU), on the other hand, is establishing its dominant data governance framework through regulations such as the General Data Protection Regulation (GDPR) and the Digital Markets Act (DMA), exporting compliance standards with strong extraterritorial effects^[10]. The EU had discussed issues related to data services in the GDPR, and the AIA completes the general principles on algorithmic systems and their operation with a risk-based approach to categorization^[11]. As discussed by Wang and Zuo, this trend not only results in highly fragmented global digital governance rules but also creates institutional tensions and disputes between different jurisdictions regarding data sovereignty, review authority, and compliance standards^[12].

Against this failure, cross-border disputes in digital services trade are beginning to exhibit new legal

characteristics and challenges: for example, do data localization requirements fall under the “necessity” exception under the GATS ^[13]? Does the algorithmic black box constitute an implicit technical barrier? These issues often involve sovereignty claims, regulatory logic, and legal cultures across different jurisdictions, and there is a lack of clear adjudication pathways and precedents under existing WTO rules and dispute resolution practices ^[14].

For China, while digital services trade is developing rapidly, it must also confront multiple challenges: on the one hand, platform companies expanding overseas are increasingly facing legal uncertainty and compliance pressures from markets such as the United States, the European Union, and India; on the other hand, for global south countries, the influence in global digital rule-making and dispute resolution mechanisms remains limited ^[15]. How to establish compliance safeguards through domestic regulations and regional arrangements in the context of institutional failure, while enhancing institutional participation and rule-shaping capabilities in international dispute resolution and data global governance, has become a key issue for promoting the sustainable development of China’s digital services trade ^[16].

This article aims to respond to the above questions and focuses on institutional responses to digital trade disputes in the context of the failure of global dispute resolution mechanisms. This article will first analyze the functional decline of the WTO dispute resolution mechanism and its institutional impact on the handling of digital trade disputes, and then assess the operational logic and practical limitations of the MPIA mechanism. Subsequently, this paper will explore the unique legal structure and international trends of digital services trade disputes, particularly in the context of global digital governance, exhibiting a multipolar and fragmented landscape. It will examine how China can establish a dispute resolution mechanism that balances compliance and strategic considerations. Through a combination of institutional analysis and case studies, this article attempts to provide theoretical support and policy recommendations for China to secure greater institutional autonomy and governance leadership in the digital age.

2. The decline of the DSM and its institutional impact on the handling of disputes in digital services trade

2.1. Structure and original functions of the DSM

The WTO Dispute Settlement Mechanism’s core design consists of a 3-stage process: consultation, panel review, and Appellate Body ruling ^[17]. Due to its automaticity, enforceability, and time limits, the mechanism was once considered one of the most successful dispute resolution models in the field of international economic law. In particular, the authoritative rulings made by the Appellate Body are not only legally binding but also form a system of “jurisprudence constante” under the WTO framework through the “accumulation of precedents,” providing institutional guarantees for the stable operation of the multilateral trading system ^[18].

Over the years, the DSM has played a positive role in resolving disputes related to traditional goods trade and certain service trade issues, including cases involving most-favored-nation treatment, national treatment, technical barriers to trade, and subsidy measures. However, entering the second decade of the 21st century, as global trade structures underwent profound transformations and the nature of disputes became increasingly complex, the institutional tensions and operational risks of the DSM began to surface ^[19].

2.2. The paralysis of the Appellate Body and the outbreak of a systemic crisis

Since 2017, the United States has continuously blocked the appointment of new judges on the grounds that the Appellate Body has “overstepped its authority” and that the Dispute Settlement Understanding (DSU) does not

sufficiently reflect member sovereignty^[20]. Finally, in December 2019, due to the lack of three judges, the WTO Appellate Body was unable to form an arbitration panel and officially became paralyzed. This marked the failure of the core mechanism of the DSM and also meant that the WTO dispute settlement system entered an “era without appeals.”

The institutional paralysis of the Appellate Body triggered a widespread crisis of institutional trust, manifested in uncertainty among member states regarding the application of rules, thereby weakening the enforceability of dispute rulings. Additionally, due to the inability to appoint new judges, the “two-tiered adjudication” system was forced to simplify into a one-instance final adjudication mechanism, lacking review procedures and final adjudication mechanisms, further impacting the quality of DSM rulings. The failure of the DSM has further negatively affected the multilateralism supported by the WTO, with some countries choosing to replace multilateral mechanisms with unilateral retaliatory measures or bilateral consultations. Of particular concern is that, although the WTO framework has not yet formed systematic rules for digital trade in services, there is a trend toward an increase in related disputes in the future. In this institutional vacuum, the WTO will be unable to perform its ruling functions normally, and there will be a serious shortage of institutional supply in the digital field.

2.3. New requirements for DSM in digital services trade

Digital services trade has legal characteristics and governance challenges that are significantly different from traditional trade, imposing new institutional requirements on dispute resolution mechanisms. First, the digital services trade is highly mobile. Second, the cross-border nature of digital services often involves multiple jurisdictions and regulatory authorities, making it difficult to apply traditional territorial jurisdiction principles. In terms of evidence review, digital services often involve complex and specialized algorithmic structures and issues related to encrypted storage and transparency crises, significantly increasing the difficulty of obtaining and verifying evidence during the adjudication process^[21]. Additionally, digital trade disputes often involve the intersection of issues across multiple dimensions, such as platform compliance obligations, data privacy rights, and national security, often leading to conflicts between multiple rights that cannot be resolved by a single rule^[22].

However, the WTO has no precedents for rulings on data localization, digital censorship measures, and cross-border compliance disputes, and there is a lack of legal logic that can be applied by analogy. For this reason, the adjudication of digital service trade disputes cannot simply rely on the application of existing GATS provisions or TBT agreements, but requires new methods of interpretation and rule construction^[23]. This requires the DSM to have a higher level of professionalism, adaptability, and institutional innovation capabilities.

2.4. The systemic impact of institutional failure on global digital trade governance

The failure of DSM is not only a procedural crisis, but also poses a structural challenge to the global digital trade governance system. First, it undermines the “predictability of rules” in cross-border data service trade. Businesses and platforms have to deal with compliance issues when it comes to data flow and service exports, which raises legal concerns. Second, it leads to “legal fragmentation” in international trade regulations^[24]. To settle digital conflicts, some members may turn to domestic laws, regional agreements, or bilateral agreements. This makes the institutional structure more fragmented^[25]. In this context, the establishment of the MPIA and the exploration of regional arbitration mechanisms reflect members’ efforts to address the shortcomings of existing mechanisms and maintain the fragile global order. Against this failure, members of the MPIA, or we say those members who hope the WTO will continue to play a role in the resolution of international trade disputes, must reevaluate their role and

strategic positioning in the global digital services trade dispute resolution mechanism, and consider how to create institutional responses in the face of institutional failure, while safeguarding national development interests and promoting the construction of a new institutional framework.

The rise of regional digital economy agreements has further exacerbated the trend toward fragmentation in global dispute resolution mechanisms. The Digital Economy Partnership Agreement (DEPA), the United States-Mexico-Canada Agreement (USMCA), and the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) all attempt to introduce high standards for data, but their dispute resolution mechanisms are mainly based on bilateral consultations, soft law frameworks, or regional arbitration, and are not subject to the unified jurisdiction of the WTO ^[26]. This trend of institutional externalization has increased rule diversity and room for experimentation in the short term, but in the long term, it may pose a challenge to the consistency of global trade law and the uniform application of WTO rules ^[27]. It is particularly worth noting that in the process of foreign countries imposing market bans or technical sanctions on China's digital service providers, dispute resolution often does not enter the WTO track but bypasses multilateral mechanisms through exceptions such as national security and data protection. This trend of "universalization of exceptions" (rather than general exceptions) has gradually eroded the institutional authority of the WTO as the "gatekeeper" of the international trade legal order, and has also placed developing members and countries in the Global South in an increasingly asymmetrical position in the institutional game ^[28].

3. Exploring the Chinese path: From compliance to controversy-driven institutional innovation

In the face of DSM's failure, the Global South countries need to re-establish institutional responses in the field of digital service trade and further transform themselves from passive "system participant" to "system shaper." This transformation is not a rash move, but is rooted in the reality of the absence of international rules and the intensification of political risks.

3.1. The incident and the absence of multilateral DSM as a case study

Take a certain international data platform service provider as an example. Since 2020, the application has faced multiple bans and national security reviews in the United States. The controversies surrounding its data services should be categorized as investment disputes, digital service freedom, and data flow conflicts. However, due to the lack of clear rules for such data-intensive services in the World Trade Organization's General Agreement on Trade in Services (GATS) and the fact that the investment dispute settlement mechanism (ISDS) is mainly dominated by investment protection treaties, the provider was ultimately forced to defend itself in US courts and even considered selling or restructuring its US business at one point ^[29].

In 2023, the European Data Protection Board (EDPB) released a review report on third-country cloud service providers, issuing a compliance warning to a certain overseas enterprise regarding its data processing practices, stating that its data access transparency and data subject rights protection were not in line with the General Data Protection Regulation (GDPR). Although the incident did not escalate into a formal dispute, it significantly hindered the enterprise's business development in Europe through the EU's internal enforcement mechanism ^[30]. This case reveals a trend toward "pre-dispute governance," where national regulatory mechanisms preemptively "set the tone" before institutional triggers are activated, effectively creating de facto market exclusion ^[31].

3.2. Dual coordination path of “policy sovereignty” and “compliance sovereignty”

Faced with an increasingly complex digital service governance landscape, China’s choice of path is no longer a simple choice between “complying with existing rules” and “withdrawing from or confronting rules,” but rather an effort to build a dual mechanism that is compatible with “policy autonomy” and “international compliance.” On the other hand, China continues to emphasize the global consensus on free trade, technology neutrality, and freedom of services in international forums, and actively participates in WTO e-commerce negotiations and regional agreements (such as RCEP) to ensure “rule security” for external digital services^[32]. By establishing data sovereignty red lines domestically and building compliant channels internationally, China aims to provide sufficient legal space and international acceptability for the actions of Chinese enterprises and the government in an era of rule fragmentation.

4. From “participant” to “leader”: China’s role transformation in global digital dispute governance

With the collapse of the WTO dispute settlement mechanism (DSM) and the surge in disputes over digital trade in services, the “multilateral narrative” of global trade governance is gradually giving way to a new order of “region-led” policy space conflict. Against this backdrop, Global South Countries not only face a lack of tools to protect their rights, but also face the systemic challenge of how to rebuild their voice in digital governance rules. This challenge is not only a legal and regulatory challenge but also a contest of institutional identity and value systems.

4.1. Mechanistic attempts to proactively shape rules

To better address these issues, Global South Countries need to shift from “adhering to existing rules” to “shaping future rules” in the field of resolving disputes in digital services trade. For example, the proposal of the Global Data Security Initiative and the integration of digital trade issues into the negotiations for the upgrading of the China-ASEAN Free Trade Area, both of which demonstrate China’s efforts to reshape the foundational rules of digital trade through multilateral or regional platforms^[33]. These institutional building attempts not only help reduce reliance on a single system but also provide developing countries with a “non-Western-centric” institutional option^[34].

More significantly, China is promoting the establishment of a digital trade dispute resolution mechanism with Chinese characteristics, such as exploring a dispute resolution path within the RCEP that focuses on “neutral mediation & expert assessment.” Such mechanisms are more flexible and efficient than the WTO dispute resolution process and can respond more promptly to disputes in the face of a rapidly changing technological ecosystem.

4.2. Systemic construction of cross-jurisdictional compliance mechanisms

In response to the increasingly complex global compliance environment, the Chinese government and businesses are concurrently advancing a more forward-looking cross-jurisdictional compliance mechanism^[35]. For instance, China has recently enacted the “Measures for the Security Assessment of Data Outbound Transfer” and the “Personal Information Protection Law,” while strengthening data governance responsibilities for platform companies^[36]. These measures are not only institutional responses to external pressures but also crucial steps to enhance China’s institutional competitiveness.

Additionally, in its digital cooperation with countries along the Digital Belt and Road Initiative (DBAR)^[37],

China's data service trade cooperation model is presenting a positive situation of "co-construction, co-governance and shared benefits"^[38]. While this mechanism may not be as systematic as the EU's General Data Protection Regulation (GDPR) in form, it places greater emphasis on flexibility and respect for sovereignty, aligning more closely with the concerns of Global South countries regarding development rights and data sovereignty^[39].

5. Conclusion: A new path for dispute resolution in the era of digital sovereignty

Under the dual impact of the ineffectiveness of the WTO dispute settlement mechanism and the resurgence of global conservatism, dispute resolution in the field of digital trade in services is entering a transitional period of "authority imbalance and order restructuring." China must find its own path of development and institutional breakthroughs amid these changes.

This article argues that the WTO Dispute Settlement Mechanism faces structural difficulties and that the MPIA is temporary and limited. It also reveals the current trend toward diversification in regional dispute resolution mechanisms in digital trade in services. At the same time, if Global South countries want to occupy a dominant position in data services trade dispute resolution and global digital trade governance, they must consider transforming themselves from rule acceptors to rule contributors, especially for countries in the Global South. such as the construction of compliance mechanisms, the promotion of regional cooperation, and the establishment of a legal basis. In the future, if China can further strengthen its discourse system in terms of institutional transparency, predictability, and data governance legitimacy, and expand its influence through institutional output and experience sharing, China will, together with other countries in the Global South, actively participate in building a new positive DSM order in international data service trade and global digital governance, to safeguard the rules-based multilateral trading system.

Disclosure statement

The author declares no conflict of interest.

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Bitcoin's Weekend Effect: Returns, Volatility, and Volume (2014–2024)

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Abstract: Using daily BTC-USD data from September 19, 2014 to January 21, 2024, this paper re-examines whether weekends differ from weekdays for Bitcoin along three margins: average returns, close-to-close volatility, and trading activity. We implement Welch mean comparisons and HAC-robust OLS with month fixed effects (bandwidths 5, 7, and 14). In the full sample and across subsamples (2016–2019; 2020–2023; early 2024), we find no detectable weekend–weekday gap in average returns, while volatility and trading activity are lower on weekends. The patterns are robust to using squared returns as a volatility proxy. The joint evidence is consistent with liquidity and attention mechanisms—quieter weekends rather than compensating return premia. Replication files reproduce all tables and figures.

Keywords: Bitcoin; Weekend effect; Day-of-the-week; Volatility; Trading volume; HAC; Cryptocurrency

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1. Introduction

1.1. Background and motivation

Calendar anomalies—such as day-of-the-week or weekend effects—have long attracted empirical scrutiny in both traditional assets and cryptocurrencies^[1–3]. Unlike equities that cease trading overnight and over weekends, Bitcoin (BTC) operates in a 24/7 environment. Continuous trading weakens exchange-hours explanations but sharpens alternative channels linked to liquidity, investor attention, and information arrival. A priori, weekends could feature lower participation and thinner order books as institutions scale down activity, with fewer macro or firm-level announcements to process; these forces can compress trading intensity and realized volatility without requiring a weekend return premium^[1–4]. At the same time, round-the-clock access and globally distributed retail participation could, in principle, generate distinct weekend dynamics. The net weekend–weekday contrast is therefore an empirical question.

1.2. Related literature and gap

Early studies on cryptocurrencies documented mixed day-of-the-week patterns in returns and activity, with

evidence often sensitive to sample windows, modelling choices, and market regimes ^[1–3]. Post-2020, structural features around participation and volatility changed markedly for BTC, motivating updates that extend the window and re-examine simple, policy-relevant outcomes ^[4]. Beyond mean returns, a practical angle for risk management is how active and how volatile weekends are relative to weekdays. Microstructure research links order-flow, depth, and spreads to realized volatility and execution costs; for crypto markets, weekend shifts in activity and depth have been discussed alongside attention proxies such as Google Trends ^[5,6]. A compact, replication-ready reassessment that foregrounds returns, close-to-close volatility, and trading activity over a long horizon remains valuable.

1.3. Research questions and contributions

This paper asks whether BTC’s weekend days differ from weekdays along three margins: (1) average close-to-close returns; (2) a volatility proxy based on absolute returns; and (3) trading activity measured by volume. Our contributions are threefold. (1) Scope: We assemble a decade-long daily sample (2014–2024), covering multiple market regimes, and study both the full sample and three subsamples (2016–2019; 2020–2023; early-2024). (2) Transparency: We use Welch mean comparisons and ordinary least squares (OLS) with Newey–West HAC errors and month fixed effects; replication files reproduce every table and figure. (3) Focus on activity: Rather than chasing unstable mean-return premia, we foreground volatility/activity contrasts that directly inform execution and timing decisions ^[1–4,6].

1.4. Preview of methods and data

We compute close-to-close log returns (in basis points, bp) from publicly available BTC-USD daily data. Weekends are coded for Saturday/Sunday. We first compare weekend and weekday means via Welch’s unequal-variance t-tests. We then estimate a parsimonious regression, $Y_t = \alpha + \beta \cdot \text{Weekend}_t + \text{Month FE} + \varepsilon_t$, where Y_t alternates between return (bp), $|\text{return}|$ (bp), and $\ln(1+\text{Volume})$. Standard errors are HAC-robust (bandwidth 7) with sensitivity checks at 5 and 14. For robustness, we replace absolute returns with squared returns ^[1–4].

1.5. Key findings and implications (preview)

We find no detectable weekend–weekday gap in average returns, whereas both absolute returns and trading activity are lower on weekends. These patterns hold across subsamples and HAC bandwidths. Interpreted through microstructure and attention lenses, BTC’s weekends look quieter rather than risk-compensated: lower participation and fewer salient information releases plausibly dampen volatility and volume without creating an excess weekend return premium ^[1–4,6]. For practitioners, execution of large, time-sensitive orders may be favored on weekdays with deeper liquidity, while small non-urgent flows may exploit quieter weekends if spreads are acceptable.

2. Materials and methods

2.1. Data and sample

Data provenance and provider conventions: We use publicly accessible BTC-USD daily data exported from Yahoo Finance under the provider’s native day boundary and aggregation. Prices and volumes are standardized to the fields Date, Open, High, Low, Close, Volume. We keep close-to-close intervals as provided, noting that alternative time-zone alignments (e.g., UTC re-aggregation) are immaterial for our weekend–weekday contrast by construction (See **Notes**).

We use daily BTC-USD data exported from Yahoo Finance. The sample spans 2014-09-19 to 2024-01-21

(inclusive). We keep the provider’s native day boundary and standardize fields (Date, Open, High, Low, Close, Volume) prior to analysis.

2.2. Variables and measurement

Variable construction: Close-to-close log returns are converted to basis points ($\text{bp} = 10^{-4}$). Our main volatility proxy is $|\text{return}|$ in bp; robustness uses squared returns in bp^2 . Trading activity is proxied by RawVolume; regressions use $\ln(1+\text{Volume})$ to limit skew. Weekend is an indicator for Saturday/Sunday. Subsamples are P1 = 2016–2019, P2 = 2020–2023, P3 = January-2024.

Return (bp): close-to-close log return reported in basis points (bp). Volatility proxy (bp): $|\text{return}|$ (bp) as the main proxy; squared returns (bp^2) for robustness. Trading activity: RawVolume; regressions use $\ln(1+\text{Volume})$. Weekend = 1 for Saturday/Sunday. Subsamples: P1 = 2016–2019; P2 = 2020–2023; P3 = 2024 (January).

2.3. Empirical design

Estimation details: Welch tests use unequal variances with two-sided p-values. For OLS, we include month fixed effects to absorb seasonality and report HAC (Newey–West) errors with a default bandwidth of 7 and sensitivity at 5 and 14. Coefficients are shown with standard errors, *P*-values, and *t*-based 95% confidence intervals.

Cleaning rules and reproducibility: We sort by date, drop rows with missing Date/Close/Volume, compute returns via first differences of log prices, and retain observations with non-missing outcomes and covariates. All steps are scripted; replication files include the cleaned CSV and code that regenerates all tables and figures.

We contrast weekend and weekday means using Welch’s *t*-tests and estimate OLS with Newey–West HAC errors (bandwidth 7; sensitivity 5 and 14) and month fixed effects. Coefficients are reported with standard errors, *P*-values, and 95% confidence intervals.

2.4. Ethics and reproducibility

Public, non-identifiable market data; replication files reproduce all tables and figures.

3. Results

3.1. Descriptive patterns

Descriptive statistics (**Table 1**) suggest lower weekend activity and tighter $|\text{return}|$ distributions; average returns look similar.

Table 1. Descriptive statistics by weekend indicator

Group	Variable	N	Mean	SD	Median	P25	P75
Weekday	Return (bp)	2436	15.17	400.18	15.23	-143.62	184.49
Weekend	Return (bp)	975	9.13	290.95	11.23	-87.94	129.37
Weekday	$ \text{Return} $ (bp)	2436	262.63	302.29	162.9	64.9	344.42
Weekend	$ \text{Return} $ (bp)	975	190.44	220.07	112.29	38.96	256.05
Weekday	$\ln(1+\text{Volume})$	2436	21.94	2.75	23.31	19.06	24.09
Weekend	$\ln(1+\text{Volume})$	975	21.69	2.76	22.94	18.75	23.82

Notes: Weekend = Saturday/Sunday. Return in bp; $|\text{return}|$ in bp; volume in log units.

3.2. Mean comparisons (Welch tests)

See **Table 2** and **Figures 1** to **3** below.

Table 2. Weekend vs. weekday: Mean differences (Welch tests)

Outcome	<i>n</i> (Wd)	<i>n</i> (W)	Mean (Weekday)	Mean (Weekend)	Diff (W – Wd)	<i>t</i>	<i>P</i>
Return (bp)	2436	975	15.17	9.13	-6.04	-0.49	0.625
Return (bp)	2436	975	262.63	190.44	-72.18	-7.73	0.0
ln(1+Volume)	2436	975	21.94	21.69	-0.24	-2.34	0.019

Notes: Welch two-sample tests with unequal variances; two-sided *P*-values.

