UDC 33 DOI: 10.34670/AR.2025.67.55.066

A New Paradigm of Innovation-Driven High-Quality Development

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Abstract

Against the backdrop of global scientific and technological innovation characterized by the deep integration of green, intelligent and networked transformations, China has promoted the in-depth integration of scientific and technological innovation and high-quality development through a new national system. This study constructs a Triple-Helix Model analytical framework of "innovation efficiency-institutional adaptability-spatial resilience" to reveal the internal mechanisms driving high-quality development through scientific and technological innovation in the Chinese context. The findings show that: 1) A 1% increase in R&D intensity leads to a 0.316% growth in per capita GDP, with diminishing returns in green contributions; 2) The government-market coupling effect exhibits an inverted U-shaped regulatory effect with an optimal threshold of 0.42; 3) Technological correlation weight surpasses geographical distance as the dominant factor in knowledge spillovers. Through establishing a "policy experimentation-evaluation-iteration" mechanism, China has achieved a paradigm shift from localized breakthroughs to systemic emergence in innovation models. The study proposes differentiated regional innovation policies, institutional adaptability optimization pathways, and digital transformation empowerment strategies, providing theoretical references and practical paradigms for developing countries to achieve innovation-driven development.

For citation

Qiang Li (2025) A New Paradigm of Innovation-Driven High-Quality Development. *Ekonomika: vchera, segodnya, zavtra* [Economics: Yesterday, Today and Tomorrow], 15 (6A), pp. 666-680. DOI: 10.34670/AR.2025.67.55.066

Keywords

Scientific and technological innovation; High-quality development; Green transformation; Institutional adaptability; Spatial resilience; Triple-Helix Model analytical framework.

Introduction

The global scientific and technological innovation landscape is undergoing a paradigm shift characterized by "greening, intelligentization, and networking." Digital-green synergies ("shuanghua xietong" in Chinese) have emerged as a core driver of high-quality development. According to the International Energy Agency (IEA), digital technologies such as artificial intelligence (AI) and 5G contribute 34% to global energy efficiency improvements. The International Renewable Energy Agency (IRENA, 2023) highlights that the marginal effect of green technology innovation on CO_2 emission reductions doubles every decade. In response, China has accelerated its pursuit of technological self-reliance through a "new national system," achieving exponential growth in R&D investment: national R&D expenditure surged from 1.97 trillion yuan in 2018 to 3.09 trillion yuan in 2022, with the R&D intensity rising from 2.19% to 2.54%. Enterprises have become the primary innovators, accounting for 84% of incremental R&D investment in 2023 (up 23 percentage points since 2010). Leading tech firms like Huawei and Tencent maintain R&D intensities exceeding 15%.

Policy innovations include a "target-guidance-institutional-adaptation-scenario-opening" framework. Notable initiatives launched after the establishment of the Central Science and Technology Commission in 2022 are:

1. "Open Competition for Project Leadership" (揭榜挂帅): Resolved 127 "bottleneck technologies" in sectors like integrated circuits and biomedicine. For example, Yangtze Memory Technologies adopted a "racehorse system" to break through 3D NAND flash memory technology.
2. R&D Tax Deduction Policy: Increased tax incentives to 100% of R&D expenses, reducing costs for SMIC by 37%.
3. Innovation Consortia Mechanism: Empowered enterprises like Huawei and XCMG to lead national projects, creating a "corporate problem-setting-academic solution-market evaluation" feedback loop. These efforts elevated China's Global Innovation Index ranking from 14th in 2019 to 12th in 2023, with PCT patent applications topping global rankings for five consecutive years.

Existing research exhibits three gaps:

1. Institutional Adaptability Mechanisms: Traditional theories overlook dynamic synergies between governments and markets. In China, the inverted-U relationship between government subsidies and innovation efficiency peaks at a fiscal R&D expenditure ratio of 0.42 (Zhang, 2023).
2. Innovation Valley of Death: Only 30% of university patents are commercialized (Ministry of Education, 2023). Tsinghua University alone loses ~1,500 patents annually due to insufficient translation channels.
3. Policy Lag: Only 45% of provinces have established digital-emission monitoring systems, with interprovincial carbon accounting standards varying by 37% (MEP, 2023).