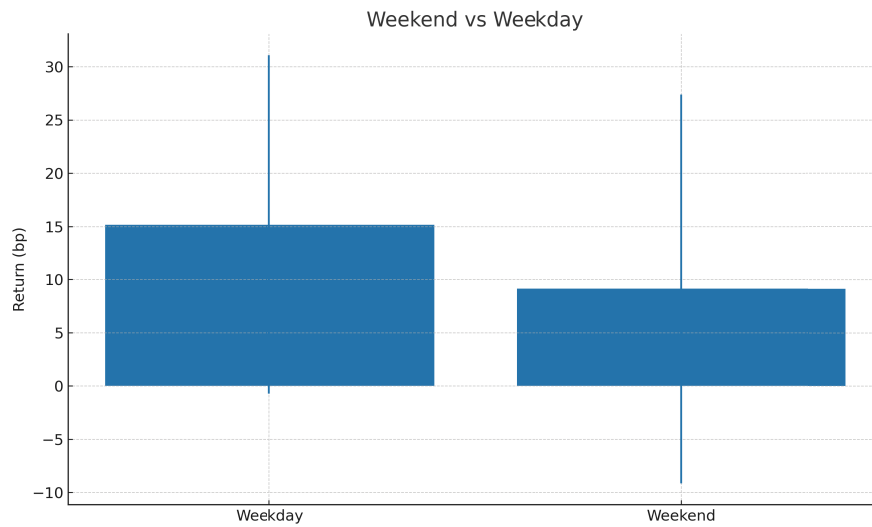


Figure 1. Mean daily Return (bp): Weekend vs. weekday (95% CI)

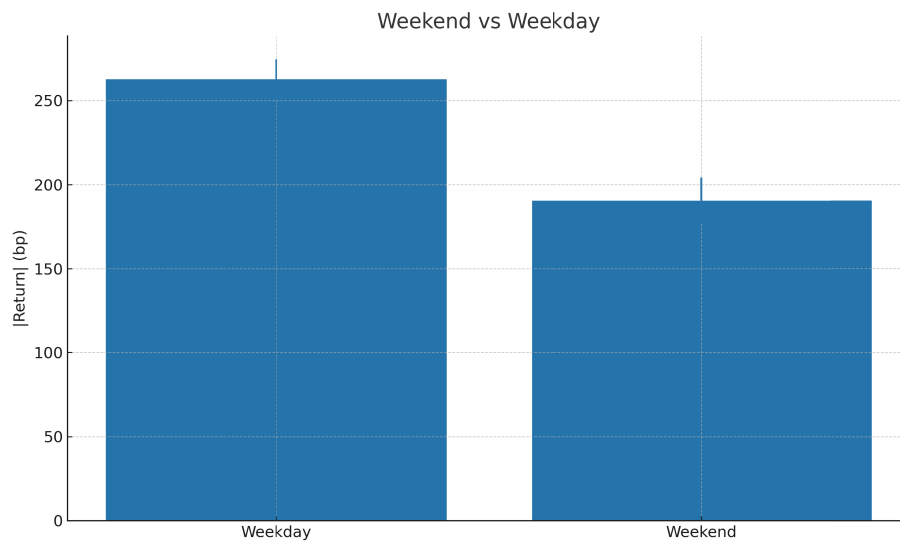


Figure 2. Mean |Return| (bp): Weekend vs. weekday (95% CI)

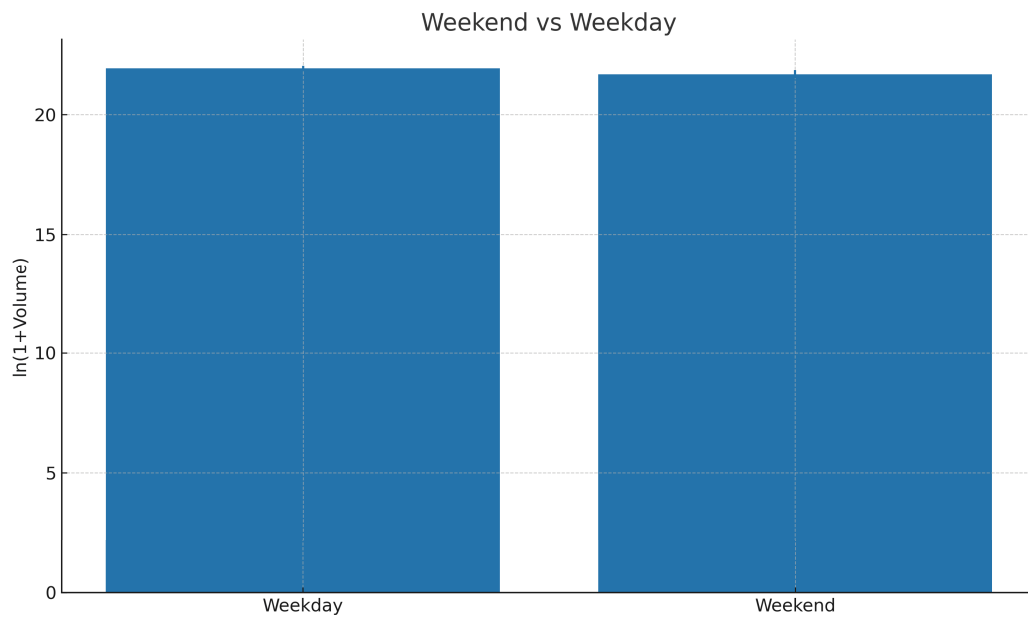


Figure 3. Mean $\ln(1+\text{Volume})$: Weekend vs. weekday (95% CI)

3.3. Baseline HAC-OLS (full and subsamples)

See **Table 3** and **Figures 4** to **6** below.

Table 3. Weekend effect (β on Weekend) — OLS with HAC(7)

Outcome	Subsample	β	SE	95% CI lo	95% CI hi	<i>P</i>	<i>n</i>
Return (bp)	full	-6.38	11.62	-29.14	16.39	0.583	3411
Return (bp)	full	-71.8	8.72	-88.88	-54.72	0.0	3411
$\ln(1+\text{Volume})$	full	-0.24	0.04	-0.32	-0.17	0.0	3411
Return (bp)	P1	9.59	19.78	-29.17	48.35	0.628	1461
Return (bp)	P1	-58.77	14.75	-87.67	-29.87	0.0	1461
$\ln(1+\text{Volume})$	P1	-0.17	0.05	-0.26	-0.08	0.0	1461
Return (bp)	P2	-12.11	15.28	-42.05	17.84	0.428	1461
Return (bp)	P2	-104.63	10.88	-125.96	-83.3	0.0	1461
$\ln(1+\text{Volume})$	P2	-0.3	0.02	-0.33	-0.26	0.0	1461
Return (bp)	P3	-69.35	50.72	-168.76	30.06	0.172	20
Return (bp)	P3	-210.28	49.51	-307.32	-113.25	0.0	20
$\ln(1+\text{Volume})$	P3	-0.66	0.1	-0.85	-0.47	0.0	20

Notes: OLS with month fixed effects; Newey–West HAC standard errors (bandwidth = 7).

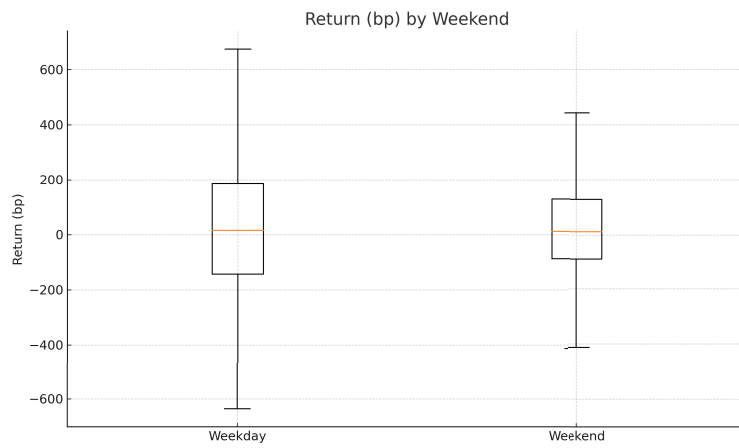


Figure 4. Return (bp): Boxplot by weekend indicator

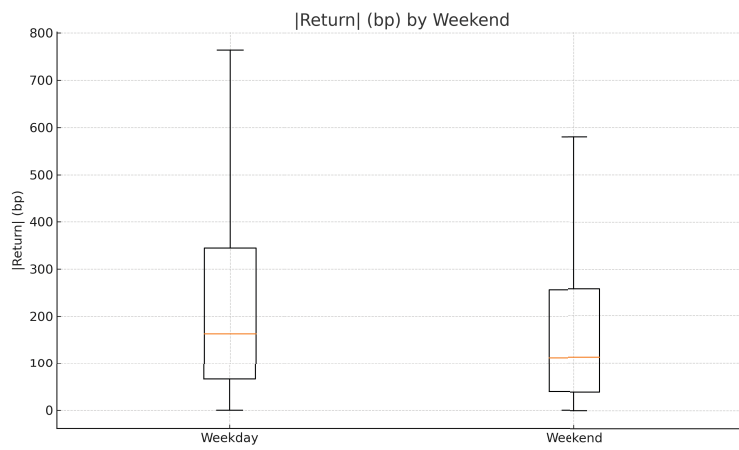


Figure 5. |Return| (bp): Boxplot by weekend indicator

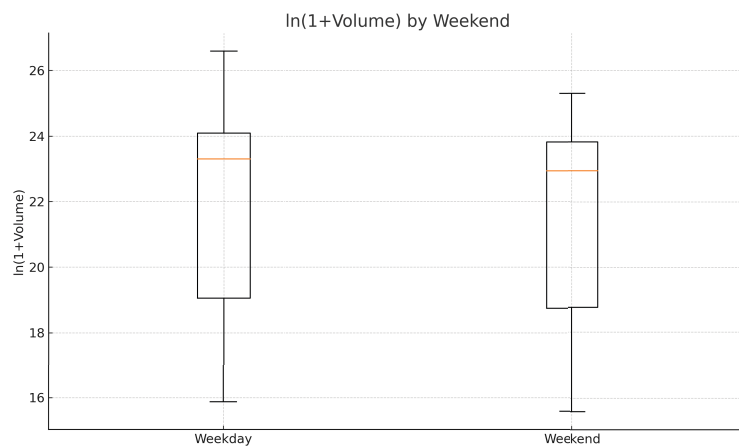


Figure 6. ln(1+Volume): Boxplot by weekend indicator

4. Discussion

4.1. Mechanisms: Liquidity, attention, and information flow

Interpreting weekend quietness: Lower $|\text{return}|$ and volume on weekends suggest thinner participation and slower information diffusion, consistent with attention-based mechanisms and microstructure links between depth, order-flow, and realized volatility ^[1–4,6]. In a 24/7 market, the absence of exchange closures does not preclude weekend-specific frictions: staffing, market-making intensity, and news cadence can still vary meaningfully across the week ^[5,6].

Our evidence—no weekend premium in average returns but lower weekend $|\text{return}|$ and trading activity—aligns with a combination of liquidity, investor attention, and information-arrival channels. Liquidity: thinner order books and fewer liquidity providers can compress trading intensity and slow price discovery on weekends ^[5]. Investor attention: participation plausibly declines on weekends due to competing activities and reduced institutional coverage, lowering order arrivals and realized volatility ^[6]. Information flow: macro and firm announcements cluster on weekdays, leaving fewer salient signals on weekends; with less news to process, both activity and volatility decrease without requiring a return premium ^[1–4].

4.2. Relation to prior studies

Prior work on day-of-the-week or weekend anomalies in Bitcoin and broader crypto markets reports mixed return patterns, often sensitive to sample windows and model choices ^[1–4]. Our results update the window through 2024-01 and emphasize activity/volatility rather than return premia, consistent with research linking trading intensity and volatility clustering.

4.3. Practical implications

For risk management, the weekend pattern highlights timing risk rather than mean-return differences: liquidity-demanding trades may face lower depth and slower price discovery. For execution, concentrating larger flows on weekdays may reduce slippage; conversely, weekend execution might suit small, non-urgent orders if spreads are acceptable.

4.4. Limitations and future work

Our inference is intentionally simple and transparent. We rely on daily close-to-close measures and provider-native day boundaries; intraday depth/spread data and alternative time-zone aggregations are promising extensions. While BTC is the most liquid cryptoasset, examining cross-asset heterogeneity (e.g., large-cap altcoins) could test whether weekend patterns scale with liquidity.

Limitations include provider-native day boundaries and volume definitions, reliance on daily close-to-close measures, and the BTC-only focus. Extensions include intraday depth/spread analysis, on-chain and attention proxies, multi-asset tests, and updating the sample beyond 2024-01.

HAC bandwidths 5 and 14, and squared-return volatility proxies, deliver the same qualitative takeaway: no weekend return premium; lower weekend volatility/activity. These checks mitigate concerns about short-run serial correlation and the form of the volatility proxy.

5. Conclusion

We document no detectable weekend–weekday gap in average returns for Bitcoin, alongside lower weekend

volatility and trading activity. These patterns persist across subsamples and remain robust under squared-return volatility and alternative HAC bandwidths. The joint evidence favors liquidity/attention mechanisms—quieter weekends rather than compensating return premia.

Notes

- (1) We adopt the data provider's native day boundary and timestamp convention for BTC-USD without re-aggregating to an alternative timezone (e.g., UTC). Our inference focuses on close-to-close differences between weekends and weekdays; results are robust to reasonable boundary variations. Replication files reproduce all tables and figures.
- (2) We treat Volume as provided natively in the downloaded CSV for BTC-USD (provider-native aggregation). Since our main analyses use $\ln(1+\text{Volume})$ and focus on weekend–weekday contrasts rather than levels, conclusions are unlikely to hinge on minor provider conventions.

Disclosure statement

The author declares no conflict of interest.

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A Review of the Research on Supply Chain Relationships and Corporate Finance

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Abstract: The interaction between supply chain relationships and corporate finance has become a focal issue in academic and practical circles, especially under the dual drivers of globalization and marketization. This paper systematically reviews existing research on this topic, covering theoretical foundations from perspectives such as agency theory, stakeholder theory, and co-opetition game theory, which explain the nature of customer-supplier relationships. It also combs through empirical studies from four core angles: competition-cooperation, signal transmission, spillover effects, and information transfer, summarizing findings on how supply chain relationships impact corporate investment, financing, operations, and performance, as well as existing controversies. The aim is to clarify the research context, identify theoretical and empirical gaps, and provide theoretical support and direction for deepening future research on supply chain and corporate finance.

Keywords: Supply chain relationships; Corporate finance; Competition-cooperation; Signal transmission; Spillover effects

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1. Introduction

Driven by globalization and marketization, competition among enterprises has gradually evolved into a collaborative contest between supply chains. As the core link in supply chain networks, the relationship between customers and suppliers increasingly influences corporate operations and management. The “organizational capital” theory points out that long-term cooperative relationships between enterprises and stakeholders are important intangible assets, which can complement tangible assets to enhance corporate value. Stakeholder theory further emphasizes that, as key participants in the product market, customers deeply engage in corporate operations through specific investments and risk-taking, with influence second only to shareholders. Against this backdrop, how supply chain relationships affect corporate financial decisions and economic consequences has become a focus of both academia and practice.

Scholars have conducted extensive research on the interaction between supply chains and corporate finance, yielding rich theoretical and empirical results. Existing literature mainly develops from four core perspectives: competition-cooperation, signal transmission, spillover effects, and information transfer. These perspectives

construct analytical frameworks for understanding the relationship between supply chains and corporate finance from the dimensions of relationship nature, information mechanisms, external impacts, and information utilization, respectively. Despite significant progress in each perspective, issues such as fragmented theoretical logic and controversial empirical conclusions remain. Especially in different institutional and market environments, a unified explanation for how supply chains affect corporate finance has not yet been formed. This paper aims to systematically sort out domestic and foreign research results on supply chains in corporate finance, integrate theoretical foundations and empirical findings from different perspectives, analyze the roots of research controversies, and prospect future directions, providing insights for deepening supply chain financial research.

2. Supply chain relationships from different theoretical perspectives

2.1. Supply chain relationships under agency theory

The customer-supplier relationship meets the two prerequisites of an agency relationship and is bidirectional. First, customers and suppliers exist as independent enterprises, satisfying the first prerequisite. Second, information asymmetry leads to role reversal: suppliers, with more information on product quality, production costs, and inventory when producing raw materials for customers, act as agents while customers are principals; conversely, suppliers may be information-disadvantaged due to uncertainty about customers' future demand, making customers agents and suppliers principals. This bidirectional relationship, lacking effective supervision and incentives, may trigger opportunistic behaviors. Customers may frequently change product demands, deliberately delay payments, or demand price reductions, directly or indirectly encroaching on suppliers' profits; suppliers, fearing uncertain demand or customer bankruptcy, may refuse to provide trade credit or invest in specific relationship assets to produce unique products for customers.

2.2. Supply chain relationships under stakeholder theory

Customers and suppliers are important stakeholders of each other. On one hand, suppliers must deliver qualified products or effective services on time; otherwise, customers may halt production due to a lack of raw materials. Customers are the main source of suppliers' cash flow, and only timely payments ensure suppliers' healthy operation. According to Freeman and Reed ^[1], both customers and suppliers are organizations that influence and are influenced by each other's goal achievement. On the other hand, both parties invest specific relationship assets and bear risks in cooperation. In summary, from the stakeholder theory perspective, the customer-supplier relationship is mutually interdependent—harm to one party will inevitably affect the other.

2.3. Supply chain relationships under co-opetition game theory

Supply chains emphasize “co-opetition,” simply meaning the coexistence of competition and cooperation. Cooperative and non-cooperative game strategies in game theory are widely recognized as optimal methods to analyze supply chain relationships: cooperative games focus on mutual cooperation, while non-cooperative games emphasize competition. From a non-cooperative perspective, if both parties pursue individual profit maximization, neither will achieve optimal results, leading to the so-called “prisoner's dilemma.” This dilemma often occurs in customer-supplier relationships: customers may frequently change demand or cut prices, eroding suppliers' profits; suppliers may secretly compromise quality to save costs, deceiving customers. For example, suppliers may refuse trade credit to customers in financial distress, causing customers to fail to purchase raw materials and face unsold products and inventory backlogs. In short, due to information asymmetry and lack of trust, both parties may

choose non-cooperation, resulting in mutual losses.

3. Literature review

3.1. The perspective of supply chain competition and cooperation

Existing literature mainly explores how supply chain relationships affect corporate investment, financing, operations, and profitability from the perspective of customer concentration. From a competitive angle, customer concentration reflects suppliers' dependence on customers—the higher the concentration, the more suppliers rely on a few major customers, enhancing customers' bargaining power. From a cooperative angle, high concentration reduces transaction partners, facilitating supply chain integration. Thus, customer concentration, reflecting both competition and cooperation, is an excellent perspective to study supply chain impacts on corporate financial behavior. A few studies also explore this relationship from the perspective of supply chain distance.

Regarding corporate investment decisions, Chu et al.^[2] examined the impact of customer-supplier geographical distance on suppliers' innovation, finding that closer distance enhances suppliers' innovation capability. The mechanism is that proximity enables timely customer feedback, allowing suppliers to adjust R&D in intermediate stages, and reduces transportation costs, increasing customer demand and stimulating innovation input.

Corporate financing includes debt and equity financing. In debt financing, Campello and Gao^[3] found that higher customer concentration increases cash flow and liquidity risks, leading to wider loan spreads, shorter terms, and more restrictive clauses. In equity financing, Dhaliwal et al.^[4] sampled U.S. listed companies and found that customer concentration increases the difficulty and cost of equity financing, especially for suppliers likely to lose major customers or suffer huge losses from such a loss.

For corporate operations, high customer concentration gives customers stronger bargaining power—suppliers must produce and invest according to major customers' orders, and frequent demand changes may cause huge losses. However, it also brings benefits, such as reduced marketing/management costs and leveraging customers' brand reputation to boost sales. Overall, customer concentration has pros and cons for suppliers, but corporate performance is the comprehensive indicator. Patatoukas^[5] found a significant positive correlation between customer concentration and supplier performance: despite lower gross margins, suppliers with concentrated customers have lower management expenses per dollar of revenue, less inventory, and higher asset turnover, resulting in a positive net impact. Irvine et al.^[6] empirically found that the correlation between customer concentration and profitability turns from negative to positive as the relationship matures: initial heavy relationship asset investment leads to poor performance, but later scale effects of these assets improve profitability. However, Hui et al. found a significant negative correlation^[7].

3.2. The perspective of supply chain signal transmission

In customer-supplier relationships, either party may terminate cooperation if it doubts the other's ability to fulfill implicit commitments^[8]. Thus, both have incentives to send positive signals about their operations to shape favorable expectations. Graham^[9] surveyed 400 executives and found that suppliers and customers of startups need more future guarantees, and stakeholders' implicit claims significantly influence these enterprises' accounting decisions. Bowen et al.^[10] noted that earnings management can enhance reputation among stakeholders, securing better transaction terms. Dou et al.^[11] found that customers use earnings smoothing to show sound financial

conditions, attracting more supplier investment in specific assets.

Corporate bankruptcy renders specific relationship assets of non-financial stakeholders worthless. Since financial leverage is directly related to bankruptcy risk, it is an important signal between customers and suppliers. Kale and Shahrur^[12] used R&D expenditure as a proxy for specific asset investment and found that more such investment from customers/suppliers leads to lower asset-liability ratios, indicating enterprises reduce leverage to attract more investment. Banerjee et al.^[13] further found that enterprises dependent on a few major suppliers or customers have lower leverage to attract beneficial specific investments, resulting in a significant negative correlation between supply chain concentration and financial leverage. However, higher supply chain concentration strengthens counterparties' bargaining power. Higher debt reduces profits available for counterparties to encroach, so enterprises facing stronger bargaining power may choose higher debt levels.

3.3. The perspective of supply chain spillover effects

Spillover effects refer to an organization's actions affecting not only itself but also others. Supply chain spillover effects arise because customers and suppliers, as key nodes in contractual networks with close competition and cooperation, inevitably influence each other. A classic example is the "bullwhip effect" in supply chains: demand forecasts, price fluctuations, and supply shortages amplify along the chain, distorting reality. In the early 1990s, U.S. companies like HP and P&G confirmed this effect, sparking extensive research in supply chain management.

Literature in corporate finance explores how events like bankruptcy, mergers, and management changes at one end of the supply chain affect the other: Hertz et al.^[14] found that customer bankruptcy announcements have significant negative contagion effects on suppliers' stock prices, mainly due to high replacement costs. Fee and Thomas^[15] found that after customers' horizontal mergers, suppliers losing relationships suffer stock price drops, while those maintaining relationships gain positive returns with no substantial operational changes. Shahrur^[16] found that corporate horizontal mergers bring positive abnormal returns to customers and suppliers, contradicting the expectation that larger scale enhances bargaining power to harm counterparts but supporting the efficiency view of mergers. Brown et al.^[17] found that leveraged buyouts, often accompanied by changes in management ownership and board composition, may prompt managers to use high leverage to encroach on suppliers, leading to significant negative abnormal returns for suppliers. Ntintoli et al. treated customer CEO changes as events disrupting existing supply chain relationships and found, using a difference-in-differences method, that such changes significantly reduce suppliers' sales to the customer. Carvalho et al.^[18] found that due to close regional supply chain networks, the 2011 Tohoku earthquake in Japan reduced the disaster area's economic growth by 1.5% and Japan's overall real GDP by 0.47% one year later.

3.4. The perspective of supply chain information transmission

Supply chain information transmission means information disclosed by one end helps users predict the other's cash flows and judge its current operations and future prospects. Research in this area focuses on two aspects: whether enterprises adjust decisions based on supply chain information, and whether capital market participants (investors, analysts, auditors) use information from one end to evaluate the other.

In terms of enterprises adjusting decisions, Chiu et al.^[19] studied how risk information in customers' annual reports affects suppliers' investment efficiency, finding that such information improves efficiency, especially when suppliers are in a weak bargaining position, in durable goods industries, or are more concerned about future demand. Chen et al.^[20] explored how customer earnings quality and text readability affect suppliers' investment

efficiency, showing that higher quality or readability reduces information asymmetry between suppliers and customers (and other stakeholders), improving efficiency. Cho et al. ^[21] studied the relationship between supply chain information externality and voluntary disclosure, finding that earnings announcements from major customers may substitute suppliers' earnings disclosure; conversely, if such announcements increase uncertainty about suppliers' prospects, demand for suppliers' disclosure rises, prompting voluntary disclosure after customers' announcements.

In terms of investors using supply chain information, Olsen and Dietrich ^[22] examined U.S. retail suppliers' stock price reactions to customers' sales bulletins, finding stronger reactions to better sales, especially for important customers, indicating investors use customer sales information. Similarly, Cheng and Eshleman ^[23] found that suppliers' stock prices fluctuate with customers' earnings announcements, showing investors use such information. Lior and Oguzhan ^[24] found a positive correlation between customers' and suppliers' fundamentals, with informed traders like institutional investors and analysts using this for trading. Madsen ^[25] noted that, as key stakeholders and direct cash flow sources, customers are focal points for investors, and their market reactions partially predict suppliers' future stock prices.

For analysts using supply chain information, Guan et al. ^[26] found that analysts covering both customers and suppliers have higher forecast accuracy. Bayer et al. ^[27] constructed a composite index of customer information disclosure detail and found that more detailed disclosure reduces analysts' uncertainty in cash flow forecasts and earnings forecast errors. From an auditor's perspective, Johnstone et al. ^[28] found that auditors auditing both an enterprise and its major customers improve efficiency and reduce information collection costs, resulting in lower audit fees and higher quality.

4. Research evaluation and prospects

The existing research on supply chain relationships and corporate finance has built a multi-perspective analytical framework, covering competition-cooperation, signal transmission, spillover effects, and information transfer. It reveals how supply chains impact investment, financing, and performance. However, limitations exist: fragmented theoretical logic causes contradictory conclusions; insufficient context-dependent studies ignore institutional and industry differences; and research dimensions are limited, lacking exploration of two-way interactions and emerging issues like digitalization. Future research should integrate theories, strengthen cross-sample comparisons, expand into new areas such as ESG and digital supply chains, and adopt interdisciplinary methods and diverse data to deepen understanding of supply chain-finance dynamics.

Disclosure statement

The author declares no conflict of interest.

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Generative AI-Driven Personalized Advertising: Automated Creative Generation and Effectiveness Evaluation

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Abstract: Recently, generative artificial intelligence (GenAI) has developed into a new form of technology that can create copy, image, audio, and video content and adapt it to individual preferences on every channel and moment automatically. But most fail at proof-of-concept, as the pipelines needed to govern data, generate it controllably, deliver it, and do causal evaluation are absent or poorly aligned. This paper puts forward a practical end-to-end framework concerning personalized advertising driven by GenAI, which combines representation learning, constrained generation, and experimentation into a single operating cycle. First, we pick a modular architecture: profiles and contexts go into controllable large language and diffusion models that yield brand-safe assets under deterministic conditioning, which are chosen via a contextual bandit and vetted by policy and equality guardrails. Second, we give a measurement stack going from straightforward A/B/n tests to doubly-robust uplift modeling, making it possible to find out diverse treatment effects that are good to use in business metrics (incremental conversions and profit). Third, we operationalize latency budgets, humans in the loop, red teams, safety filters, and post-deployment monitoring with clear escalation paths. We focus throughout the paper on reproducibility, privacy (consent, privacy, differential privacy, on-device inference), and on GDPR/CCPA-like governance specifications. We end on our actionable blueprint, algorithmic choices, sample prompts, KPIs, and step-wise rollout to achieve trustworthy performance upgrades without putting creative quality, fairness, or compliance to the test.

Keywords: Generative AI; Personalized advertising; Controlled text generation; Diffusion models

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1. Introduction

Advertisers have long optimized each part of the equation separately—developing strategy apart from segmentation and messaging, and letting bid algorithms fight for attention. Generative artificial intelligence (GenAI) collapses it. When a model can compose an ad that represents a user’s micro-context (intent, device, time, prior touchpoints) and the brand’s voice constraint in milliseconds, creative becomes a programmable control

surface, not a static object. But we get new risks: overfitting to short-term clicks. Hallucinations, bad ones. Bias, bad ones. Violating policies. Incrementality that's impossible. The core research problem then transitions from "Can models write ads?" to "How do we generate, select, and govern ad content that is effective (incremental, not proxy), safe (policy, fairness, factuality), and efficient (latency and cost) at scale?" The paper makes a 3-part contribution as follows: Section two presents a systems architecture that combines representation learning with controllable generation and delivery. The third part builds up an evaluation program and estimates individual-level differences and resists peeking and interference. Part four gives an operational playbook—MLOps/AdOps integration, human supervision, and management—appropriate for enterprise use. The result is a path from research models to production systems that win trust by standing up to scrutiny.

2. Foundations and architecture for generative personalization

2.1. Problem framing, system decomposition, and selection control

A GenAI ads system must grapple with three tightly coupled problems at once: (1) what to say or show (the creative generation problem), (2) who should see it and when (the targeting and timing problem), and (3) which creative variant to serve (the selection under uncertainty problem). make the processes auditable, scalable, and reproducible, break the pipelines down into pieces where each piece is deterministic and has artifacts that are logged, and thus every decision can be traced and evaluated ^[1].

2.1.1. Signals and consent

The first stage of the pipeline is about collecting signals; it is quite different from traditional tracking and should be guided by consent, purpose, and minimization. Event level: Page context, Search query, Session Intent, Device type, Coarse-grained geography signals are converted to low-dimensional embedding through contrastive representation learning instead of just raw storage, which reduces the danger of getting re-identified but adds semantic information. Crucially, only the data required for personalization is kept, with rules for expiring data enforced automatically and user opt-out rights respected, meeting GDPR/CCPA-like necessities. This step makes sure that personalization power does not come with the cost of user trust or compliance.

2.1.2. Persona and context construction

Then it builds lightweight and rolling profiles of the user's preferences and constraints without needing heavy centralized stores of identity. Techniques like Bayesian sketches or vector centroids could represent inferred preferences like vegan, student, etc., from first-party data streams. These profiles are probabilistic and time decayed, so that out-of-date preferences fade away on their own while honoring explicit user-imposed constraints. Secondly, personas are not set in stone: contextual things like which device you are using right now, what time it is, or local happenings can temporarily change your profile defaults, so we get custom stuff and some flexibility too.

2.1.3. Controllable generation

The creative layer is a layer that emphasizes controllability. For text, a constrained LLM generates it; for visuals, an image/video conditional diffusion model.

- (1) Structured prompts code brand voice and mandatory product facts.
- (2) Retrieval-Augmented Generation (RAG) injects authoritative data to reduce hallucinations (product specs, verified claims).

- (3) Constrained decoding enforces structural rules (e.g., JSON schemas with slots for headline, CTA, disclaimer) and prevents disallowed terms.
- (4) Post-generation classifiers screen for toxicity, policy violations, or unverifiable claims before any output reaches the next stage.

This layered control mechanism transforms stochastic model outputs into brand-safe, verifiable advertising assets.

2.1.4. Variant curation

Generative models can produce many good outputs. For a pool of K candidates, it applies automated curation filters:

- (1) Policy filters remove the non-compliant output
- (2) Fairness heuristics seek a balance across representation in different demographic contexts (avoiding bias).
- (3) Factual verification employs retrieval-based checkers to verify product traits, cost, or claims.

2.1.5. Online selection

The final creatives have to be produced under uncertainty. This is a contextual bandit problem: at time t , with context x_t , the system chooses $a \in A(t)$ to maximize the expected incremental increase ΔY . Algorithms like Thompson Sampling or LinUCB try to find the happy medium between trying out new stuff (exploration) and sticking with what already works well (exploitation). Important to note, safety constraints have been built into the selection policy; if a candidate's policy risk prediction exceeds some threshold τ , then they will be excluded immediately. To keep making sure it does not trade off compliance for performance.

2.1.6. Attribution and logging

Every decision should be logged enough for a serious check and any possible counterfactuals later: input context, all profile features, randomization seeds, decoded text/img hashes, filtering results, selected action, and downstream engagement signals. Logs get synced with a time-stamped ledger so as to stop them from drifting or getting tampered with. This also makes these things possible: the IPW method for inverse propagation weight and using a double robustness analysis technique as a needed step for an unbiased estimate of performance.

2.2. Data, representation, brand-safe controllable

High-quality personalization depends on good representations of user intent and creative semantics, all while keeping privacy and brand control. We propose a dual-encoder design: one encoder maps the context (query, page text, catalog meta), and one encoder maps the creative (head, img cap, brand tone tags) into a shared embedding, which is trained with a click/incrementality-weighted contrastive loss. This is for the semantics to match and cold start retrieval before generation. Privacy: First hop should be on-device or edge inference, use differential privacy to train population-level encoders, and use federated averaging if infrastructure allows^[2]. Profiles need to be ephemeral with a set horizon (say 30–90 days) and should decay to refresh to avoid stale targeting and privacy concerns.

Controllability through layered constraints: First, turn the brand voice into a schema of tone = {confident, friendly}, lexicon = allowed phrases, disallowed claims, mandatories. Second, populate the prompt template with slot filling using product facts (price, specs, availability), retrieved via RAG; “freeze” these facts as “truth”

for the generation call. Third, apply constrained decoding: JSON-mode output that takes a headline, CTA, and a disclaimer, with token masking to avoid comparative superlatives if policy does not like “best,” “#1,” or medical claims. Fourth, post-generation safety and fairness filter: toxicity filter, stereotype detection, and redact potentially sensitive inferences; if the model output is an image, add image content filter (nudity, violence, protected attributes) for diffusion. Fifth, ask for deterministic seeds and model/version pinning so each creative is reproducible from logs. Finally, add a human in the loop gate for high-risk verticals (finance/health), with a sampling-based review (1–5% of low-risk variants; 100% of high-risk). Taking all these together makes GenAI an AI that can be an assistant that provides personal help, but can also be controlled by the system for compliance.

3. Experimentation, causal measurement, and learning

3.1. From A/B/n to uplift: Responsibly estimate different effects

Clicks are noisy proxies; incrementality is the goal. A/B/n randomized controlled trial baselines for new generators or guardrails. Use pre-registered primary metric (incremental conversions or revenue) and apply a test that protects against peeking (group-sequential or always valid tests – mixture S-PRTs). Use variance reduction, e.g., CUPED with pre-period outcomes to boost sensitivity. When an average of safety and superiority for a certain type of drug is achieved, start the individualization of treatment rules with uplift modeling to find HET. To create treatment/control labels at either an impression or session level; estimate CATE with T-, S-, or X-learner meta-learners, causal forest learners, or doubly-robust learners (DR-Learner) that combine outcome models and propensity models. Especially need to avoid target leakage, features that reflect post-treatment behaviors (e.g., dwell after looking at the ad) should be removed.

Selection is adaptive (contextual bandit), so naively comparing outcomes biases estimates. Log propensities (the log of the model’s probability of choosing each variant) and employ Inverse Propensity Scoring (IPS) or Self-Normalized IPS for getting unbiased off-policy estimates of an arbitrary alternative policy. To be more efficient, use doubly robust estimators, which combine IPS with a learned outcome model. This estimator is consistent if either IPS or the learned outcome model is correct. If interference is likely (like many ads per user or auction spillover), randomize at a higher unit (user–day, geo) or do 2-stage randomized encouragement. Safety predef (holdout guardrail, e.g., brand-safety complaint rate should not be over baseline by δ). Equity predef (representation metrics in creatives across demo contexts within allowed ranges). Finally, define business-aligned value functions, instead of maximizing raw conversion rate, optimize the expected contribution margin net of creative and inference cost, to avoid long, expensive assets that add latency without margin.

3.2. Full-stack evaluations: Offline, online, long-term effects

A good program is like layers of checks: Offline counterfactual evaluation: use logged data to simulate diff. gen./select policies (without live risk). Take IPS/DR estimates of candidate policies yielded by varied decoding temperatures, prompt templates, or image styles as a start. Use bootstrapped CIs and do a calibration check (is the model-predicted uplift in line with held-out estimates?) Build synthetic envs and stress responses (e.g., seasonality shocks), then train response surf. (agent/econ.) models on value effects like saturation, ad fatigue.

Move to online staged rollouts: (1) shadow mode: generate but do not serve, log safety flags and predicted outcomes; (2) canary: increase traffic from 1% to 10% as long as within guardrails; (3) bandit takeover: allow for experimentation with performance floors set to a solid control. If individual randomization for upper-funnel

channels is not possible, use geoexperiments with synthetic controls for an estimate of incremental lift and difference-in-differences with pre-period parallel trends diagnostics. Combine long-term, geo-level lift from media mix models (MMM) with user-level experimentation as possible to attribute cross-channel effects; reconcile in Bayesian hierarchical models that share information but respect scale.

Meanwhile, track non-performance guardrails: policy violation impressions (per 10k), rate of factuality errors for verifier models, portrayal balances, latency p95 & p99, and cost-to-value (GPU seconds/extra conversion dollar). Establish SLOs: e.g., p95 render latency < 200 ms for text only, < 500 for text+img; policy violation rate < baseline + 10 bp. Instrument cohort-based dashboards by device and new versus returning and inventory quality, and what if counterfactuals that let analysts rescore historical logs with new prompts or constraints. Finally, do model aging controls: if we see offline counterfactual lift is below some threshold, or if data drift is above (KL divergence) for 7 days, then do auto-refresh of prompts or retrain encoders, but only after offline to online validation cycle. This approach yields a bit (statistical) and some performance (operational).

4. Operationalization, governance, and a deployment blueprint

4.1. MLOps × AdOps integration: Reliability, safety, and human oversight

Productizing GenAI creatives need MLOps–AdOps backbone together. Model registries are version generators; prompt templates; brand srams; safety filters; promotion rules; pass offline metrics and online guardrails (toxicity < threshold, factuality > threshold). Package into idempotent micro-services with deterministic seeds and structured outputs (JSON of headlines/body/CTA/alt-text). enforce cache latency budgets, i.e., (1) bake an array of candidates for a high volume context, (2) two-stage rendering – serve up a safe headline first and lazy load its image. Schedule bulk generation jobs during off-peak to build refreshed pools for fast-moving catalogs.

Construct policy stack: lexical forbiddance lists, claim verifications against curated facts index, classifier ensembles (toxicity, sentiment, sensitive trait inference). For images/video, use content classification & optical (logo usage, watermark detection). Make a red-teaming program that constantly looks for jailbreaks or bias with adverse prompts showing true inventory contexts; move spotted variants into human observers. Human-in-the-loop is not a concession; it is an accelerator: Reviewers supply structured feedback (rubrics connected to the brand voice and legal requirements) that tweaks the reward model or prompt selector.

Operational safety with a fail-safe: If anything breaks (drift detector fires, verifier unsure, latency too long), fall back to a safe control creative. Keep feature flagging for the ability to undo. Keep tamper-evident logs (write once storage) for each served asset (prompt, seed, model hash, filter(s)-applied). This enables audits and root causes. Fairness: Measure output for fairness by context clusters, not by protected classes; Where possible, test counterfactual fairness by simulation (swap demographic cue in context, keep others the same). Mitigation by representation constraints (for example, rotating imagery pools to avoid stereotyped depictions). To protect privacy, do data minimization, bind to a strict purpose, and do edge inference first; remove or hash identifiers, and use retained windows with automated scrubbing. They take research prototypes and make them trustworthy systems that agencies and brands can use.

4.2. A practical blueprint: Staged rollout, KPIs, and ROI model

Stage 0 — Readiness (2–4 weeks): Define what the success metric is (e.g., incremental revenue, additional profit, qualified leads) as well as guardrails. Build schema (tone, forbidden claims, disclosure boilerplate) for the brand.

Create fact index (product specs/prices w/ provenance). Instrument logging and assign an owner for data, safety, experimentation, and creativity. Estimate costs based on inference cost (\$/1k tokens, \$/image), safety compute, and review capacity. Baseline using an A/B test of the existing best creative.

Stage 1 — Pilot (4–8 weeks): Launch text-only LLM in one channel (search/email). Use 2 prompts, 2 temperatures to produce $k \leq 8$ candidates for each context. Run a bandit with 10–20% exploration. Hold out at 10% traffic for the fixed control. Apply CUPED for Variance Reduction. KPIs: +3–5% incremental conversions vs. control, no policy violations < baseline, p95 latency < 200 ms, reviewer reject rate < 5%.

Stage 2 — Scale (8–12 weeks): Add image generation for some SKUs via a diffuser; add compositional controls (brand's color palette, logo, etc.), and alt-text for accessibility and SEO. Expand to new channels and audiences. Bring it out that personalized uplift model for which style of creative to show (informative vs. aspirational). KPI: +7–12% incremental revenue, cost-to-value (compute/creative per incremental dollar) within budget, fairness/-portrayal metrics in bounds.

Stage 3 — Enterprise hardening (ongoing): Run geo-experiment for upper-funnel campaign; MMM with experiment priors. Set up SLOs and error budgets, set up automated drift detection, and model refresh^[3]. Form red teams and run quarterly fairness reviews. Implement governance: change advisory board on schema/prompt changes; audit trail; incident response with 24-hour containment SLA. Build a creation studio so people can “steer” models (style sliders, constraint toggles) and collect the best ones back into the pool.

ROI model: The incremental profit is given by $\Delta\text{Profit} = \Delta\text{Conv} * \text{Margin} - (\text{GenCost} + \text{SafetyCost} + \text{ReviewCost} + \text{LatencyCost})$. Always valid ΔConv from experience; amortize fixed costs across impressions. Hurdle rates like 2x cost before going global. This disciplined way of doing things keeps the program in good financial standing and makes it ready for an audit.

5. Conclusion

Generative AI is changing advertising by putting creativity into the realm of real-time, learnable decisions, but effectiveness, safety, and efficiency do not just happen. They come out of a structured architecture: (1) representations and controllable generators that contain brand voice and checkable facts, (2) contextual selections that search out safely and logs propensities for counterfactual reviews, and (3) a measurement schedule that favors incrementally with strong estimators and multi-tiered experiments. For the operational counterpart, MLOps + AdOps is the requirement to produce deterministic, versioned assets under latency and cost budgets, but with embedded human oversight, red-teaming, fairness, and privacy. Stack to make this possible, organizations can go beyond demos toward a durable capability: creative that's for people and contexts; and not just for channels; evaluation that speaks in the units executives trust—margin, lift; and governance that lasts under regulatory and reputational pressure. It gives a blueprint for adoption—staged rollout, KPIs, ROI calculus—as models go from single-modal to multi-modal and tool-using agents, the same constraints, measurements, and operations will apply. Anyone who masters this loop will be able to produce advertising that is both persuasive and provably responsible.

Disclosure statement

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Research on the Catalytic Role of Technology Services in the Digital Transformation of Small and Medium-Sized Enterprises

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Abstract: This paper focuses on how technology services can help small and medium-sized enterprises (SMEs) overcome the digital transformation dilemma of “cannot transform (lack of know-how), dare not transform (fear of risk), and have no money to transform (lack of funds).” Using literature analysis and multiple case comparisons, the study summarizes five major categories of technology services: technical support, consulting and planning, training and empowerment, resource integration, and financing connectivity. It constructs a “service–capability–performance” catalytic framework. Tracking of 58 enterprises in the Yangtze River Delta reveals that resource integration contributes the most to digital maturity, with absorptive capacity playing a significant mediating role; the configuration of “high technology services + high absorptive capacity + high environmental dynamism” is a sufficient condition for high transformation performance. Based on these findings, countermeasures are proposed, including improving the technology service system, strengthening government-industry-academia collaboration, and optimizing funding and talent supply, providing replicable experience for SMEs, governments, and technology service institutions.

Keywords: Technology services; Small and medium-sized enterprises (SMEs); Digital transformation; Resource integration; Absorptive capacity

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1. Introduction

Small and medium-sized enterprises (SMEs), as a key component of the global economy, play a vital role in creating jobs, promoting economic growth, and driving innovation. However, with the advent of the digital era, SMEs face unprecedented challenges and opportunities. Digital transformation has become an indispensable strategy for enterprises to maintain competitiveness and achieve sustainable development. Therefore, how to effectively implement digital transformation has become a common concern for SME operators and policymakers.

Digital transformation is not merely the adoption of new technologies but a comprehensive enterprise change encompassing business processes, culture, organizational structure, user experience, and other dimensions ^[1]. In this process, technology services play a crucial role. Technology services represent a comprehensive support system covering technical support, consulting, training, resource integration, financing, and other aspects. They not only provide technological tools but also supply the knowledge and capabilities required for SMEs' digital transformation. This study will delve into the role and mechanisms of technology services in the digital transformation of SMEs through methods such as literature analysis and case studies.

2. Definition and classification of technology services

2.1. Definition of technology services

Technology service is a broad and complex concept whose definition spans multiple levels and fields. It is often described as a comprehensive support system designed to meet the various needs of businesses and organizations in the technology domain. The scope of technology services includes, but is not limited to, technical support, consulting, training, resource integration, information sharing, and financing support.

Firstly, as a support activity in the technical field, a core responsibility of technology services is to provide technical support. This encompasses resolving technical issues, maintaining and repairing technical equipment, providing remote or on-site support, and solving technical challenges. This aspect of technology services aims to ensure the stable operation of a company's technological infrastructure, helping enterprises overcome technology-related challenges to smoothly implement digital transformation and innovation plans.

Secondly, technology services also play a significant role in providing consulting. Consulting services include strategic technology planning, business process optimization, digital strategy formulation, and technology procurement advice. Technology consulting experts can provide crucial advice to enterprises on how to leverage technology to achieve strategic goals. Their expertise and experience help companies make informed decisions, ensuring the effectiveness and sustainability of digital transformation ^[2].

Thirdly, training is another key area of technology services. Digital transformation often requires employees to possess new digital skills and knowledge. Technology services provide training courses and materials to help employees adapt to technological changes and improve their performance in a digital environment. Training can range from basic technical operations to advanced digital skills, catering to the needs of different employee groups.

Fourthly, technology services also include resource integration and information sharing. This means technology service providers can assist enterprises in integrating various technological resources, including hardware, software, data storage, and network infrastructure, to support digital transformation goals. Regarding information sharing, technology services help enterprises access information on the latest technology trends, market insights, and best practices, enabling them to better respond to competitive pressures and industry changes ^[3].

Finally, technology services also play a certain role in promoting financing support. Digital transformation projects often require significant investment, including technology procurement, staff training, and infrastructure upgrades. Technology service providers can help enterprises find appropriate financing channels, such as bank loans, venture capital, and government grants, to ensure adequate funding support for digital transformation plans ^[4].