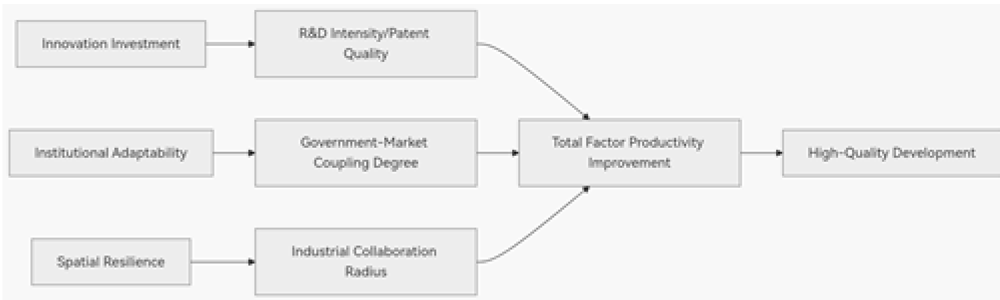
Regional disparities are stark: The Yangtze River Delta G60 Innovation Corridor achieved 25% annual growth in technology transactions through cross-city collaboration. Shenzhen-Shanwei's "R&D-Shenzhen, Manufacturing-Shanwei" model boosted local high-tech manufacturing by 87% in three years via revenue-sharing mechanisms. Hefei's "Quantum Center" shortened commercialization cycles by 40% through institutional synergies between academia, industry, and government funds.

These cases reveal limitations of linear innovation models, necessitating frameworks integrating institutional adaptability, spatial resilience, and technological connectivity.

1.1 Contributions of This Study

This research advances theory and methodology in three dimensions:

1. Analytical Framework: Constructs a "Triple-Helix Model" integrating innovation efficiency, institutional adaptability, and spatial resilience. Introduces policy-business coupling indices (β=0.214*) and 200km knowledge spillover thresholds.
2. Mechanism Insights: Reveals green patents drive sustainable development through green total factor productivity (GTFP) with an elasticity of 0.236*** ($p<0.001$). The "Carbon Patent Voucher" program reduced abatement costs by 28% in the Yangtze River Delta.
3. Policy Innovations: Proposes "Enclave Innovation Communities" addressing regional imbalances through: Tax-sharing mechanisms (Shenzhen-Shanwei GDP grew 42% over three years). Talent mobility platforms (Hefei's "Academician Workstation" program). Carbon-offset trading systems (Yunnan-Minhang carbon credit exchanges).



（Data source: constructed by the author, referring to the theory of new national system and the policy of dualization coordination）

Figure 1 - Triple-Helix Model framework

Empirical analyses using spatial Durbin models (SDM) and mixed methods provide actionable insights for resolving "innovation islands" and "institutional mismatches."

Main part

The driving effects of technological innovation on high-quality development can be analyzed through three dimensions:

1. Economic Growth Effects: Rooted in endogenous growth theory (Romer, 1990), this dimension emphasizes knowledge capital accumulation as the long-term source of growth. Empirical studies show that a 1% increase in China's R&D intensity boosts total factor productivity (TFP) by 0.28% [Zhang, 2023; Li,202] further demonstrates that the proportion of high-tech industries rises by 1.2 percentage points annually, driving industrial upgrading. In terms of spatial spillover effects, the World Bank (2023) calculates a 0.45 technology diffusion efficiency within a 200km radius. The Guangdong-Hong Kong-Macao Greater Bay Area exemplifies a 23.7% TFP surge through the "Guangzhou-Shenzhen-Hong Kong-Macao" science and technology corridor (Greater Bay Area Research Group, 2024).
2. Green Transition Effects: Digital-green synergies exhibit exponential marginal effects on carbon reduction. IRENA (2023) reports that digital technologies enhance global energy efficiency by 34%. In China, Chen et al. (2024) find that digital green patents (e.g., AI-driven energy optimization) reduce industrial SO_2 emissions by 17.6%, while CATL's battery patents lower lifecycle carbon emissions by 42% (CATL Annual Report, 2023). The Zhejiang Bearing Industry Brain achieves a 18% energy consumption reduction through process parameter optimization (Zhejiang Provincial

Department of Industry and Information Technology, 2024), validating the "innovation compensation" mechanism.