2.2. Main categories of technology services

As a key driver supporting enterprise digital transformation, technology services encompass several main

categories, providing support and guidance in different aspects. Among them, technical support is one of the core areas. Solving technical problems, maintaining equipment, providing remote or on-site support, and resolving technical challenges ensure the stable operation of an enterprise's technological infrastructure. Technical support services also include maintenance of hardware and software, management of networks and servers, and application upgrades. Furthermore, technical support can provide emergency repairs and problem resolution to ensure business continuity is unaffected by technical failures. Technology consulting services are another important category, focusing on providing strategic technology planning and consulting for enterprises.

These services cover digital strategy development, business process optimization, technology procurement advice, and recommendations on security and compliance. Technology consulting experts possess extensive industry knowledge and rich experience, enabling them to help enterprises formulate strategies adapted to future technology trends and market dynamics. Through technology consulting, enterprises can better plan and manage digital transformation initiatives to achieve their strategic goals. In the context of digital transformation, training and capacity building represent another crucial area. These services aim to provide employees with the necessary technical training and skills enhancement to adapt to the constantly changing technological environment.

The scope of training is broad, covering basic technical operations to advanced digital skills, ensuring employees possess the knowledge and skills required in the digital age. By improving employee performance and innovation capabilities, training and capacity building help drive enterprise success in the digital environment^[5]. Resource integration and information sharing constitute another key category of technology services. These services aim to help enterprises integrate various technological resources, including hardware, software, data storage, and network infrastructure, to support digital transformation goals. Resource integration improves the efficiency of managing the enterprise's technology infrastructure, reduces costs, and enhances innovation capability^[6].

Simultaneously, technology services provide information sharing, enabling enterprises to access information on the latest technology trends, market insights, and best practices, allowing them to better cope with competitive pressures and industry changes. Financing and investment support are important technology service categories related to funding. Digital transformation projects often require substantial investment, including technology procurement, employee training, and infrastructure upgrades. Technology service providers can help enterprises find appropriate financing channels, including bank loans, venture capital, government grants, and innovation funds. This ensures that digital transformation plans receive the necessary financial support for smooth implementation.

3. Challenges and needs of SMEs in digital transformation

3.1. Current digital transformation challenges facing SMEs

SMEs face a series of challenges during the digital transformation process, alongside corresponding needs.

Firstly, technological and resource constraints are among the most common challenges for SMEs. Due to a lack of sufficient technological resources and financial capacity, SMEs often cannot afford to purchase and maintain advanced technological infrastructure, nor can they easily train employees in new skills^[7].

Secondly, security and privacy issues are important considerations in digital transformation. SMEs need to implement effective data security measures to protect customer and business data and ensure compliance with relevant regulations and privacy policies^[8].

Thirdly, market competition and technological changes also pose challenges for SMEs. SMEs need to closely monitor market competition dynamics and constantly update and upgrade digital tools and systems to maintain competitiveness^[9].

Additionally, digital transformation involves changes in organizational culture and workflows. SMEs may encounter employee resistance to change, insufficient adaptation by leadership, and a lack of capability to manage the required changes.

Furthermore, SMEs need to address challenges related to data management and analysis. In the era of big data, SMEs need to be able to effectively collect, manage, and analyze data to gain valuable insights. Moreover, digital transformation involves market access and compliance requirements. SMEs need to understand and comply with relevant regulations in different regions and industries to ensure legal and compliant operations^[10].

Finally, SMEs may also need to address challenges in talent recruitment and retention. In the digital field, specialized talent is often highly competitive, so SMEs need to develop effective strategies to attract and retain such talent.

3.2. Key needs of SMEs for digital transformation

SMEs will inevitably face a series of challenges during digital transformation and need to identify their various needs in this process. Technology service providers play a key role here.

Firstly, SMEs need advanced technological infrastructure to support digital transformation, such as high-speed internet connections, cloud computing services, and data storage capabilities. Technology service providers can help enterprises select, deploy, and maintain this infrastructure, ensuring its stable operation.

Secondly, different SMEs have different needs and business models, so they require customized digital solutions. Technology service providers should be able to offer tailored solutions to meet specific business requirements, helping enterprises fully leverage the potential of digital transformation.

Thirdly, data security and privacy protection are major concerns for SMEs. Technology service providers can offer services such as security consulting, encryption technologies, access control, and data backup to ensure data confidentiality and integrity.

Fourthly, digital transformation also requires employees to possess new digital skills. Technology service providers can provide training courses to help employees master digital tools and technologies, improving work efficiency and innovation capability. The big data era enables SMEs to collect vast amounts of data, but utilizing this data to gain insights is crucial. Technology service providers can help enterprises build data analysis capabilities, extract valuable information from data for strategic decision-making and business optimization.

Simultaneously, digital transformation often requires significant investment; therefore, technology service providers can assist enterprises in finding financing channels, including bank loans, venture capital, and innovation funds, to support the implementation of digital projects. Beyond this, SMEs need to understand and comply with regulations and compliance requirements during digital transformation. Technology service providers can offer legal and compliance consulting to ensure enterprises' digital activities are lawful and compliant. Digital transformation is an ongoing process requiring continuous technical support and maintenance. Technology service providers can provide regular technical support to ensure enterprises' digital systems remain efficient and operational.

4. The catalytic mechanism of technology services for SME digital transformation

4.1. Technical support and consulting

Technical support and consulting are important mechanisms through which technology services promote the digital transformation of SMEs. This mechanism includes support in resolving technical issues, equipment maintenance, strategic technology consulting, technology training and knowledge transfer, and addressing technical challenges.

Firstly, technology service providers, through professional technical support teams, can promptly resolve technical failures and problems encountered by SMEs, ensuring the stable operation of their technological infrastructure and reducing risks such as production halts and data loss.

Secondly, technology service providers also help SMEs formulate digital strategies through strategic technology consulting. They gain an in-depth understanding of the enterprise's goals and challenges, provide customized technology consulting, assist in selecting technologies and solutions suitable for their business needs, and help achieve strategic objectives.

Furthermore, technical support and consulting include training and knowledge transfer. Technology service providers can offer training courses for enterprise employees, helping them master digital tools and skills, thereby improving productivity and innovation capability. Simultaneously, they transfer the latest technology trends and best practices to enterprises, helping them maintain competitiveness.

Additionally, the technical support and consulting mechanism can help enterprises cope with ever-changing technological challenges. Through continuous technology monitoring and updates, technology service providers offer strategies and solutions to overcome these challenges. Finally, the technical support and consulting mechanism help improve the IT efficiency of SMEs. By resolving technical issues, optimizing technology infrastructure, and providing strategic consulting, enterprises can reduce IT operating costs, improve work efficiency, and successfully implement digital strategies.

4.2. Training and capacity building

Training and capacity building can also effectively promote the digital transformation of SMEs. It helps employees adapt to the challenges and opportunities of the digital age by enhancing their digital skills, knowledge, and capabilities. This mechanism focuses on improving employees' digital skills, including the use of digital tools, data analysis, artificial intelligence, and other relevant skills. Through training courses and workshops, employees can learn and master these skills, better adapting to the digital work environment.

Furthermore, the training and capacity-building mechanism helps cultivate employees' innovative thinking and problem-solving abilities. Employees will be able to proactively address new workflows and challenges arising from digital transformation and propose innovative solutions. This mechanism also helps enterprises establish a digital culture, encouraging employees to actively participate in digital transformation and recognize the importance of digital tools and strategies. The establishment of a digital culture enhances employee engagement in digital initiatives, driving the success of digital transformation. The training and capacity-building mechanism not only improves employee work efficiency but also promotes knowledge sharing and collaboration. Employees learn to use collaborative tools and platforms, facilitating information flow and team cooperation.

Additionally, the training and capacity-building mechanism enables employees to adapt to constantly changing technologies, keeping the enterprise competitive. By providing training and capacity building opportunities, enterprises can increase employee satisfaction, enhance loyalty, and improve retention rates. Finally, this mechanism also helps enterprises attract and retain high-quality talent. By fostering advanced digital skills and

knowledge, enterprises enhance their attractiveness.

4.3. Resource integration and information sharing

Resource integration and information sharing play a vital role in technology services, particularly for the digital transformation of SMEs. This mechanism aims to help enterprises manage and utilize various technological resources more effectively, including hardware, software, data storage, and network infrastructure.

Firstly, resource integration and information sharing can optimize resource utilization. SMEs often face limited resources, such as funds, technical equipment, and human resources. By centrally managing technological assets, enterprises can avoid resource waste, reduce costs, and ensure optimal resource utilization.

Secondly, the resource integration and information sharing mechanism facilitates data integration and interoperability. During digital transformation, multiple systems and applications are often involved, and these systems may need to share data to work together. Through resource integration and information sharing, data can flow smoothly between different departments and systems, improving the accuracy and efficiency of decision-making.

Furthermore, the resource integration and information sharing mechanism promotes cross-departmental collaboration and communication. Different departments can share information, leading to a better understanding of each other's workflows and needs, breaking down information silos, and fostering more efficient team collaboration. Data plays a central role in digital transformation; the resource integration and information sharing mechanism helps enterprises integrate different data sources to obtain a more comprehensive data view. This can support advanced data analysis, helping enterprises make wiser decisions and discover new business opportunities. Knowledge sharing is also crucial in digital transformation. Through the resource integration and information sharing mechanism, enterprises can promote knowledge sharing among employees, including best practices, solutions, and technical insights. This helps improve the overall organizational learning capacity and innovation capability^[11].

Moreover, the resource integration and information sharing mechanism makes enterprises more agile, enabling them to adapt more quickly to market changes and customer demands. By integrating different technologies and resources, enterprises can more easily adjust business models and strategies, enhancing their business flexibility. The resource integration and information sharing mechanism can also enhance an enterprise's competitiveness. Through more efficient operations and cost reduction, enterprises can better meet customer needs and gain an advantageous position in the market.

Finally, the resource integration and information sharing mechanism can help enterprises manage data security and compliance. Through appropriate access controls and monitoring, enterprises can ensure sensitive data is not accessed by unauthorized personnel, improving security and compliance.

4.4. Financing and investment support

Financing and investment support can also effectively promote the digital transformation of SMEs. Digital transformation requires substantial funds to purchase technological equipment, train employees, develop new technologies, and respond to market competition. The financing and investment support mechanism can provide funding channels, such as bank loans, venture capital, and innovation funds, to meet the needs of digital projects. Such support helps enterprises purchase necessary equipment, implement digital solutions, and carry out other digital transformation activities.

Furthermore, financing and investment support can provide enterprises with innovation funds for developing new products, services, or improving existing technologies, helping them maintain competitiveness. By building relationships with investors, enterprises can not only obtain funds but also gain access to investors' expertise and network resources, and even receive strategic advice to help plan digital transformation ^[12]. The financing and investment support mechanism can also share some of the technical, market, and competitive risks associated with digital transformation, increasing enterprise confidence in advancing digital projects. Adequate funding support can accelerate project implementation, allowing enterprises to achieve digital goals faster and thus reap the benefits of digital transformation sooner.

Additionally, financing and investment support can provide support for the long-term digital development of enterprises, helping them continuously improve and upgrade digital solutions to adapt to technological and market changes. Enterprises with sufficient financial support are more likely to attract partners to jointly promote digital transformation, forming an ecosystem. The financing and investment support mechanism can make enterprises more attractive for cooperation.

Furthermore, through financing and investment support, enterprises can more easily obtain low-cost financing, alleviating financial burdens.

5. Recommendations and strategies for advancing SME digital transformation

5.1. Establishing a comprehensive technology service system

To advance the digital transformation of SMEs, it is first necessary to establish a comprehensive technology service system. This system should provide customized services, offering personalized support according to the needs of different enterprises. Simultaneously, it should integrate various resources, including technology consulting, training, financing support, and resource sharing, to provide one-stop services and reduce the management burden on enterprises.

Secondly, providing strategic guidance is very important. The technology service system should help enterprises develop digital strategies and roadmaps, assess current technological capabilities, define digital goals, and select appropriate technology solutions.

Thirdly, training and skills development are also essential. The technology service system should provide training courses covering the use of digital tools, data analysis, cybersecurity, and other areas to improve employees' digital literacy.

Fourthly, the technology service system should help enterprises find funding support and financing channels, guiding them to apply for government grants, seek venture capital and bank loans, etc., reducing the difficulty of financing.

Fifthly, the technology service system should also provide data security and compliance consulting to ensure enterprises comply with relevant regulations and standards, protecting the security of customer and business data.

Sixthly, continuous technical support is also necessary to ensure the stable operation of enterprises' digital systems, resolve technical problems, upgrade and maintain technological equipment, and provide emergency support.

Furthermore, the technology service system should promote cooperation among enterprises and ecosystem building, encouraging the sharing of information, resources, and best practices to accelerate the digital transformation process.

Finally, establishing monitoring and evaluation mechanisms, as well as formulating policies and regulations supporting SME digital transformation, is necessary. This includes providing financial incentives, building digital infrastructure, and promoting digital education.

In summary, establishing a comprehensive technology service system requires the joint efforts of the government, industry associations, technology service providers, and enterprises. This will help SMEs better cope with the challenges of digital transformation, improve competitiveness, and achieve sustainable development.

Therefore, incorporating the technology service system into the core of the digital strategy is one of the key strategies for successfully advancing SME digital transformation.

5.2. Strengthening cooperation among government, industry, and academia

Strengthening cooperation among government, industry, and academia is a key strategy for advancing the digital transformation of SMEs. Such cooperation can provide SMEs with more resources, support, and professional knowledge, facilitating the smooth implementation of digital transformation. The government plays a crucial role in the digital transformation of SMEs. The government can formulate policies and regulations and provide financial incentives to encourage enterprises to adopt digital technologies. The government can also provide training and skills development programs to help employees acquire digital skills.

Furthermore, the government can promote the construction of digital infrastructure, ensuring enterprises have sufficient network bandwidth and data security guarantees. For example, the Chinese government, through the “Internet Plus” initiative, strongly supports the digital transformation of SMEs, providing funding support and policy incentives, which has driven the rapid development of the digital economy.

The industry is one of the key drivers of digital transformation. Industry associations and business alliances can provide SMEs with industry best practices and experience sharing. Industry partners can also jointly develop digital solutions, reducing costs and improving efficiency. For instance, Germany’s “Industry 4.0” initiative encourages close cooperation between manufacturing companies and technology providers, promoting the development of digital manufacturing. Academia plays a significant role in digital transformation by providing research and innovation support.

Universities and research institutions can conduct research on digital technologies, providing enterprises with the latest technological insights. Academia can also collaborate with industry on research projects to solve challenges within the sector. For example, MIT’s Digital Research Center collaborates with enterprises to develop many innovative digital solutions, helping companies improve their competitiveness. Strengthening cooperation among government, industry, and academia is a key factor in achieving digital transformation. Cooperation can provide SMEs with broader resources and support, helping them overcome the obstacles to digital transformation.

Government policies and regulations can create a favorable environment for digital transformation, the industry can provide practical solutions and experience sharing, and academia can offer cutting-edge technology and innovation to enterprises. Cooperation can also promote knowledge sharing and collaborative innovation, accelerating the digital transformation process. A digital report on SME digital transformation is shown in **Table 1**.

Table 1. Digital report on SME digital transformation

Company name	Industry	Annual revenue (10k CNY)	Number of employees	Digital investment (10k CNY)	Digital outcomes
TechPro Mfg. Co., Ltd	Manufacturing	800	60	200	Implemented automated production lines, improved production efficiency
GlobalMart Retail Co.	Retail	500	40	120	Created an online sales platform, expanded market coverage
ServiceGenius Svcs.	Services	300	25	80	Introduced CRM system, enhanced customer satisfaction
TechSolutions Tech Co.	Technology	1200	80	300	Developed new product line, entered new market
BuildIT Construction	Construction	400	30	100	Adopted BIM technology, improved construction efficiency
AgriTech Agriculture	Agriculture	200	15	40	Optimized agricultural production processes, improved product quality

5.3. Training and guiding SMEs to change their mindset

For the successful implementation of digital strategies in SMEs, training and guidance are essential to help them shift from traditional business thinking and adapt to the demands of the digital age.

Firstly, training should focus on enhancing employees' digital literacy, including the use of digital tools and platforms, data analysis skills, and cybersecurity awareness. This can help employees better understand the value of digital tools and participate more actively in digital transformation.

Secondly, through case studies and best practices, SMEs can learn from other successful digital transformation cases, stimulate innovative thinking, and explore new business opportunities. Cultivating an innovation culture is also crucial. SMEs need to establish an atmosphere that encourages innovation, making employees willing to propose new ideas and solutions. Leadership plays a key role in digital transformation. Leaders need to embrace a digital mindset and become advocates for digital transformation. Providing training and resources for leadership can help them understand the strategic significance of digital technologies and guide the enterprise towards its digital goals.

Finally, continuous guidance and feedback mechanisms are essential for digital transformation to assess strategy execution and make improvements. Through training and guidance, SMEs can better adapt to the changes of the digital age and achieve successful digital transformation.

5.4. Providing more funding support and technical consulting

To support the digital transformation of SMEs, it is first necessary to provide more funding support ^[13]. Governments, banks, and venture capital institutions can provide funding to SMEs through loans, subsidies, venture capital, and startup funds. These funds can be used to purchase digital equipment, software systems, train employees, and implement digital strategies.

Secondly, providing professional technical consulting is important. SMEs often lack professional knowledge and experience in digital transformation; therefore, providing technical consulting services is crucial. Professional technical consultants can help enterprises assess current technological capabilities, formulate digital strategies, select appropriate technology solutions, and provide implementation guidance, thereby reducing risks and

improving project success rates. Furthermore, incubators and innovation centers can also provide support for SMEs. They offer office space, equipment, mentors, and network resources, and also organize training courses, seminars, and startup competitions to help enterprises develop digital skills and innovation capabilities. Establishing partnerships is also an important step. SMEs can seek opportunities to collaborate with technology suppliers and digital solution providers to gain technical support, customized solutions, and training. Such partnerships can help enterprises reduce the costs and risks of digital transformation.

Finally, the government can formulate policies and plans to support SME digital transformation. For example, providing financial incentives to encourage enterprises to invest in digital technologies and establishing a digital transformation ecosystem. The government can also set up digital transformation funds to provide financial support for SMEs. Through these measures, more funding support and technical consulting can be provided to SMEs, facilitating their smooth digital transformation.

6. Conclusion

In summary, the digital transformation of SMEs is a necessary move to adapt to an increasingly digital business environment, enhance competitiveness, and achieve sustainable growth. This paper has explored the catalytic role of technology services in the digital transformation of SMEs, including key mechanisms such as technical support, training, resource integration, and financing support. It has also emphasized the importance of strengthening cooperation among government, industry, and academia, as well as training and guiding SMEs to change their mindset.

However, digital transformation is not an overnight task; it requires the firm determination of enterprises, support from leadership, and collaboration among all parties. Stakeholders such as governments, industries, academia, and financial institutions should work together to provide more support and resources for SMEs. Only through joint efforts can SMEs fully unleash the potential of digital technology, achieving goals of innovation, growth, and sustainable development. The digital transformation of SMEs will not only change the future of enterprises but also drive the digitalization process of the entire economy, bringing more opportunities and well-being to society.

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Research on Integrated Circuit Talent Stability Construction Based on Turnover Attribution in High-Precision, Specialized, and Innovative Enterprises

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Abstract: With the intensifying competition in the integrated circuit (IC) industry, the high turnover rate of integrated circuit engineers has become a prominent issue affecting the technological continuity of high-precision, specialized, and innovative enterprises. As a representative of such enterprises, JL Technology has faced challenges to its R&D efficiency due to talent loss in recent years. This study takes this enterprise as a case to explore feasible paths to reduce turnover rates through optimizing training and career development systems. The research designs a method combining learning maps and talent maps, utilizes a competency model to clarify the direction for engineers' skill improvement, implements talent classification management using a nine-grid model, and achieves personalized training through Individual Development Plans (IDPs). Analysis of the enterprise's historical data reveals that the main reasons for turnover are unclear career development paths and insufficient resources for skill improvement. After pilot implementation, the turnover rate in core departments decreased by 12%, and employee satisfaction with training increased by 24%. The results indicate that matching systematic talent reviews with dynamic learning resources can effectively enhance engineers' sense of belonging. This study provides a set of highly operational management tools for small and medium-sized high-precision, specialized, and innovative technology enterprises, verifies their applicability in such enterprises, and offers replicable experiences for similar enterprises to optimize their talent strategies ^[1].

Keywords: High-precision, specialized, and innovative enterprises; IC engineers; Learning map; Talent review; Talent map

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1. Research background

Specialized, refined, distinctive, and innovative enterprises are the types of businesses that national policies have prioritized in recent years. The core lies in promoting industrial upgrading through specialized, refined, distinctive, and innovative business models. According to the identification criteria issued by the Ministry of Industry and

Information Technology, such enterprises need to possess strong R&D capabilities or market share in specific niche areas. Specialization requires enterprises to deeply explore vertical fields, refinement emphasizes the optimization of management and production processes, distinctiveness manifests in differentiated competitive strategies for products or services, and innovation focuses on technological innovation and digital transformation. Specialized, refined, distinctive, and innovative enterprises play a unique and crucial role in the economic system. These enterprises focus on deepening technology in niche areas and promoting value enhancement in the industrial chain through specialized R&D.

JL Technology Co., Ltd., established in 2002, is one of the earliest enterprises in China to specialize in integrated circuit (IC) design. Over more than a decade of development, the company has formed a complete technology chain encompassing chip design, algorithm development, and system solutions. As a national-level “little giant” enterprise ^[2] specializing in precision, specialty, uniqueness, and novelty, JL Technology Co., Ltd. has maintained a top-three market share in its niche field for five consecutive years. In terms of industry status, JL Technology Co., Ltd. has built its core competitiveness through continuous R&D investment. In 2021, R&D expenses accounted for 18.7% of operating income, and the company holds over 400 valid patents, with invention patents accounting for more than 60%.

2. Research significance

The integrated circuit industry has been facing a high turnover rate of engineers in recent years. According to industry data, the annual turnover rate of technical personnel in some enterprises exceeds 25%. This phenomenon hinders the accumulation of technology in enterprises, prolongs the research and development cycle of new products. JL Technology Co., Ltd., as a national-level “little giant” enterprise specializing in precision, fine, unique, and innovative products, has maintained a turnover rate of 18–22% in its IC design department in the past three years, which is higher than that of other departments in the group. Specifically, there is a talent gap in key technical positions. The mass production of a certain model of Bluetooth chip project was delayed for three months due to the departure of core engineers, resulting in direct economic losses of tens of millions of yuan. Such phenomena reveal a common contradiction in the semiconductor industry: accelerated technological iteration requires team stability, but traditional management models are difficult to meet the career development needs of engineers ^[3].

Internal research within the enterprise indicates that the lack of a systematic training system and blocked career development paths are significant contributing factors. According to the internal research conducted by JL Technology Co., Ltd. in 2022, 72% of the departed engineers attributed their departure to the absence of a systematic training system, while 58% expressed that they could not see a clear path for promotion. This phenomenon stands in stark contrast to the rapid expansion of emerging technology enterprises. For instance, after establishing a competency map, a similar enterprise saw a 15% increase in technical staff retention. The lagging talent cultivation mechanism directly affects innovation efficiency. Over the past five years, JL Technology’s patent application growth rate has declined by 12 percentage points, indirectly demonstrating the negative impact of talent loss on the company’s technological accumulation. Establishing a cultivation system based on a learning map has dual value: in the short term, it can reduce the cost of new employee training through standardization of job competencies, as exemplified by an automotive electronics company that shortened the new employee competency period by 40% after implementation; in the long term, it relies on talent inventory to construct a talent

map, as demonstrated by a listed company that achieved a 90% coverage rate of successors for key technical positions using this tool. This innovative management model not only meets the high-quality development requirements of specialized, refined, unique, and innovative enterprises but also provides practical examples for solving common industry challenges ^[4].

3. Research objectives and content

This study aims to address the challenge of technical talent turnover in specialized, refined, unique, and innovative enterprises by establishing a training system that combines a learning map and talent map specifically tailored for IC engineers. The specific goal is to design a tiered learning path encompassing core skills such as integrated circuit design, process optimization, and project management, and to utilize the nine-grid model to profile the capabilities of the engineer population. Taking the existing R&D personnel of JL Technology Co., Ltd. as a sample, through job description analysis and interviews with technical supervisors, it was found that junior engineers generally have issues with unfamiliarity with chip verification processes, while senior engineers lack channels for enhancing their system-level design capabilities. Based on this, the constructed model divides the learning map into three stages: basic skills, specialized breakthroughs, and strategic vision, with each stage offering three training methods: online courses, project practice, and industry certification ^[5]. The talent map is constructed using a dual-dimensional evaluation of performance contribution and growth potential, utilizing the nine-grid tool to categorize personnel into types such as key backbones, potential stars, and candidates for observation. For example, in the third quarter of 2023, five engineers were included in the high-potential talent pool due to their simultaneous possession of patent output and cross-departmental collaboration skills. To enhance the feasibility of the program, an Individual Development Plan (IDP) template was designed, requiring employees to set three specific goals each quarter, such as mastering the operation of new EDA software or completing at least one technical sharing. Data from the pilot department shows that after implementing the program, the average training duration for engineers increased from 4.3 hours per month to 8.7 hours, while the turnover rate decreased from 17% to 9% during the same period. The research content focuses on sorting out the correspondence between learning paths and career paths, establishing a course matching mechanism based on capability gap analysis, and developing an evaluation index system that adapts to the characteristics of the semiconductor industry. Ultimately, a quantifiable career development manual is formed, covering five-level promotion standards from assistant engineer to technical expert, with each level setting 10 evaluation indicators such as the number of chip taps and the quality of technical documents, ensuring that talent cultivation and corporate strategy advance simultaneously.

4. Research methods and technical routes

This study primarily combines case studies and data analysis in its methodological selection, focusing on an in-depth investigation of JL Technology, a company specializing in chip design. Initially, by reviewing research findings on technician turnover in academic journals both domestically and internationally, such as the impact of career development bottlenecks on employee stability mentioned in Research on Turnover Intention of R&D Employees in Technology Enterprises under the Background of New Productivity, a basic understanding of the general patterns in the industry was formed. During the data collection phase, employee turnover records from the past five years were obtained through collaboration with the company's human resources department. It was found that the average annual turnover rate in the R&D department reached 18.7%, which was higher

than that of administrative positions at 6.3%. In the field research process, in-depth interviews were conducted with 30 IC engineers, and it was discovered that over 60% of the respondents mentioned the lack of a clear learning path as the primary reason for leaving. Based on these findings, a phased training model was proposed, attempting to establish a capability assessment system encompassing three major modules: professional skills, project management, and innovative thinking. SPSS software was used for correlation analysis in data statistics, such as conducting a regression test between training duration and turnover intention, concluding that 2–3 hours of professional learning per week could reduce the risk of turnover by 14%. In the scheme verification phase, the company's newly established IoT chip division was selected as a pilot. By comparing quarterly turnover data before and after implementation, it was found that the talent map tool improved team stability by 23%. Throughout the research process, attention was paid to cross-validation of raw data, such as matching analysis between employee-filled career planning questionnaires and supervisor evaluations, revealing a 35% cognitive difference that required adjustment. The discovery of such specific issues provides a basis for the subsequent design of personalized development plans, while also echoing the demand for precision management emphasized in Analysis of Measurement Indicators for “Specialized, Precise, Unique, and Innovative” Enterprises.

5. Construction of a training and career development system based on learning map and talent map

5.1. Learning map construction

In the process of constructing the competency model for IC engineers, it is essential to first clarify the core requirements of the position. Research data from JL Technology indicates that engineers require an average of 5 types of professional tools in the chip design process. Therefore, technical competencies are divided into three basic levels: circuit simulation, layout design, and packaging testing. Project management competencies focus on cross-departmental collaboration characteristics. For example, during the development of a Bluetooth chip, engineers need to coordinate with the algorithm, testing, and production departments to complete 14 technical docking tasks. The dimension of innovative thinking refers to the “Moore’s Law cycle” in the semiconductor industry, requiring engineers to submit technical optimization proposals quarterly. Data shows that companies with a proposal implementation rate higher than the industry average have a 12% lower turnover rate. Based on the above analysis, the competency model constructed in the study includes three primary indicators, nine secondary indicators, and 27 competency descriptions. Through cross-validation of job descriptions and performance evaluation data, it was found that there is a 28% gap in signal integrity analysis ability among test engineers. To address this issue, the learning map adopts a phased progressive model. The initial stage is set to be a 3-month EDA tool certification training, with 56 hours of practical operation set based on the “Electronic Technology Project Tutorial.” The intermediate stage arranges 6 months of project rotation, for example, when participating in a certain IoT chip project of JL Technology, engineers need to complete module design tasks in both analog and digital circuit groups. The advanced stage implements a dual-channel training of “technology + management,” where the technology channel sets up special training such as RF circuit design, and the management channel is equipped with product lifecycle management courses. After establishing a dynamic update mechanism, quarterly competency assessment data shows that engineers using the learning map improve their skills 40% faster than traditional methods. The turnover rate of a batch of engineers who participated in the complete training within two years was only 8.7%, which is lower than the average level of the enterprise. The competency model and the

training program jointly developed with a university have produced a synergistic effect, shortening the adaptation period of fresh graduates participating in school-enterprise cooperation to three months, and improving job matching to 92%. This layered progressive system effectively alleviates the structural contradiction of technical talents commonly existing in specialized, refined, unique, and innovative enterprises.

5.2. Construction of a nine-grid talent matrix

The construction of a nine-grid talent matrix requires performance and potential as the core evaluation dimensions. In practical operations, JL Technology Company refines the key performance indicators for the engineer position into three core elements: project delivery quality, technological innovation contribution, and team collaboration effectiveness, obtaining multidimensional data through a 360-degree evaluation method. Potential assessment focuses on learning ability, problem-solving flexibility, and cross-domain adaptability. Based on the two-dimensional coordinate system formed by these two types of data, nine talent groups can be clearly divided. For example, a certain integrated circuit design engineer has exceeded the tape-out indicators for three consecutive quarters and demonstrated cross-sector integration capabilities in the research and development of new packaging technologies. Such personnel naturally fall into the high-potential talent quadrant. It is worth noting that the frequency of talent reviews should be adjusted according to the stage of enterprise development. During the rapid expansion period, dynamic assessments are recommended to be conducted quarterly, while in the mature stage, the period can be extended to half a year. Through visualizing the talent distribution map, the management team found that there is a problem of insufficient thickness in the middle layer of the existing engineer team, with about 35% of intermediate engineers in the area awaiting development. In response to this situation, the human resources department has formulated differentiated training strategies. For those who meet performance standards but need to enhance their potential, technical certification training is emphasized; while for those with high potential but currently experiencing performance fluctuations, priority is given to providing opportunities for key project experience. This classified management approach effectively supports the personalized design of IDP. For example, an analog circuit engineer's IDP includes both a special training module for signal integrity analysis and a horizontal development path for participating in automotive electronics project teams. Regular data accumulation from reviews can also form a talent flow trend analysis. After implementing the nine-grid management, JL Technology's key position succession readiness increased from 52% to 78%, and the voluntary turnover rate of engineers decreased by 14 percentage points year-on-year^[6].

5.3. Talent map and IDP construction

The drawing method of the talent map mainly includes three key steps. The first step is to determine talent evaluation indicators, which requires selecting appropriate talent measurement standards based on the strategic goals of the enterprise. JL Technology focuses on technical research and development capabilities and the number of patent achievements when evaluating engineers, while incorporating team collaboration levels into the assessment scope. This approach can effectively reflect the actual value of employees. In the data collection stage, diversified tools need to be used. Some enterprises record employees' daily performance through online systems and obtain career development aspirations through quarterly interviews. This method can ensure data integrity and help identify hidden issues. When conducting talent inventory, JL Technology found a 20% deviation between department heads' evaluations of employees' innovation abilities and actual project outcomes, indicating that relying solely on subjective judgments can easily lead to errors. When analyzing the current status of talent, a

multi-dimensional evaluation system should be established. Employees are divided into technical and management types, with the former focusing on product development efficiency and the latter emphasizing resource allocation capabilities. This classification method helps accurately identify talent gaps. When data is visualized, the human resources department can intuitively discover the succession pool for key positions. For example, a nine-square grid chart of a certain enterprise shows that 35% of the personnel in the quality inspection department are in the development-waiting area, which directly led to the launch of a special training program^[7]. In practical application, the drawing of talent maps often requires dynamic adjustments. A semiconductor enterprise updates talent data quarterly and found that there is a correlation between the talent turnover rate in the market expansion department and performance evaluation standards. This continuous tracking provides a basis for the enterprise to adjust incentive policies. In the implementation process, collaboration between departments is particularly important. The finance department provides human cost data, while the technology department feeds back changes in capability requirements. This cross-departmental collaboration mechanism can enhance the accuracy of talent evaluation. The final talent map usually includes three core modules: existing talent structure, capability distribution, and development potential, providing visual support for the enterprise to formulate recruitment plans and promotion schemes.

The process of developing an IDP typically consists of four stages^[8]. The first stage involves employee self-assessment, where employees analyze their skill levels and career preferences through competency assessment forms or career interest questionnaires. JL Technology requires engineers to fill out assessment forms covering dimensions such as technical proficiency and project management experience, forming a personal competency radar chart for subsequent analysis. The second stage involves feedback from supervisors based on business needs. JL Technology's managers provide improvement suggestions for employees' weaknesses in areas such as chip design and process optimization^[9]. The third stage involves setting development goals that balance short-term ability improvement and long-term career paths. The company sets learning goals for junior IC engineers to master advanced packaging technology within three years, while also clarifying the possibility of promotion to technical experts after five years. The fourth stage involves translating abstract goals into specific measures when formulating action plans, such as engineers participating in a 5G communication chip research and development project to accumulate practical experience, or regularly attending packaging process training courses to enhance professional knowledge. Since implementing IDP, the proportion of employees actively participating in training at JL Technology has increased by 40%, and the promotion cycle for technical positions has been shortened by 1.2 years. Research shows that after implementing IDP, the company's annual turnover rate is 6–8 percentage points lower than the industry average, and the turnover rate of technical backbones has decreased^[10].

6. Implementation effect evaluation

By comparing the data before and after JL Technology implemented its talent development program, it can be observed that the annual voluntary turnover rate of IC engineers decreased from 15% to 9%. The score for the "career development support" option in the employee satisfaction survey increased from 62 to 78. The promotion cycle in the R&D department was shortened by an average of 4.7 months. The coverage rate of talent reserves for core positions increased from 30% to 67%. Among them, seven RF circuit design engineers who had originally planned to leave changed their decisions after receiving customized IDP plans. During the talent review process, 28% of high-potential engineers were identified using the nine-grid tool. After formulating targeted IDP plans,

career development satisfaction increased by 42%. This data proves that accurately identifying employee capability gaps and providing growth resources is key to stabilizing the technical team.

Utilizing learning maps and talent maps can effectively reduce employee turnover rates. By establishing a chip design competency model, the company decomposed job skills into nine core modules, including analog circuit design and process knowledge, and provided a tiered training curriculum system to support them. After six months of implementation, the voluntary turnover rate of employees in the pilot department decreased by approximately 30% compared to the same period last year, which is similar to the trend of turnover rate changes observed in manufacturing companies after improving their training systems. During the talent review process, the use of the nine-grid tool identified 28% of high-potential engineers. After formulating targeted IDP plans, career development satisfaction increased by 42%. This data demonstrates that accurately identifying employee competency gaps and providing growth resources is key to stabilizing technical teams, and this continuous improvement mechanism is worthy of reference for similar enterprises.

7. Conclusion

Taking JL Technology as a case study, this research identifies that the core causes of turnover among IC engineers in “high-precision, specialized, and innovative” enterprises are the ambiguity of career development paths and insufficient resources for skill enhancement. The subsequently constructed “Learning Map + Talent Map + IDP” system has achieved remarkable results: the annual voluntary turnover rate of IC engineers has dropped from 15% to 9%, the satisfaction with career development support has risen from 62 points to 78 points, the talent reserve coverage rate for key positions has reached 67%, and seven IC engineers who intended to resign have been retained through customized IDPs. These outcomes fully verify the crucial role of accurately matching growth resources in stabilizing talent. This system provides actionable tools for small and medium-sized “high-precision, specialized, and innovative” IC enterprises, such as the five-level promotion standards and phased training modules, which align with the industry’s demand for precise management. However, the research sample focuses on a single enterprise, so the generalizability of the conclusions in fields like semiconductor manufacturing and packaging and testing needs to be verified. Additionally, the data emphasizes short-term effects, and the long-term impact requires continuous tracking. In the future, the sample scope can be expanded, and the competency model can be optimized in conjunction with technological iteration to further facilitate the coordinated development of talent and the industry.

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Disclosure statement

The authors declare no conflict of interest.

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The Impact of the Rise of Internet Celebrity Cities on Hainan's Cultural Tourism Industry

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Abstract: In recent years, numerous internet-famous cities have rapidly gained popularity on social media through their unique tourism appeal, attracting massive tourist flows and profoundly impacting local cultural tourism industries. This paper analyzes the reasons behind these cities' breakout success and explores their development models, offering insights for Hainan's cultural tourism sector. The study reveals that such urban phenomena primarily stem from four key factors: crafting distinctive city IPs, implementing innovative marketing strategies, providing premium travel experiences, and building community-driven city identities. Drawing from these lessons, Hainan's cultural tourism industry should leverage its unique cultural resources to develop tourism IPs, adopt new media-driven marketing approaches, enhance service quality, strengthen brand building, and promote high-quality development to boost the region's tourism visibility and competitiveness.

Keywords: Internet celebrity city; Hainan cultural tourism industry; Cultural tourism IP; Marketing promotion; Service experience

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1. Introduction

1.1. Research background and significance

With the widespread adoption of the internet and the evolution of social media, the tourism industry has undergone profound transformations. Internet-famous cities have emerged as new hotspots in the travel market. By leveraging unique cultural elements, culinary delights, and scenic attractions through new media platforms like short videos and live streaming, these cities have rapidly gained widespread recognition, attracting massive tourist traffic and maintaining rising popularity in the travel sector^[1-3]. For example, Zibo has become famous for its barbecue, and Harbin has become famous for its ice and snow tourism and "creative ways to pamper tourists." The success of these Internet-famous cities has not only boosted local tourism but also had a positive impact on urban economic development and image improvement^[4].

As an important tourist destination in China, Hainan has rich natural resources and a unique cultural heritage, which provides a good foundation for the development of the cultural tourism industry ^[5]. However, amid the increasingly fierce competition in the tourism market, Hainan's cultural tourism industry faces challenges such as product homogenization, outdated marketing approaches, and room for improvement in service quality. Studying the phenomenon of viral cities gaining popularity and their underlying logic holds significant practical value for Hainan's cultural tourism sector. By learning from successful models of internet-famous cities, Hainan can better leverage its unique strengths to develop distinctive cultural tourism brands, drive high-quality development of the industry, and support the construction of Hainan as an international tourism consumption hub ^[6].

1.2. Domestic and international research status

International research primarily focuses on the impact of destination marketing strategies, brand development, and social media on tourism. Scholars emphasize that destinations should attract visitors through distinctive brand positioning and effective marketing approaches, while social media plays a crucial role in disseminating travel information and influencing tourist decisions. Regarding service experiences, studies prioritize visitor satisfaction and loyalty, proposing that enhancing service quality remains key to boosting a destination's competitiveness ^[7,8].

Domestic research on internet-famous cities and cultural tourism industry development has been extensive. On one hand, in-depth analysis has been conducted on the formation mechanisms, development models, and impacts of internet-famous cities, highlighting that their breakout success stems from multiple factors, including unique urban resources, new media dissemination, government guidance, and market-driven initiatives. On the other hand, regarding cultural tourism industry development, studies have covered aspects such as cultural-tourism integration, innovation in tourism products, and marketing strategies. Regarding Hainan's cultural tourism sector, existing research primarily focuses on its resource advantages, current status, and challenges, proposing suggestions like enhancing cultural exploration and improving tourism service quality. However, studies leveraging the experience of internet-famous cities to promote Hainan's cultural tourism industry remain relatively scarce.

1.3. Research methods and innovations

This study employs a literature review methodology by examining domestic and international research on internet-famous cities and cultural tourism development, systematically organizing existing scholarship to establish theoretical foundations. Through case analysis, it selects representative internet-famous cities such as Zibo, Harbin, and Chongqing, conducting in-depth analyses of their viral success factors, development models, and best practices, with specific insights for Hainan's reference. Comparative analysis is applied to evaluate Hainan's current cultural tourism industry against these iconic cities, identifying gaps and shortcomings while proposing targeted development strategies.

This study's innovation lies in integrating the phenomenon of internet-famous cities breaking through their local boundaries with Hainan's cultural tourism industry development, offering a fresh perspective on exploring growth pathways. Through a comprehensive analysis of multiple internet-famous cities, we systematically summarize their success stories. Combining these insights with Hainan's specific conditions, we propose innovative and actionable recommendations to provide fresh approaches and methodologies for advancing Hainan's cultural tourism sector.

2. Analysis of the reasons for the rise of Internet celebrity cities

2.1. Unique city IP shaping

Internet-famous cities often have unique urban IP, which can be food, culture, landscape, and other characteristic elements ^[9,10]. Zibo barbecue has become the city's iconic culinary symbol, celebrated for its unique preparation method and distinctive flavor. This specialty features a signature combination of "small skewers, crispy pancakes, and scallions," paired with specially crafted dipping sauces to create a unique dining culture. The experience has drawn massive tourist crowds, making it a viral social media sensation that fuels Zibo's tourism boom. Harbin, meanwhile, crafts its city identity around ice and snow culture, with attractions like the Ice and Snow World and Sun Island Snow Expo gaining worldwide fame. Its grand-scale ice sculptures and exquisite designs showcase the artistry of winter landscapes, attracting countless visitors each year to witness spectacular ice displays and immerse themselves in the charm of ice culture. Chongqing, with its magical 8D terrain and mountainous landscape, has become a filming hotspot for numerous movies and TV series. Landmarks like Hongya Cave and the Liziba Light Rail Pier, renowned for their architectural uniqueness and transportation marvels, have gone viral online as must-visit spots, transforming Chongqing into a captivating internet-famous city.

2.2. Innovative marketing and promotion methods

New media platforms have played an important role in the breakout of Internet celebrity cities. Short video platforms such as Douyin and Kuaishou, as well as social media platforms such as Weibo and Xiaohongshu, provide a broad space for the promotion of cities ^[11,12]. Internet-famous cities showcase their unique charm through posting exquisite images, engaging short videos, and vivid textual content on these platforms to attract user attention and sharing. Harbin has released numerous short videos on short video platforms featuring ice-snow landscapes, local delicacies, and folk culture. This content highlights the magical night views of the Ice and Snow World, the distinctive flavor of Madie'er ice pops, and captivating performances of Northeastern Errenzhuan (a traditional Chinese folk art), garnering massive likes, comments, and shares from netizens, which has steadily boosted Harbin's tourism popularity. These cities also actively invite influencers and travel bloggers to share their experiences through store visits and travel tips. With their massive fan bases and high influence, these influencers effectively attract followers' attention and spark travel desires. Zibo invited numerous food bloggers to taste its signature barbecue and share culinary experiences online, rapidly elevating the fame of Zibo barbecue and attracting a large number of tourists to visit.

2.3. Excellent tourism service experience

Internet-famous cities focus on improving the quality of tourism services to provide tourists with a high-quality tourism experience. In terms of tourism infrastructure, they continue to improve transportation, accommodation, catering, and other supporting facilities to facilitate tourists' travel and play ^[13]. During the peak season for ice and snow tourism, Harbin has increased public transport services and launched tourist shuttle routes to facilitate visitors' access to various attractions. Meanwhile, authorities have strengthened supervision of accommodation and catering industries to ensure tourists enjoy safe and comfortable lodging environments along with delicious and hygienic dining services. The city also focuses on personalized needs by offering customized travel services. For instance, some cities provide tailored tour itineraries designed according to travelers' interests and schedules, catering to individual preferences. Some scenic spots even offer unique guided tours featuring historical and cultural explanations or folk custom experiences, allowing visitors to gain deeper insights into local culture and

history^[14].

2.4. Building a city image with the participation of all

The rise of internet-famous cities stems from collective efforts in shaping their urban identity through public participation. Governments, businesses, and citizens collaborate to create welcoming tourism environments and services. Authorities actively guide and support the development of the tourism industry by formulating policies, increasing investments in infrastructure construction, and enhancing promotional campaigns to boost tourism^[15]. Meanwhile, the government has strengthened market supervision to maintain order and protect tourists' rights. Following the explosive popularity of Zibo barbecue, the municipal government swiftly introduced policies to regulate the market and enhance food safety oversight, ensuring visitors enjoy premium dining experiences. The city also organizes barbecue festivals and tourism events to boost its reputation. Enterprises actively develop distinctive tourism products and services to elevate travel quality. Accommodation providers like hotels, homestays, and restaurants continuously improve service standards, creating unique brands that offer comfortable and convenient stays. Citizens enthusiastically contribute to shaping the city's image through warm hospitality, showcasing the city's charm. In Harbin, residents spontaneously assist tourists by offering free rides, recommending attractions, and sharing local cuisine – demonstrating their hospitality and enhancing the city's image^[16].

3. Analysis of the current situation and problems of Hainan's cultural tourism industry development

3.1. Current situation of cultural tourism industry development in Hainan

Hainan boasts unparalleled natural resources, including sunshine, sandy beaches, azure seas, and clear skies, making it a renowned coastal tourism destination in China. Popular beaches like Yalong Bay and Haitang Bay in Sanya attract countless vacationers with their pristine sands and crystal-clear waters. The islands' abundant marine resources offer diverse water sports such as diving, surfing, and sea fishing, providing visitors with multifaceted experiences. Hainan's cultural tapestry is equally rich, blending Li and Miao ethnic traditions, maritime heritage, and the Dongpo cultural legacy. Unique Li craftsmanship, Miao Panhuang Festival celebrations, and other folk performances showcase distinctive ethnic charm. Maritime culture shines through fishing practices, maritime history, and oceanic beliefs—exemplified by the Mazu worship tradition in the South China Sea that reflects locals' deep connection with the sea. Dongpo culture, rooted in Su Shi's life and literary works in Hainan, is preserved at historical sites like Dongpo Academy and Guanlang Nunnery. In recent years, Hainan has boosted its tourism sector through policy reforms, investing heavily in infrastructure upgrades, product development, and promotional campaigns. The construction of the Hainan Island Ring Road now seamlessly connects the island's scenic spots. To facilitate tourists' travel and sightseeing, Hainan also holds various tourism and cultural activities, such as the Hainan International Tourism Island Carnival Festival and Sanya International Music Festival, to enhance the visibility and influence of Hainan^[17].

3.2. Problems existing in Hainan's cultural tourism industry

Some tourist attractions in Hainan suffer from product homogenization, lacking distinctive features and innovation. Beach destinations predominantly offer repetitive activities like beach walks and sea bathing, with few standout attractions. Tourism performances also face issues of repetitive content and monotonous formats, failing to meet

diverse visitor demands. The island's marketing strategies remain traditional, relying heavily on travel agencies and trade fairs while underutilizing new media platforms. In the social media era, Hainan's online promotion lacks sufficient effort to showcase its unique charm, resulting in relatively low online visibility and engagement. Service quality requires improvement, with overcrowding and delayed responses at peak seasons. The uneven professionalism among staff—particularly inadequate service awareness and professional competence among tour guides—impairs visitor experiences. Despite its rich cultural resources, Hainan's cultural exploration and utilization remain underdeveloped. Some cultural sites lack depth in presentation, failing to fully demonstrate the island's unique cultural appeal. The integration of culture and tourism remains insufficient, with cultural elements not being adequately incorporated into tourism offerings. In terms of products and services, the cultural added value of tourism products is low ^[18].

4. The impact of Internet celebrity cities on Hainan's cultural tourism industry

4.1. Digging into characteristic cultural resources and building cultural tourism IP

Hainan should fully leverage its rich cultural resources to develop distinctive cultural tourism IPs. As a hallmark of Hainan's identity, Li and Miao cultures could form the foundation for creating immersive attractions like cultural theme parks and traditional villages. These destinations would showcase authentic Li architecture, ethnic handicrafts, and folk performances, allowing visitors to experience the unique charm of these heritage traditions firsthand. Developing culturally-themed products such as Li brocade garments and Miao silver ornaments would significantly enhance the value of tourism offerings. The province's historical legacy, including iconic sites like Dongpo Academy and Hai Rui's Former Residence, provides an unparalleled backdrop for preserving and promoting this cultural heritage ^[19]. We can develop historical and cultural tourism routes by leveraging these heritage sites, delving into their profound historical significance. Through cultural lectures, themed exhibitions, and related activities, visitors can gain insights into Hainan's historical evolution and cultural legacy. As a vital component of Hainan's cultural identity, marine culture offers opportunities to create specialized tourism projects like ocean-themed museums and parks. Ocean museums showcase biological specimens and maritime artifacts, allowing visitors to appreciate the rich tapestry of marine culture. Marine theme parks can host educational programs and adventure activities, providing immersive experiences that highlight the ocean's cultural essence.

4.2. Using new media platforms to innovate marketing methods

Hainan should actively use short video platforms, social media platforms, and other new media for tourism promotion ^[20]. On short video platforms such as TikTok and Kuaishou, well-produced Hainan tourism videos showcasing the island's natural landscapes, culinary culture, and folk customs are created. Through creative filming techniques and engaging content, these videos attract user attention and sharing, thereby boosting the online popularity of Hainan tourism. On social media platforms like Weibo and Xiaohongshu, travel guides, recommended attractions, and food information about Hainan tourism are published to interact with users, answer their questions, and enhance their understanding and interest in Hainan tourism. Influencers such as travel bloggers and internet celebrities are invited to experience and promote Hainan tourism. They showcase the island's scenic beauty, culinary delights, and unique travel experiences through short videos, travel diaries, and live streams to attract followers to visit Hainan. Collaborating with renowned travel bloggers to launch "Traveling with Bloggers in Hainan" campaigns, these influencers recommend Hainan's featured travel routes and attractions based on their

own experiences, stimulating followers' travel desires.

4.3. Improving the quality of tourism services and optimizing the tourist experience

Hainan should enhance tourism infrastructure development by improving transportation, accommodation, and catering facilities. Regarding transportation, the island needs to optimize its network by increasing public transport frequency and routes to boost convenience. During peak seasons, implementing measures like advance ticket booking and time-slot entry systems will help manage visitor congestion effectively. For lodging, stricter management of hotels and homestays is required to elevate service quality and meet diverse tourist needs. In the catering sector, strengthened food safety oversight should be paired with promoting Hainan's local specialties to enrich dining experiences. The province should also prioritize staff training to improve service professionalism, including regular coaching for tour guides to enhance their interpretive skills and delivery techniques. Professional ethics education for tourism personnel is crucial to cultivating a positive service image and delivering warm hospitality. Timely feedback collection through surveys and online reviews will help identify service gaps, enabling prompt improvements to boost tourist satisfaction. By gathering visitor opinions via questionnaires and digital platforms, Hainan can continuously refine its tourism services. The needs and feedback of customers are constantly optimized to improve tourism products and services and enhance tourists' travel experience.

4.4. Strengthening the construction of the urban brand and creating a good tourism atmosphere

Hainan should establish a clear urban brand positioning that highlights its unique characteristics and advantages to create an internationally influential tourism destination. The province could position itself as an "International Tropical Island Tourism Destination," emphasizing its tropical landscapes, maritime culture, and distinctive travel experiences to attract domestic and international visitors. To support this positioning, unified brand slogans and visual identity systems should be developed, with multi-channel promotional campaigns to enhance the brand's visibility and reputation. Hainan should intensify city branding efforts to boost its global tourism market presence. By participating in international tourism exhibitions, showcasing local resources and products to draw attention from global travel companies and tourists, and collaborating with renowned media outlets for coverage, the province can significantly increase its exposure in international markets. Domestically, organizing cultural tourism events and attending national exhibitions will help attract more domestic travelers. Additionally, urban environmental improvements are crucial to foster a welcoming tourism atmosphere. This includes enhancing green spaces, improving ecological conditions, and elevating the city's overall image. Furthermore, stricter management of tourist attraction areas is essential to maintain pristine surroundings. Cleanliness and beauty. We advocate civilized tourism, improve the civilized quality of citizens, create a warm and friendly tourism atmosphere, so that tourists can feel the warmth of home in Hainan.

5. Countermeasures and suggestions for the development of Hainan's cultural tourism industry

5.1. Strengthening the integration of culture and tourism, enriching the supply of tourism products

Hainan should further strengthen the integration of culture and tourism by deeply exploring cultural resources and developing culturally rich tourism products. In scenic area development, cultural elements should be incorporated

to create theme-based attractions. For instance, at Nanshan Cultural Tourism Zone, Buddhist cultural elements should be thoroughly explored to develop immersive experiences where visitors can appreciate natural landscapes while immersing themselves in profound Buddhist philosophy. When designing travel routes, emphasis should be placed on connecting cultural elements through themed itineraries. The “Hainan Historical Culture Tour” exemplifies this approach, linking cultural landmarks like Dongpo Academy, Hai Rui’s Former Residence, and Yazhou Ancient City to help travelers understand Hainan’s historical legacy. Hainan should continuously innovate tourism products to meet diverse visitor needs. Rural tourism should leverage local characteristics to create idyllic landscapes, folk culture experiences, and agricultural activities that let visitors enjoy rural life. Wellness tourism should capitalize on Hainan’s climate advantages and natural resources to offer hot spring therapy, forest wellness programs, and traditional Chinese medicine treatments. Educational tours should utilize Hainan’s natural and cultural resources to develop marine science education, Li and Miao ethnic culture programs, and tropical plant exploration projects for students to provide opportunities for extracurricular learning and practice.

5.2. Strengthening policy support to promote the development of the cultural and tourism industry

The government should enhance policy support for the cultural tourism industry by introducing preferential policies to encourage corporate investment. Regarding land use, priority should be given to meeting the land requirements for cultural tourism projects, ensuring adequate land allocation for their development. Tax incentives should be implemented to reduce operational burdens on enterprises and promote business growth. A dedicated development fund should be established to support project construction, tourism infrastructure upgrades, and promotional campaigns. Financial incentives such as subsidies and loan interest rate discounts should be provided to incentivize corporate investment. The government must strengthen strategic planning by formulating scientific development plans that outline clear priorities for the industry. Enhanced approval processes and rigorous supervision will ensure project quality and effectiveness. Enterprises should be guided to develop tourism resources rationally, avoiding reckless or excessive exploitation to achieve sustainable growth in the cultural tourism sector.

5.3. Cultivating professional talents and enhancing industrial competitiveness

Hainan should strengthen collaboration with universities and research institutions to establish cultural tourism talent training bases, offering specialized programs and courses to cultivate professionals with industry-specific expertise. Through industry-academia-research partnerships, students will gain hands-on experience and enhanced practical innovation capabilities. Enterprises are encouraged to partner with academic institutions for customized training programs that align with corporate needs, ensuring targeted and practical talent development. The province should implement preferential policies to attract top-tier cultural tourism professionals from home and abroad. By providing competitive work environments and attractive compensation packages, Hainan can recruit management experts, tourism planners, marketing specialists, and other professionals. A performance-based incentive system should be established to reward outstanding contributors to the cultural tourism sector, thereby stimulating creativity and motivation among talents.

6. Conclusion

The breakout success of internet-famous cities in Hainan has provided valuable insights for the development of

its cultural tourism industry. Analysis reveals that three key factors drive their popularity: crafting unique city IPs, implementing innovative marketing strategies, and delivering premium tourism experiences through community engagement. Drawing from these models, Hainan's cultural tourism sector should: (1) Tap into its distinctive cultural resources to create compelling tourism IPs; (2) Leverage new media platforms to innovate marketing approaches; (3) Continuously improve service quality and visitor experiences. Simultaneously, enhancing brand building and fostering a tourism-friendly environment will boost industry growth. Furthermore, measures like integrating cultural and tourism resources, increasing policy support, and cultivating professional talent will diversify offerings and drive high-quality development in the sector.

As China's only tropical island province, Hainan boasts irreplaceable natural resources and a rich cultural heritage, positioning it as a prime candidate for becoming a "long-lasting" cultural tourism destination. While the viral buzz of internet-famous cities marks the beginning, sustaining visitor retention is the key to long-term success. The Hainan tourism industry should not chase fleeting online popularity but instead transform the breakout success of these cities into sustainable growth momentum. Through continuous product innovation, service upgrades, and cultural exploration, we can turn temporary traffic into a lasting reputation, shifting from superficial check-in tourism to immersive cultural experiences.

In the future, with the continuous advancement of Hainan's construction as an international tourism and consumption hub and the deepening integration of culture and tourism, Hainan is expected to break through current development bottlenecks and create a cultural tourism brand with international influence. By absorbing the successful experiences of internet-famous cities and exploring differentiated development paths based on its own characteristics, Hainan will not only become a favored tourist destination for domestic visitors but also secure a place in the international tourism market. This will showcase the unique charm of China's tropical islands to the world, tell the story of Hainan's cultural tourism well, and contribute "Hainan Power" to the development of China's cultural tourism industry.

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Strategies and Practices of Enterprise Human Resource Management in the Era of Big Data

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Abstract: With the comprehensive development of modern information technology, big data technology has been integrated into various industries and has become a pillar technology supporting industrial upgrading and transformation. In enterprise human resource management, big data technology also has a broad application space and important application value. To gain higher market competitiveness and comprehensively improve the quality and efficiency of human resource management, enterprises need to rely on big data technology for comprehensive reform and optimization, thereby building an efficient, fair, open, and scientific human resource management model. This paper analyzes the problems and changes of enterprise human resource management in the era of big data, and then puts forward effective strategies for enterprise human resource management based on the era of big data.

Keywords: Big data era; Enterprises; Human resource management; Strategies

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1. Introduction

In the process of rapid social and economic development, enterprises must continuously improve their development capabilities through innovative development models to adapt to the needs of the times and gain better development space. Human resource management imposes significant constraints on the development of enterprises. Traditional human resource management is of low quality, with problems such as insufficient recruitment capabilities, an inaccurate grasp of training, inadequate incentives for work enthusiasm, and difficulties in retaining outstanding talents. In this regard, enterprises need to fully leverage big data technology to solve the problems faced in enterprise human resource management.

2. Big data era: Issues in enterprise human resource management

2.1. Low management level and efficiency

At present, most enterprises have not fundamentally innovated their human resource management models. The

application of big data is still based on the framework of traditional management models, which not only restricts the functions and value of big data, but also makes it difficult to truly solve human resource management problems with the help of big data technology due to employees' insufficient understanding of big data technology^[1]. It even brings new problems to enterprise development and causes negative feedback effects.

2.2. Outdated management concepts and cognition

Currently, the management of some enterprises lacks awareness and cognition of updating management concepts. On the one hand, they fail to recognize the important significance of human resource management for the long-term development of enterprises; on the other hand, they ignore the training of employees on big data technology and related management knowledge. As a result, even if enterprises implement big data application measures, they still face widespread human resource management problems, leading to the failure of big data technology to reflect its due value and role in recruitment, training, management, and other links^[2].

2.3. Lagging management measures and technologies

Human resource managers in some enterprises still believe they have rich management experience, thus ignoring the application value of big data technology. This leads to traditional human resource management measures and technologies becoming one of the important factors affecting enterprise development. On the one hand, it weakens the enterprise's own market competitiveness; on the other hand, enterprises also ignore investment in the construction of human resource management systems using big data technology and fail to introduce human resource management concepts, measures, and plans that meet their needs^[3].

2.4. Low management quality and capability

For modern enterprises, the traditional human resource management model is no longer compatible with the current enterprise structure, thus resulting in insufficient management quality and capability. For example, due to limitations in recruitment practices and space, the efficiency of talent recruitment is low, and the speed of selecting high-quality talents is slow; another example is that in terms of performance appraisal and evaluation, fairness risks are prone to occur, which is detrimental to the long-term development of employees^[4]. Obviously, traditional human resource management methods can no longer adapt to the sharply increasing data volume and data processing needs in the context of the information age, which requires enterprises to fully implement the application of big data technology.

3. Changes in enterprise human resource management in the era of big data

3.1. Upgrade of training methods

In traditional human resource management, enterprises could only adopt a unified employee training model. This model was unable to design training content based on each employee's development needs and ability foundation, nor could it ensure that employees achieve the desired goals through training. However, big data support has solved this problem. By analyzing employees' data and information, it can establish employee profiles, identify employees' work competencies and weaknesses^[5], and then propose targeted training content and suggestions based on factors such as positions and employee characteristics. This provides significant support for employees' individual development.

3.2. Transformation of management methods

Traditional human resource management methods had flaws, such as incomplete collection of employee information, which made it difficult to achieve good results and goals in management work. The application of big data has transformed enterprises' human resource management methods. Firstly, it improves the fairness and transparency of employee performance appraisals, ensures that employees have reasonable and scientific promotion channels, and thereby achieves an incentive effect. Secondly, it can also obtain data related to each employee's personality, abilities, psychology, etc. ^[6], enabling enterprises to provide salary levels that match each employee's capabilities and potential, further boosting employees' work enthusiasm.

3.3. Optimization of performance management

In traditional enterprise human resource management, performance management could only evaluate employees' performance over a certain period to a certain extent. It could neither motivate employees nor point out the weaknesses that employees need to address for their subsequent development. With the support of big data technology, a more scientific and comprehensive employee evaluation index system can be constructed. Different evaluation contents and standards are set for different positions ^[7], which not only enhances fairness and objectivity but also avoids the influence of appraisers' subjective attitudes. This can effectively reflect employees' abilities and qualities, and based on this, formulate planning schemes for employees' long-term development.

4. Enterprise human resource management strategies in the big data era

4.1. Leveraging big data to optimize human resource planning and management

For enterprises, human resource planning and management represent the primary target for the application of big data technology. This not only helps rationalize and scientize human resource planning but also effectively improves the quality and effectiveness of human resource management, thereby demonstrating the important role of the human resource management department in enterprise development.

First, enterprises should integrate big data technology with human resource planning. They need to establish a big data platform to collect human resource-related information from internal and external environments, including employee data and talent market data ^[8]. Based on the analysis and research of such information and data, enterprises can formulate scientific human resource development strategies aligned with their current-stage development needs and assess the actual status and development demands of their human resources. Second, a big data analysis system should be established, incorporating human resource-related planning information, performance evaluation information, and compensation management information. By leveraging computers to analyze and process basic data sorting work, the quality and efficiency of work can be enhanced. Third, enterprises should rely on big data to build accurate employee profiles. Based on employees' daily behavior information, a behavior prediction mechanism can be established to assess each employee's capabilities, qualities, development needs, and skill gaps. Furthermore, a comprehensive quantitative index system for employee assessment can be developed ^[9] to analyze each employee's contribution to enterprise development, including both current and future contributions. This enables a scientific evaluation of employees' work value and provides data support for human resource management and talent job adjustments. Finally, a human resource management system should be established, with big data as the foundation, to build corresponding modules such as self-service, strategic management, business management, and human resource management. Under the human resource management module, sub-modules like personnel information management, compensation management, attendance

management, and performance management can be further established, thereby forming a systematic human resource management model.

4.2. Improving human resources recruitment and training with big data

Big data technology also holds significant application value in the recruitment and training aspects of enterprise human resources. It can effectively reduce the workload and pressure on human resource managers, transforming traditional manual-based resume screening and interviews into big data-assisted screening and online interviews. This not only enhances the quality of enterprise talent recruitment and training but also maximizes the strengths and capabilities of talent.

Firstly, in human resources recruitment, the traditional model relies solely on managers to manually screen and review resumes. After identifying potential candidates, they send emails or make phone calls to invite them for offline interviews. This process is not only cumbersome and complex but also involves a great deal of ineffective work. Additionally, the capabilities of interviewees vary widely, making it difficult to select talents that meet the company's needs. In the assessment of talents' qualities and abilities, reliance is placed solely on interviewers' experience and subjective judgments, which lack scientific rigor and objectivity. It also easily leads to nepotism, resulting in mismatches between talents and positions. The application of big data technology can transform this recruitment model and process. By leveraging online recruitment platforms, enterprises can intelligently screen through a vast number of resumes, selecting candidates that match requirements based on criteria such as educational background, professional field, and work experience^[10]. After highly precise searches, staff only need to manually review a small number of resumes to find the most qualified candidates. Secondly, big data technology also has important applications in talent training. Big data enables the construction of a more comprehensive training system. On one hand, based on employee profiles, companies can understand each employee's professional skills and comprehensive qualities, thereby developing personalized training programs tailored to individual needs. On the other hand, intelligent training platforms can be established, where big data analytics intelligently recommend relevant professional books, video courses, and other resources^[11], providing employees with opportunities for independent learning and development.

4.3. Leveraging big data to advance the construction of human resources data modules

In the process of building enterprise human resources data modules, big data is also an indispensable technology. It enables enterprises to implement hierarchical and classified management of human resources, thereby enhancing the scientificity and efficiency of human resource management. Modern enterprises attach great importance to the construction of human resources data modules. With the help of big data technology, they can conduct in-depth analysis to understand the work characteristics of different positions and employees' development goals. By organizing and managing the specific data and information of all employees in a classified manner, targeted data support and services can be provided for other work. Specifically, enterprises can establish modules such as basic data, capability data, efficiency data, and potential data. Through the division of different data modules, unstructured data can be collected via crawler technology, classified, and stored in the corresponding modules^[12].

First, in the basic data module, data such as employees' gender, age, position, rank, political affiliation, education level, skill level, and foreign language proficiency are mainly collected to demonstrate their comprehensive capabilities and basic qualities^[13]. Second, in the competence data module, the focus is on collecting information related to employees' work abilities, daily performance, and personal qualities in their

current positions or before taking up positions, including specific details like training experience, training results, competition achievements, and award records, so as to determine whether employees meet the requirements of their current positions. Third, in the efficiency data module, based on individual tasks, data such as the duration of each employee's work in different positions, error rate, and work completion efficiency are recorded to assess their work standards and efficiency levels, thereby providing a basis for customizing training programs. Fourth, in the potential data module, a comprehensive analysis is conducted on information such as employees' work efficiency improvement, income growth, and professional title promotion frequency. This helps observe the potential indicators of employees' continuous development and growth, and thus enables the judgment of their long-term development qualities, which is of great guiding significance for the construction of enterprise talent training plans and career planning ^[14].

4.4. Establishing a talent team guarantee for human resources relying on big data

Employees are the implementers and executors of work deployment, task fulfillment, and management practice. Therefore, excellent human resources management talents are indispensable for the development of enterprise human resources management. Enterprises must thus rely on big data to establish a talent team guarantee for the human resources management department, so as to ensure the comprehensive reform and optimization of human resources management work.

First, a sound training mechanism for staff in the human resources department should be established. Enterprises should carry out regular training activities and set up special training courses focusing on big data technology application, information literacy, big data thinking, and computer knowledge and skills ^[15], to ensure that the department's personnel can use computer systems and big data platforms to complete various tasks. Second, enterprises should also regularly organize outstanding employees to participate in external exchange programs, further study, or even overseas visits and investigations, so as to learn advanced experiences and methods and solve practical problems faced by the enterprise. In addition, enterprises should actively introduce high-quality and interdisciplinary talents majoring in human resources management, ensuring that they possess certain big data application capabilities, information literacy, and data thinking. At the same time, through strict assessment activities to evaluate their comprehensive skills and professional quality, enterprises can select outstanding talents who meet the needs of current enterprise human resources management positions based on big data systems, thereby providing a talent team guarantee for the development and construction of the enterprise's human resources management department.

5. Conclusion

In summary, against the backdrop of the big data era, human resources management is becoming increasingly important for the development of enterprises. Modern enterprises should fully leverage big data technology to optimize the level of human resources planning and management, improve human resources recruitment and training work, promote the construction of human resources data modules, and establish a talent team guarantee for human resources, thereby providing important support for the modernized management and data-driven construction of enterprises.

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Research on Tax Planning and Risk Prevention Paths for Multinational Enterprises under the Stricter International Tax Policy Environment

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Abstract: As global economic integration accelerates, countries are strengthening tax transparency and information exchange. Policies such as the OECD's BEPS Action Plan, digital services taxes, and a global minimum effective tax rate have been introduced, posing increasingly severe compliance and risk challenges for multinational enterprises. Building on an analysis of the evolution and trends of international tax policy, this paper combines literature review with case study analysis to examine how multinational firms can, on a compliant basis, leverage legislative and policy tools, optimize organizational structures, and arrange transfer pricing to achieve effective tax planning. We then propose an internal control framework encompassing tax risk identification, early warning, and monitoring. Our findings indicate that by dynamically adjusting group structures, judiciously applying double non-taxation treaties, and deploying digital monitoring systems, enterprises can significantly improve planning efficiency while reducing noncompliance costs. Finally, we offer recommendations for enhancing internal governance, strengthening cross-border coordination, and responding to policy changes, providing both theoretical guidance and practical reference for the stable development of multinational enterprises.

Keywords: International tax policy; OECD BEPS; Multinational enterprises; Tax planning; Risk prevention

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1. Introduction

Driven by both global economic integration and digital transformation, governments worldwide have become increasingly concerned about cross-border profit shifts and the erosion of tax bases. Since the OECD launched its Base Erosion and Profit Shifting (BEPS) Action Plan in 2013, a series of new international tax rules—such as digital services taxes and a global minimum effective tax rate—have emerged. Tax authorities have responded by enhancing transparency, automating information exchange, and tightening compliance scrutiny. While these measures curb aggressive tax arbitrage, they also elevate the compliance risks and costs associated with traditional

planning models. At the same time, the COVID-19 pandemic and geopolitical conflicts have heightened national attention on the tax contributions of foreign-invested enterprises, forcing multinational groups to seek a balance in an increasingly complex tax environment. In this context, an in-depth analysis of international tax policy evolution and its impact on multinationals is of great theoretical and practical significance for helping firms build robust tax planning and risk prevention systems. This paper aims to systematically explore, against the backdrop of tightening international tax policies, the tax-planning paths and risk-prevention mechanisms available to multinational enterprises on a compliant basis. First, we synthesize existing literature and interpret key policy texts to map out the frameworks of the OECD BEPS Action Plan, digital services taxes, and the global minimum effective tax rate. Next, we analyze several representative multinational case studies to uncover best practices in group-structure design, transfer-pricing arrangements, and treaty utilization. Finally, based on the identified planning strategies and potential risks, we construct an integrated path diagram covering risk identification, early warning, and internal-control monitoring. Our methodology combines policy-text analysis, case comparison, expert interviews, and secondary-data validation, with the intention of offering multinational enterprises actionable planning ideas and effective risk-management tools.

2. Literature review

2.1. Research progress on the tightening of international tax policy

In recent years, as issues of profit shifting and base erosion by multinational enterprises have become increasingly prominent, both academia and policy institutions at home and abroad have conducted extensive research on the trend toward stricter international tax policy. On the one hand, the OECD's BEPS Action Plan has become a focal point for study. Numerous scholars have systematically evaluated its design, implementation progress, and the compliance costs imposed on enterprises from perspectives such as tax competition, information transparency, and the effectiveness of multilateral agreements. Their findings show that while BEPS has been effective at harmonizing member-state legislation and strengthening information exchange, uneven implementation and enforcement gaps remain. On the other hand, digital services taxes (DSTs) and global minimum tax regimes have attracted growing attention. Research in this area focuses on methods for measuring tax bases, pricing models for cross-border digital firms, and the impact of new taxes on international investment flows. Some empirical studies indicate that DSTs promote fairness in digital-economy taxation but may also give rise to double-taxation concerns. Meanwhile, international organizations such as the IMF and the World Bank have simulated policy outcomes on global fiscal stability and economic growth, highlighting the need for further refinement in rate setting, anti-haven measures, and multilateral cooperation mechanisms. Domestic research has tended to concentrate on the compliance challenges and response measures facing Chinese multinationals, using case studies to explore how, under the Belt and Road Initiative, firms can balance tax planning with risk prevention. These studies provide localized insights for China's participation in crafting international tax rules. Overall, existing literature offers an in-depth discussion of policy evolution, policy effects, and corporate response strategies, but there remains room for more granular work on multidimensional risk assessment and dynamic-monitoring mechanisms.

2.2. Current research on multinational tax planning and risk prevention

Current scholarship centers on the planning methods and associated risk-management mechanisms that multinationals employ in a complex tax environment. On the planning front, researchers have examined optimized

uses of transfer pricing, intra-group financing, and profit repatriation tools. Case-based studies reveal how firms design related-party transaction prices, leverage double non-taxation treaties, and select low-tax jurisdictions to minimize global tax burdens. At the same time, other studies warn that excessive reliance on aggressive tax planning may invite audits and reputational harm, recommending that enterprises balance tax efficiency with compliance and transparency. In terms of risk prevention, both academics and practitioners emphasize establishing a full-process, multi-tiered internal-control system^[1]. The literature suggests drafting tax policies and operating manuals at both headquarters and subsidiary levels, supported by real-time monitoring platforms that collect transaction data to deliver dynamic risk-warning signals. Some scholars have introduced big data and AI technologies to develop tax-risk models, enabling the prediction of high-risk transactions and informed decision-making. Cross-departmental collaboration—among finance, legal, and compliance teams—is also highlighted as essential for mitigating potential penalties and additional tax liabilities arising from planning activities. Despite significant advances in tool applications and framework development, unified standards for multidimensional risk assessment and dynamic monitoring in emerging digital-economy contexts remain underdeveloped. Future research could delve deeper into integrating algorithmic models with governance processes^[2].

3. Evolution and trend analysis of international tax policy

3.1. OECD BEPS Action Plan and its domestic implementation

Since 2013, the OECD, together with the G20, has launched the BEPS Action Plan to close gaps in international tax rules and prevent multinationals from exploiting cross-border tax disparities. The Plan comprises fifteen detailed measures addressing tax-transparency enhancements (e.g., the Common Reporting Standard, CRS), reallocation of taxing rights (e.g., multilateral conventions and digital-economy taxation), substance requirements (e.g., Controlled Foreign Company rules), and anti-avoidance safeguards (e.g., anti-abuse clauses and interest-limitation rules). At its core lies multilateral cooperation: member countries are encouraged to adopt the BEPS Multilateral Instrument (MLI) to swiftly embed these measures into bilateral tax treaties, ensuring consistent and coordinated implementation. Domestically, China's Ministry of Finance and State Taxation Administration have, since 2016, introduced various implementing rules and guidelines. First, amendments to the Enterprise Income Tax Law and its regulations strengthened CFC rules and interest-deduction limitations to curb excessive intra-group financing and profit shifting. Second, China has actively signed and ratified the BEPS Multilateral Instrument, updating more than ten bilateral tax treaties by 2025 to incorporate anti-abuse provisions and dispute-resolution mechanisms^[3]. Third, to implement the CRS, China piloted automatic exchange of cross-border financial-account information in 2017 and formally launched CRS in 2018, requiring domestic financial institutions to collect and share data on foreign residents' accounts with tax authorities. Additionally, the State Taxation Administration issued transfer-pricing guidelines and a Tax-Risk Alert Manual for Multinational Enterprises, and rolled out advance pricing agreements (APAs) and self-assessment platforms to reduce post-filing disputes and additional tax assessments. These multifaceted measures signify China's thorough integration of BEPS principles into its tax-law reforms, offering clearer compliance and planning pathways for multinationals^[4].

3.2. Comparison between the global minimum tax and digital services tax regimes

The global minimum tax, or Pillar 2, proposed under the OECD/G20 BEPS two-pillar framework, seeks to ensure that multinationals pay at least a 15 percent effective tax rate (ETR) in every jurisdiction where they operate. It

employs an Income Inclusion Rule (IIR) and an Undertaxed Payments Rule (UTPR) to collect top-up taxes either at the parent-company level or from recipients of undertaxed payments, directing tax shortfalls to the parent's jurisdiction or the source jurisdiction. Effective implementation requires participating countries to adopt uniform ETR calculations, profit-allocation principles, and dispute-resolution rules in domestic legislation, thereby preventing harmful tax competition and rate inversion ^[5]. While Pillar 2 curbs profit shifts to low-tax havens, it imposes significant compliance, reporting, and treasury-structure demands on enterprises. In contrast, DSTs are unilateral or transitional measures enacted by individual countries before the completion of Pillar 1 negotiations. They target a narrow base of value-generating digital services—such as online advertising, intermediary platform fees, and monetization of user data—often levying rates between 3 and 7 percent and applying revenue and profit thresholds. Unlike the multilateral Pillar 2 approach, DSTs risk double taxation, trade disputes, and fragmentation of the international tax system. Nevertheless, they play a complementary role: in the short term, DSTs enhance tax fairness in the digital economy, while Pillar 2 offers a sustainable, unified solution for long-term tax stability and equity ^[6].

4. Tax planning strategies and pathways for multinational enterprises

4.1. Leveraging legislative and policy instruments under a compliance premise

In an increasingly stringent international tax environment, multinational enterprises must first respect the compliance “red lines” of domestic tax laws and multilateral agreements when engaging in tax planning. On one hand, they can draw on exemption and reduction clauses in bilateral or multilateral tax treaties—combined with exemption-and-credit principles—to maximize benefits such as interest-and-tax-before-cost deductions and cross-border dividend exemptions. On the other hand, they should proactively apply for Advance Pricing Agreements (APAs) and tax rulings, negotiating in advance with tax authorities over transfer-pricing methods and profit-allocation standards to reduce post-filing disputes and adjustments. Moreover, companies ought to monitor country-specific incentives—such as R&D super-deductions, high-technology enterprise preferential rates, and foreign-investment loss-offset provisions—to optimize their group's overall effective tax rate. Finally, by utilizing international information-exchange and mutual-assistance channels like the Common Reporting Standard (CRS) and Mutual Agreement Procedure (MAP), firms can correct or contest undue tax adjustments in a timely manner, achieving a dynamic balance between planning efficiency and compliance risk ^[7].

4.2. Organizational structure optimization and transfer-pricing arrangements

To achieve both optimal resource allocation and an efficient tax burden, multinationals should begin with their group structure—carefully establishing holding companies, functional entities, and regional operating centers. First, they may locate a headquarters or financing platform in treaty-friendly jurisdictions that offer favorable tax treatment, centralizing cash management and intellectual property. Simultaneously, high-value-added activities like core R&D and brand management should be concentrated in locations offering R&D super-deductions or high-technology enterprise incentives ^[8]. Next, by establishing branches or permanent establishments for low-risk, low-profit functions such as sales, distribution, and after-sales service in local markets, companies can both reduce local tax obligations and substantiate genuine economic substance. In transfer pricing, enterprises must adhere to the “arm's-length principle,” selecting the most appropriate method—Comparable Uncontrolled Price (CUP), Cost-Plus, or Profit Split—based on each entity's functions, assets, and risk profile. For transactions

involving intangibles or integrated services, bilateral or multilateral profit-split models can ensure that profits are allocated reasonably across jurisdictions, supported by rigorous comparability analyses and financial adjustments^[9]. At the same time, firms should strengthen their transfer-pricing documentation—preparing a Local File, Master File, and Country-by-Country Report (CbCR)—and lock in key parameters through APAs to minimize post-filing disputes and additional tax assessments. Through the synergy of structure optimization and transfer-pricing design, multinationals can both minimize their tax burden within a compliant framework and solidify the economic substance and transparency of their profit allocations^[10].

5. Tax-risk identification and monitoring mechanisms

5.1. Tax-risk types and root-cause analysis

Multinational enterprises face four major categories of tax risk in a diversified global tax regime: transfer pricing risk, compliance filing risk, information exchange risk, and tax policy change risk. Based on internal audits and tax authority reviews of fifty large multinationals over the past two years, **Table 1** summarizes each risk’s annual occurrence frequency and primary causes.

Table 1. Major tax-risk types and annual occurrence rates

Risk type	Annual occurrence	Primary causes
Transfer pricing risk	42%	Insufficient comparables; inadequate documentation; flawed FAR analysis
Compliance filing risk	28%	Mismatched filing deadlines; divergent formats and requirements
Information exchange risk	18%	CRS exchange delays; incomplete systems testing
Tax policy change risk	12%	Failure to anticipate new regulations; lack of cross-border policy monitoring

Transfer pricing risk is the most prevalent, driven by the complexity of intra-group transactions and varying comparability standards across jurisdictions. Compliance filing risk arises from inconsistent filing windows and divergent format requirements, leading to omissions or errors. Information exchange risk was acute during the early CRS rollout, when some firms had not completed system integrations or failed to update account holder data. Tax policy change risk stems from frequent introductions of digital services taxes, minimum tax rules, and other measures without forward-looking monitoring mechanisms in place. To quantify potential financial exposure, **Table 2** estimates the average additional tax liability associated with each risk category.

Table 2. Average potential additional tax costs by risk type

Risk type	Average estimated additional tax (USD 10k)
Transfer pricing risk	850
Compliance filing risk	420
Information exchange risk	260
Tax policy change risk	310

Given these figures, multinationals should prioritize mitigating transfer pricing and compliance filing risks by enhancing their Functions-Assets-Risks (FAR) analysis, reinforcing documentation and process controls,

and deploying automated tools for real-time data validation—thereby curbing both financial and compliance exposures.

5.2. Building a risk-warning and compliance-monitoring system

To enable rapid response and dynamic control of tax risks, firms should develop a comprehensive compliance monitoring platform that integrates data collection, indicator tracking, early warning triggers, and emergency response. This system comprises four key components: Define quantifiable monitoring metrics tied to the risk categories above—such as deviation in related-party gross margins, number of late filings, CRS data-match rate, and policy-change response time—and establish tiered thresholds as shown in **Table 3**.

Table 3. Compliance monitoring indicators and response measures

Indicator	Data source	Threshold	Severity	Response
Related-party gross margin deviation	ERP / Transfer pricing system	± 5% from benchmark	High	Conduct immediate FAR review; revise documentation
Filing-delay count	National tax filing logs	> 2 per year	Medium	Notify Finance; initiate special internal audit
CRS data-match rate	CRS exchange system	< 98%	Low	Collaborate with IT to upgrade the interface; complete data
Policy-change response time	Policy monitoring tool	> 30 days	Medium	Convene compliance team; draft amendment plan
Accrued vs. actual tax variance	Internal tax management system	> 10%	High	Adjust accruals; conduct special disclosure

Consolidate ERP, shared services, tax data, external policy feeds, and third-party risk scores in a hybrid data warehouse and real-time streaming architecture to standardize, cleanse, and unify information across systems and regions. Employ a rules engine and lightweight machine learning models to calculate indicators in real time or at set intervals. When a threshold is breached, the system automatically notifies the head of tax compliance, the CFO, and relevant subsidiary executives via email and SMS, and visually flags anomalies on a dashboard. Define tiered response workflows: High-risk events: Complete a special review and submit a detailed report within 24 hours. Medium-risk events: Finalize internal remediation within three business days. Low-risk events: Address during the routine monthly compliance meeting. All investigative steps and resolutions are archived in a compliance knowledge base to inform future strategy and process optimizations. By linking risk identification with real-time alerts and iterative improvement, this closed-loop system enables multinationals to pursue proactive tax planning while maintaining robust compliance in a rapidly evolving international tax landscape.

6. Case study analysis

6.1. Successful tax-planning case study of a multinational group

A global electronic manufacturing group (“X Group”) operates production sites and sales branches worldwide and faced heavy tax burdens due to varying jurisdictional tax rates. Beginning in 2019, X Group applied a FAR analysis to implement the following key planning measures: Centralize core R&D and intellectual property in Singapore, leveraging local high-technology enterprise incentives and licensing R&D outcomes to other entities.

Establish a sales and service center in Ireland, allocating profits through transfer pricing in Ireland’s 12.5 % low-tax regime. Secure an APA for key components through its China subsidiary, locking in a comparable profit margin and significantly reducing audit uncertainty. **Table 4** compares X Group’s effective tax rates (ETR) and annual tax savings before and after planning:

Table 4. X Group’s effective tax-rate comparison and annual savings

Jurisdiction	Pre-planning ETR	Post-planning ETR	Annual tax savings (USD million)
China	25.0%	25.0%	0.0
Singapore	17.0%	10.0%	3.2
Ireland	12.5%	5.0%	4.8
Other regions	22.3%	18.7%	2.5

As shown, by reallocating R&D and sales functions, X Group reduced ETRs by 7 percentage points in Singapore and 7.5 points in Ireland, achieving over USD 10 million in combined annual savings—4.5% of pre-tax global profit. Key success factors include: (1) strict adherence to arm’s-length principles and prior consultation with tax authorities; (2) full utilization of local incentives for R&D, regional headquarters, and financial platforms; and (3) use of APAs and double-non-taxation treaties to eliminate post-filing adjustment risk. This case not only optimized the group’s overall tax burden but also set a strong compliance precedent in financial reporting and audits, offering a replicable model for future expansions into other business lines and emerging markets. Continuous monitoring of BEPS Pillar 2 implementation and shifting policies is essential to maintain a compliant, dynamic strategy.

6.2. Lessons learned and replicable best practices

This case highlights several critical elements for achieving tax optimization under tight regulation, offering clear lessons for other multinationals: (1) Prior consultation: Securing APAs or rulings early establishes agreed comparables and profit-split standards, reducing audit disputes. (2) FAR analysis: Precisely identifying value-creation points enables concentration of high-value activities (e.g., R&D, brand management) in incentive-rich jurisdictions while distributing routine operations locally. (3) Treaty network utilization: Leveraging double non-taxation clauses and information-exchange agreements both prevent double taxation and provide MAP channels for dispute resolution. (4) Dynamic monitoring: Post-implementation, firms must regularly reassess local ETRs and policy changes via a compliance-monitoring platform, allowing rapid organizational and pricing adjustments in response to BEPS pillars, digital services taxes, and minimum-tax rules. These best practices can be replicated across various operational scenarios and jurisdictions, helping multinationals remain agile and compliant amid evolving global tax regimes.

7. Recommendations

7.1. Enhancing internal controls and governance

Multinational enterprises should establish a unified tax-governance framework at headquarters, integrating tax compliance and planning into enterprise-wide risk management, with clearly defined roles, responsibilities, and approval workflows. Develop group-level tax policies and operating manuals to standardize practices for related-

party pricing, cross-border fund flows, and incentive applications. Strengthen the independence of internal audit and compliance functions through regular process audits and on-site reviews, focusing on transfer-pricing documentation, APA compliance, and CRS reporting completeness. Utilize automation tools and data analytics platforms to monitor key risk indicators in real time and shift from reactive remediation to proactive prevention and dynamic adjustment—ensuring robust planning under multiple layers of tax oversight.

7.2. Policy coordination and external engagement

Faced with rapidly evolving international tax rules and uneven legislative timelines, multinationals should actively engage in policy analysis and industry collaboration. Join trade associations and chambers of commerce to share experiences and conduct joint research, and maintain ongoing dialogue with regulatory authorities. Before major policies take effect, convene expert teams for impact assessments, draft white papers, and hold pre-consultations with local tax bodies. Engage third-party advisors and law firms to track global legislative developments and BEPS two- and three-pillar implementation details, enabling timely adjustments to group structures and pricing models. Through internal-external coordination, enterprises can leverage policy benefits while retaining the flexibility needed to adapt to new regulations and ensure sustainable growth.

8. Conclusion

Against the backdrop of tightening international tax policies, this paper systematically reviewed the evolution of OECD BEPS measures, the global minimum tax, and digital services taxes, and analyzed a representative multinational case to develop compliant tax-planning strategies and pathways. Findings demonstrate that the combined use of bilateral and multilateral treaties, pre-filing agreements (APAs), structural optimization, and FAR-based transfer-pricing arrangements enables multinationals to minimize their tax burden while controlling compliance risk. An indicator-based, ERP-integrated monitoring platform provides dynamic early warnings and closed-loop management for key risks—reducing potential additional tax liabilities and reputational harm. The X Group case validates these approaches and offers a replicable model for other enterprises. Future research should explore advanced machine learning-driven risk models, tax incentives in emerging sectors like green hydrogen and the digital economy, and refinements to global minimum-tax coordination—further enhancing the integration of algorithmic analytics and governance processes in multinational tax management.

Disclosure statement

The author declares no conflict of interest.

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The Influence of Private Consumers' Perceived Value on Sticky Behavior in the Digital Age

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Abstract: With the rapid development of the digital age, the perceived value of private consumers has changed to varying degrees, which has a profound impact on consumption stickiness. Based on the existing research results, this study constructs a model with four dimensions of perceived value as mechanism variables (namely, perceived functional value, perceived emotional value, perceived economic value, and perceived social value), and studies the influence of private domain consumers' perceived value on consumption sticky behavior in the digital age. The empirical study finds that private domain consumers' perceived functional value, perceived emotional value, and perceived economic value positively affect consumption sticky behavior, showing a relationship that sticky behavior increases with the increase of the above three dimensions, while private domain consumers' perceived social value has a negative effect.

Keywords: Private domain consumers; Perceived value; Sticky behavior

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1. Introduction

With the development of the digital economy, the maturity of the social business model, and the deepening of time fragmentation of private domain consumers, data shows that the scale of private domain consumers in China will exceed 650 million in 2025, and 78.3% of consumers of Generation Z will take private domain channels as their first choice for daily shopping^[1]. Private domain consumption has profoundly changed the daily consumption scene and has become one of the main shopping methods. At the same time, private domain consumers are showing brand-new behavior characteristics different from traditional consumers. In the scene of the digital private domain, the perceived value of private domain consumers changes; the formation of consumer stickiness in the private domain is essentially a dynamic accumulation process of "trust-commitment-ownership" realized through continuous value exchange. Based on the theory of perceived value and behavior, the value perception of private consumers will affect their consumption sticky behavior.

To sum up, under the background of the digital age, this paper discusses the influence of consumers' perceived value on sticky behavior in the private domain. In order to provide a reference for enterprises to enhance

consumer stickiness and increase market competitiveness in private domain operations.

2. Theoretical basis and research hypothesis

2.1. Theoretical basis

2.1.1. Private consumers

Rolling thinks that private domain consumers refer to the user groups that enterprises directly reach and operate for a long time through enterprise WeChat, community, APP, applet, etc. These users have the characteristics of a high repurchase rate, strong interaction, and precipitable data, which can bring higher lifelong value to enterprises. Jiao thinks that it is very necessary to manage the relationship between enterprises and private consumers. Using a private community to provide interaction, such as tasting and pre-sale, can enhance the stickiness of private consumers ^[2].

Therefore, based on the above research results, this study believes that private domain consumers are high-value consumers who have been directly contacted by enterprises through their own channels and have been operating for a long time. They have the characteristics of a high repurchase rate, strong interaction, and precipitable data. Their essence is to reduce decision-making costs through professional services and trust relationships, thus enhancing the stickiness of private domain consumers.

2.1.2. Consumer perceived value

Zeithaml proposed that consumer perceived value is the overall evaluation of the benefits and costs paid by consumers ^[3]. Sheth et al. put forward a multidimensional value model, emphasizing that consumer behavior is comprehensively influenced by functional, social, emotional, cognitive, and situational factors ^[4]. Chen thinks that customer perceived value involves five dimensions: perceived product value, information value, entertainment value, perceived economic value, and social value ^[5]. Therefore, based on the above research results, this study integrates the views of Chinese and foreign scholars, defines consumer perceived value as perceived functional value, perceived social value, perceived emotional value, and perceived economic value, and discusses the influence on sticky behavior from these four dimensions.

2.1.3. Sticky behavior

Cai pointed out that stickiness behavior is characterized by repeated purchase, time investment, and multi-dimensional resource investment, and consumers' perceived value has a positive impact on stickiness ^[6]. Zou pointed out in the research on the sticky behavior of new media users that the sticky behavior of consumers presents a dynamic development feature, which shows a gradual process from initial non-sticky to strong sticky, and the degree of investment is positively correlated with the sticky strength ^[7]. Therefore, based on the above research results, aiming at the sticky behavior of private consumers, this study holds that sticky behavior is a continuous interactive behavior of consumers in their own channels, which is characterized by not only repeated purchase and time investment, but also multi-dimensional resource investment.

2.2. Research hypotheses

Zhang's research on Weibo users' sticky behavior based on the technology acceptance model shows that four key factors, namely perceived ease of use, subjective norms, perceived interest, and perceived usefulness, will significantly enhance users' willingness to use, and the willingness to use will have a significant positive impact on

users' sticky behavior. Therefore, these factors together constitute an important driving force to promote the user's sticky behavior^[8]. Based on the analysis of new media consumers, Zou's research shows that perceived cognitive value, perceived emotional value, perceived social value, and perceived interactive value can positively promote the sticky behavior of new media users^[7].

Based on the above analysis, the following assumptions are put forward:

H1: The functional value of private consumers has a positive impact on sticky behavior.

H2: The emotional value of private consumers has a positive impact on sticky behavior.

H3: The economic value of private consumers has a positive impact on sticky behavior.

H4: The social value of private consumers has a positive impact on sticky behavior.

To sum up, the theoretical model of this study is shown in **Figure 1**.

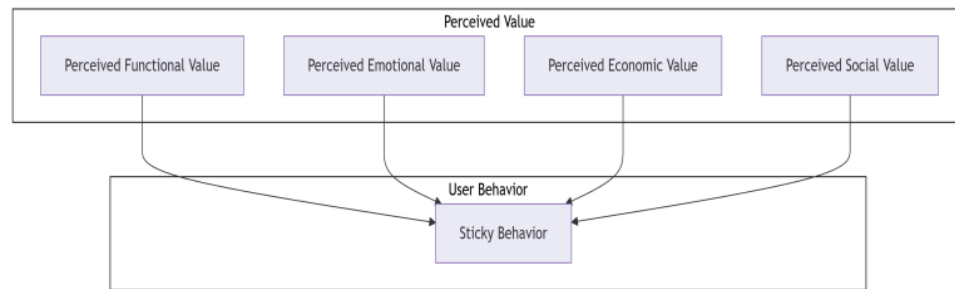


Figure 1. Theoretical framework model

3. Research design and methods

3.1. Description of samples

This study selected consumers who have been shopping in private areas in the past year as the research subject to ensure the scientific results of the survey. In this study, a questionnaire survey was used for empirical research. Firstly, the questionnaire was designed and generated using the platform of Questionnaires. Subsequently, the QR code of the questionnaire was published through social media platforms such as WeChat, Weibo, and Tik Tok, and qualified samples were recruited by using the paid service of Questionnaires. A total of 354 questionnaires were distributed, and 326 questionnaires were recovered, with a recovery rate of 92.1%. Excluding some unqualified questionnaires, 321 valid questionnaires were obtained.

3.2. Questionnaire design

In order to ensure the accuracy and clarity of the questionnaire, the questionnaire design of this paper was modified according to the relevant scales of many experts and scholars. The contents of the questionnaire include: basic information, consumer perceived value survey in private domain, and consumer sticky behavior survey in private domain, and each dimension includes multiple questions, using the Likert scale method.

The measurement of the scale of perceived value of private consumers mainly draws on the scale of perceived value of Yi Chen and Bingyan Zhao^[9], including four dimensions: perceived functional value, perceived emotional value, perceived economic value, and perceived social value, with five items in each dimension; a total of 20 items were used for measurement.

The measurement of sticky behavior draws lessons from the scale design of Zou^[7] and Bao^[10], and adopts five items, which are scored by a Likert 5-point scale, where 1 means "very inconsistent," 5 means "very

consistent,” and 3 means “average” (see **Table 1**).

3.3. Validity and reliability

Reliability test: The analysis of the reliability test results is shown in **Table 2**. Cronbach’s α coefficient of the scale is higher than the standard 0.8, both of which are above 0.85, indicating that the scale has good internal consistency and reliability, and the measurement results are stable and credible.

Validity test: The analysis of validity test results is shown in **Table 3**. The overall KMO value of the scale is higher than the standard 0.7, reaching 0.880, and the Sig value of the Bartlett spherical test is 0.000, reaching a significant level, indicating that there is a significant correlation between variables, and the data is suitable for factor analysis. There is a significant correlation between the display variables, which fully meets the prerequisite for factor analysis.

Table 1. Scale design

Variable name	Number	Questions
Perceived functional value	A1	The products provided by private domain channels are better than other platforms in terms of functionality.
	A2	The customized product scheme through private domain customer service can accurately meet my needs.
	A3	Private domain members’ exclusive version of goods has a more practical functional configuration.
	A4	The product use tutorial in the private community helps me to better understand the function of the goods.
	A5	Before purchasing through private channels, I can fully understand the product functions through the real experience of other members.
Perceive emotional value	B1	The process of buying and using goods in private communities makes me feel happy.
	B2	The exclusive care of the brand’s private domain makes me feel valued.
	B3	Sharing shopping experiences with other members in the private community makes me feel a sense of belonging.
	B4	The personalized service of private customer service makes me emotionally dependent on the brand.
	B5	Participating in weekly interactive activities in the private domain makes me have more feelings for the brand.
Perceived economic value	C1	The exclusive discount provided by private domain channels is more favorable than other platforms.
	C2	I will increase unplanned purchases because of limited-time special offers in the private domain.
	C3	The price rights corresponding to the private domain membership level make me more willing to continue spending.
	C4	I feel that the “cash back from drying orders” provided by the private domain customer service is worth it.
	C5	Even if the goods are not discounted, the additional benefits provided by the private domain make me feel cost-effective.
Perceive social value	D1	Membership in private brand communities makes me feel more dignified.
	D2	My shopping experience shared in a private community is often praised and recognized by other members.
	D3	Participating in private brand activities makes me feel like an insider.
	D4	Products purchased through private channels bring more joy when they are in the circle of friends.
	D5	KOL/KOC recommendation in the brand’s private domain community convinces me more than other channels.
Sticky behavior	E1	Compared with other channels, I will give priority to buying goods in private channels.
	E2	I am willing to actively recommend a brand’s private domain to my friends and introduce its benefits.
	E3	I often participate in private activities
	E4	I will feel sorry if the private community is closed.
	E5	I am willing to provide product improvement suggestions or participate in research for a private brand.

Table 2. Analysis of reliability test results

Variable	Cronbach's α	Number of terms
Perceived functional value	0.863	5
Perceive emotional value	0.871	5
Perceived economic value	0.859	5
Perceive social value	0.869	5
Sticky behavior	0.868	5

Table 3. Analysis of validity test results

KMO		0.880
Bartlett spherical test	Approximate chi-square	3368.991
	df	300
	Sig.	0.000

4. Result analysis

Pearson coefficients of the variables studied are analyzed as shown in **Table 4**. The maximum Pearson coefficient among variables is 0.319, which does not reach the threshold of multicollinearity of 0.75, so the multicollinearity among variables is not significant. According to the results, it is found that there is a positive correlation between perceived functional value ($r = 0.235$, $P < 0.01$) and sticky behavior, and there is a positive correlation between perceived emotional value ($r = 0.189$, $P < 0.01$) and sticky behavior. Perceived economic value ($r = 0.213$, $P < 0.01$) is positively correlated with sticky behavior, while perceived social value ($r = -0.216$, $P < 0.01$) is negatively correlated with sticky behavior. In this paper, it is found that assumptions H1, H2, and H3 are preliminarily tested except assumption H4, which provides some empirical support for the follow-up research.

There is a negative correlation between perceived social value and sticky behavior, and the assumption is not valid. This negative correlation does not mean that the perception of social value itself is not good, but comes from the double-edged sword effect of “perception of social value” and the change of consumer motivation in the private domain. When private consumers pay too much attention to or passively accept a certain social value, it may have the opposite effect. Li et al. found that private consumers will receive information from businesses and other consumers at the same time, which may lead consumers to face excessive information. Faced with information overload, private consumers will have evasive behavior, and the social business effect will decline^[11].

Table 4. Correlation analysis

Variable	Perceived functional value	Perceive emotional value	Perceived economic value	Perceive social value	Sticky behavior
Perceived functional value	1				
Perceive emotional value	0.319**	1			
Perceived economic value	0.245**	0.270**	1		
Perceive social value	-0.262**	-0.227**	-0.342**	1	
Sticky behavior	0.235**	0.189**	0.213**	-0.216**	1

Note: ** means $P < 0.01$.

5. Conclusion and enlightenment

In the digital age, the perceived value of private consumers is increasingly affecting consumers' sticky behavior. This paper discussed the influence of private consumers' perceived functional value, perceived emotional value, perceived economic value, and perceived social value on sticky behavior. The results show that: firstly, perceived functional value, perceived emotional value, and perceived economic value all have significant positive effects on sticky behavior. It shows that the convenient service and rich product information provided by the private domain platform are the basis for attracting private domain consumers to retain and reuse. Positive emotional experiences, such as pleasure, a sense of belonging, and trust gained by consumers in the private domain, can effectively enhance their stickiness. The incentives of exclusive benefits, discounts, bonus points, and other economic benefits directly satisfy the pursuit of cost performance of private consumers, and are a powerful driving force for them to produce repeated purchases and continuous attention behavior. Second, social value has a negative correlation with the sticky behavior of private consumers. It shows that the social value perceived by some private domain consumers through private domain platforms is not the main driving factor for their sticky behavior. When consumers in the private domain receive too much information from merchants and other consumers, this may lead to information overload for consumers, and consumers in the private domain will exhibit evasive behavior.

This study shows that in order to effectively enhance the stickiness of private consumers, operators should give priority to consolidating the functional foundation, optimizing emotional experience, and providing attractive economic incentives. In contrast, it may not be the most effective strategy to invest too many resources in building the social value perception of private consumers. In the future, private domain operations should strive to become a "useful, interesting, and beneficial" value hub for private domain consumers, so as to cultivate a group of private domain consumers with high loyalty.

Disclosure statement

The author declares no conflict of interest.

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Research on the Impact of Digital Trade Rule Depth on China's Digital Services Trade

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Abstract: This paper empirically studies the impact mechanism of the depth of digital trade rules on China's digital service trade exports and explores the improvement paths for China accordingly. Based on the transaction cost theory and other foundations, this paper systematically classifies rule provisions into four categories: access and facilitation, cross-border data flow, digital intellectual property rights, and privacy protection and data security. It also uses the gravity model of trade to quantitatively analyze 22 Regional Trade Agreements texts involving China. The empirical results show that: the depth of digital trade rules as a whole significantly promotes digital service trade exports; the core driving factors include the gap in digital infrastructure, differences in higher education levels, urbanization levels, and GDP gaps; all four categories of provisions show a significant positive impact, among which access and facilitation provisions have the most prominent promotional effect. Heterogeneity analysis further reveals that the depth of rules has a significantly stronger promotional effect on trade partners in developed countries than in developing countries; sector-specific tests show that the financial services sector benefits the most, while the intellectual property sector is inhibited. Based on this, this paper proposes that China should actively participate in the construction of global rules, improve digital infrastructure, deepen the implementation of provisions, orderly expand opening-up in the digital field, strengthen intellectual property protection to balance innovation incentives and market expansion, and improve laws and regulations to ensure data security.

Keywords: Digital service trade; Digital trade rules; Gravity model of trade; Regional trade agreements (RTAs)

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1. Introduction

With the rapid development of the digital economy and digital service trade, the rules originally applicable to traditional trade can no longer address the new phenomena and problems emerging in economic development. Governments and regions around the world have successively introduced their own digital trade rules and formulated a series of such rules with varying depths to safeguard and maximize the development and interests of their domestic digital service trade. For example, the United States emphasizes the liberalization of digital trade, and its rules often include provisions such as cross-border data flow and non-mandatory localization of source

code ^[1]; while the European Union focuses more on “conditional freedom” and sets exception clauses related to digital trade in its rules ^[2].

China has currently signed Regional Trade Agreements (RTAs) with 22 countries or regions, and the digital trade rules in these agreements also show different focuses. However, there are relatively few studies on how China’s signed digital trade rules affect the development of its digital service trade. Therefore, this paper takes China as a case to further analyze the potential impact of the overall depth of regional digital trade rules and the depth of various sub-clauses on China’s digital service trade, aiming to provide a new perspective and enrich the theoretical research on the influencing factors of digital service trade.

2. In-depth measurement of digital trade rules in RTAs signed by China

Based on the analysis of the TAPED database, as of 2024, China has signed approximately 22 RTAs. Drawing on the research by Mao et al., digital trade clauses are categorized into four major types based on clause categories, representative clauses, and clause characteristics: “Market Access and Facilitation,” “Cross-Border Data Free Flow,” “Digital Intellectual Property Rights,” and “Privacy Protection and Data Security.”

Then, assign values based on whether the clauses are binding, with the value range being 0 to 3 points. 0 points means there is no content related to the issue. 1 point indicates that the issue is non-binding, i.e., a “soft” commitment. That is, when the other party fails to fulfill the commitment, these clauses only require the contracting parties to comply with the provisions or principles “on a best-efforts basis,” and no claims can be made against their non-compliance. 3 points mean the issue is binding, i.e., a “hard” commitment that can be enforced by the other contracting party. If the committing party fails to comply, a claim can be made, and it will be included in the dispute resolution mechanism of the agreement. 2 points indicate that the issue falls between binding and non-binding.

Subsequently, drawing on the measurement methods for the depth of digital trade rules proposed by Gao and Sheng, Li, and Monteiro, the depth of digital trade rules (Digitaldepth) is defined by the following formula:

$$Digitaldepth_H = \frac{\sum_{i=0}^n Index_L}{n(Index_L)}$$

Among them, the subscript H represents a high-level indicator, L represents the low-level indicators included in the high-level indicator, depth_H represents the calculated value of the high-level indicator (i.e., clause depth), Index_{L_i} denotes the i-th indicator in a set of low-level indicators, and n(Index_L) is the number of indicators in the set of low-level indicators.

Finally, the depth of digital trade rules in the bilateral trade agreements and regional trade agreements signed by China is calculated.

3. Empirical analysis of the impact of digital trade rules on China’s digital services trade

3.1. Research hypotheses

3.1.1. Depth of digital trade rules

The essence of trade rules is to regulate the trade behaviors and outcomes of trade entities by establishing an

institutional environment of incentives and constraints, so as to ensure the compliance and facilitation of trade activities. In the era of rapid digital economy development, digital trade rules can effectively reduce bilateral service trade barriers, boost the confidence of trade entities, and thus create a fair and convenient institutional environment. In addition, complex technical certification standards not only undermine the confidence of trade entities but also impose additional trade costs on enterprises. Therefore, the integration of regulatory and technical certification systems can not only enhance the confidence of trade entities, shorten institutional distance, but also reduce trade costs ^[3].

Accordingly, this paper proposes the following hypothesis:

Hypothesis 1: The depth of digital trade rules in RTAs has a promoting effect on China's digital services trade, and the depth of different types of digital trade rule clauses also plays a facilitating role in digital services trade.

3.1.2. Level of economic development

Generally speaking, there is a close relationship between economic scale and trade scale. Economic scale exerts varying degrees of influence on the starting point of foreign trade, foreign trade dependence, and the initiative in foreign trade. A larger economic scale indicates a larger potential demand scale in the country, and the market demand for digital service-related products is also greater. Although the digital services trade is a product of the integration of the digital era and trade, and its trade methods have changed significantly compared with traditional trade, it still follows the laws of traditional international trade theories. Differences in the level of digital economic development among countries are bound to have a certain impact on the scale of digital services trade ^[4].

Thus, this paper puts forward the following hypothesis:

Hypothesis 2: The impact of the depth of digital trade rules in RTAs on the digital services trade of economies with different levels of economic development is heterogeneous.

3.1.3. Industry differentiation

According to the UNCTAD report, among the 12 subcategories of services trade in the Extended Balance of Payments Services (EBOPS) classification, six are related to digitally deliverable services trade, i.e., digital services trade. They are insurance services, financial services, intellectual property services, ICT services, other commercial services, and personal, cultural, and recreational services. The corresponding industrial development and international division of labor among these six subcategories of digital services trade vary greatly, so their proportions in the digital services trade are different. At the same time, the depth of digital trade rules has varying degrees of impact on these six sub-sectors of digital trade ^[5].

Therefore, this paper proposes the following hypothesis:

Hypothesis 3: The impact of the depth of digital trade rules in RTAs on the six sub-sectors of digital services trade is heterogeneous.

3.2. Model construction and data sources

The gravity model of trade is widely applied in empirical studies on bilateral trade flows, and its theoretical foundation has become increasingly sophisticated. Based on the gravity model of trade, this paper constructs a model by integrating the characteristics of digital services trade and digital trade rules in regional trade agreements, as follows:

$$\ln Trade_{ijt} = \beta_0 + \beta_1 Depth_{ijt} + \beta_2 \ln GDPgap_{ijt} + \beta_3 \ln INT_{ijt} + \beta_4 \ln dist_{ij} + \beta_5 \ln EDU_{ijt} + \beta_6 Regu_{ijt} + \beta_7 Urban_{ijt} + \beta_8 comlang_{ij} + \varepsilon_{ijt}$$

Among them, the subscripts i, j , and t represent China, countries or regions that have signed RTAs with China, and the year, respectively. The explained variable “Trade” denotes the digital services trade flow between the two countries, with data sourced from the UNCTAD Services Trade Statistics Database and the OECD-ITSS Database. The core explanatory variable “Depth” refers to the depth of digital trade rules between the two countries, which is measured using the method mentioned above. Control variables include the following: the GDP gap between the two countries (GDPgap), with data from the World Bank’s WDI Database; the difference in network infrastructure between the two countries (INT), which is proxied by calculating the absolute value of the difference in broadband subscriptions between them, with data from the World Bank’s Telecommunication Indicators Database; the geographical distance between the two countries (dist), using data from the CEPII Database; the difference in educational levels between the two countries (EDU), proxied by calculating the absolute value of the difference in higher education expenditure between the trading parties, with data from the World Bank’s Education Data Indicators; the level of corporate regulatory quality among countries (regu), using data from the Regulatory Quality indicator in the World Bank’s WGI Database; the urbanization level of each country (urban), with data from the World Bank; and whether the two countries share a common language (comlang), which is assigned a value of 1 if they share a common official language and 0 otherwise, with data from the CEPII Database. β_0 is the constant term, β_1 – β_8 is the parameter to be estimated, and ε is the random error term.

3.3. Benchmark regression results

This paper uses the Hausman test for judgment. The results show that the P -value is 0.000, which is much less than 0.05, leading to the rejection of the null hypothesis. This indicates that the fixed effects model is superior to the random effects model.

According to the model, the regression coefficient of rule depth is 1.317, and the P -value is significant at the 1% level, meaning that an increase in the depth of digital trade rules can boost bilateral services trade flows.

To further verify the specific impact of each clause on the scale of digital services trade, this paper classifies the trade clauses covered by regional digital trade rules into four categories: “Access and Facilitation,” “Cross-border Data Free Flow,” “Digital Intellectual Property,” and “Privacy Protection and Data Security,” and conducts regression analysis again. The results are shown in **Table 4**. It can be seen that the digital trade rules in regional trade agreements still have a significant impact on digital services trade flows. Among them, the “Access and Facilitation” clauses have the greatest impact, followed by “Cross-Border Data Free Flow” clauses and “Privacy Protection and Data Security” clauses, with “Digital Intellectual Property” clauses coming last. The above analysis confirms that Hypothesis 1 holds.

4. Policy recommendations

4.1. Improving fundamental work for digital service trade

First, improve digital trade infrastructure. China should strengthen the top-level design and planning for network infrastructure construction, and formulate clear development strategies and action plans. This includes identifying priority areas for network infrastructure development, such as 5G, fiber optic networks, and data centers, as well

as formulating corresponding policies and regulations to guide and encourage investment in and construction of network infrastructure. Second, continuously enhance the level of higher education. In digital service trade, human capital is mainly reflected in workers' knowledge and skills, cultural and technical levels, and health status, among other aspects. These factors directly affect the ability to provide digital services and service quality. China should pursue the concept of building a strong education country, continuously promote educational reform, improve educational quality, attach importance to the cultivation of students' comprehensive quality and innovative ability, and train interdisciplinary talents; at the same time, the government should also formulate preferential policies to attract overseas talents, absorb advanced technologies and concepts from other countries, and facilitate China's own development ^[6].

4.2. Conditionally expanding opening-up in the digital sector

Among the secondary classification clauses of digital trade rules, the "Access and Facilitation Clauses" have the strongest positive promoting effect on digital service trade volume. Measures such as reducing e-commerce barriers, promoting paperless transactions, and strengthening the use of electronic authentication and electronic signatures not only improve the convenience of digital trade but also effectively reduce transaction costs, thereby driving the development of digital service trade ^[7].

The "Cross-Border Data Flow Clauses" also exert a positive impact on the development of digital service trade. While promoting the free flow of data, we should establish a hierarchical regulatory mechanism. For data involving national security, corporate privacy, and personal privacy, strict regulatory measures should be implemented to prevent potential risks; for normal commercial transaction data, its free flow should be ensured to boost the prosperity of digital service trade.

4.3. Strengthening intellectual property protection, expanding digital service trade markets, and stimulating innovation vitality

Most products in the digital service trade are knowledge-intensive, making intellectual property protection play a crucial role in this field. By providing economic incentives for innovators, intellectual property rights not only promote technological innovation but also create favorable conditions for optimizing the business environment and attracting foreign direct investment ^[8].

First, improve relevant laws and regulations, clarify the ownership and protection scope of intellectual property rights, and provide solid legal safeguards for right holders; second, strengthen law enforcement, crack down severely on infringement acts to safeguard legitimate rights and interests and boost market confidence; third, promote technological innovation, encourage enterprises and individuals to carry out R&D activities, thereby enhancing the practical value of intellectual property rights ^[9].

4.4. Improving relevant laws and regulations to safeguard national digital network security

The formulation of data security and privacy protection policies and rules directly affects consumers' acceptance and trust in digital services, and has become an important consideration in digital service trade. In formulating digital trade rules, it is necessary to strengthen international cooperation, upgrade data protection policies, and establish competitiveness and credibility in the global digital service market. Additionally, an effective network security regulatory mechanism should be established to ensure that digital services operate in a secure environment and reduce potential network risks ^[10].