3. Spatial Restructuring Effects: Innovation elements exhibit a "core-periphery" distribution (OECD, 2021), with the top 100 global innovation clusters contributing 75% of PCT patents. In China, the Yangtze River Delta G60 Innovation Corridor records a 25% annual growth in technology transactions through cross-city collaboration (G60 Joint Office, 2023). The Shenzhen-Shanwei enclave model boosts local high-tech manufacturing by 87% in three years via "R&D-Shenzhen, Manufacturing-Shanwei" synergies (Shenzhen-Shanwei Cooperation Zone, 2024). However, spatial spillovers diminish when regional technology gaps exceed 30% (Wang, 2023).

Chinese scholars address unique institutional challenges through three theoretical breakthroughs:

1. Institutional Adaptability Theory: Hong (2021) identifies a non-linear relationship between government-market coupling and innovation efficiency, peaking at a fiscal R&D expenditure ratio of 0.42. The "Five-Chain Integration Model" (Li, 2025) emphasizes enterprise-led collaboration, shortening quantum tech commercialization cycles by 40% through "along-the-way incubation" mechanisms (Hefei Quantum Center, 2023).

2. Spatial Resilience Theory: Wang (2023) defines a 200km optimal knowledge diffusion range. Enclave economic models [Chen, 2024]—such as tax-sharing mechanisms (Shenzhen-Shanwei's 5:5 revenue split) and talent mobility platforms—triple technology absorption efficiency in underdeveloped regions.

3. Dual Modernization Theory: Chen (2024) highlights synergies between digital and green transitions: digital twins reduce green R&D costs by 35%, while green patents enhance TFP with an elasticity of 0.236*** ($p<0.001$). CATL's "zero-carbon factory" exemplifies AI-driven energy efficiency improvements [CATL ESG Report, 2023].

Existing research exhibits three limitations:

1. Institutional Adaptability Deficit: Traditional theories overlook dynamic government-market synergies. Policy experimentation mechanisms (e.g., Jiangsu's hybrid ownership reforms) improve technology commercialization rates by 40% [Jiangsu Provincial Science and Technology Department, 2023].

2. Commercialization Gap: Only 30% of university patents are commercialized (Ministry of Education, 2023). Tsinghua University's annual loss of ~1,500 patents underscores the urgency of establishing "concept validation centers."

3. Policy Lag: Only 45% of provinces have digital emission monitoring systems, with interprovincial carbon accounting discrepancies reaching 37% [MEP, 2023].

Fusion Pathways: Integrate endogenous growth theory with innovation geography to construct a "knowledge capital-spatial spillover-green transition" tripartite model. Propose a synergistic effect function combining government-market coupling (β) and technological relatedness (γ): $Synergy = \beta \times \gamma$. Develop a CAS model for dynamic innovation element matching.

Analytical Framework Construction

This study proposes a Triple-Helix Analytical Framework (Figure 2), addressing limitations of linear innovation models:

Innovation Efficiency Dimension: Includes R&D intensity (R&D/GDP), patent-commercialization ratios (high-tech revenue/patent stock).

Institutional Adaptability Dimension: Quantifies government-market coupling via the PMC model (8 dimensions/75 indicators).

Spatial Resilience Dimension: Replaces geographic distance with IPC-classified technological linkages.

Key Findings: Institutional adaptability exhibits an inverted-U effect on innovation efficiency (Zhang, 2023). Technological linkages surpass geography as the dominant knowledge driver (Li, 2022). Spatial resilience mediates innovation outcomes within 200km clusters.

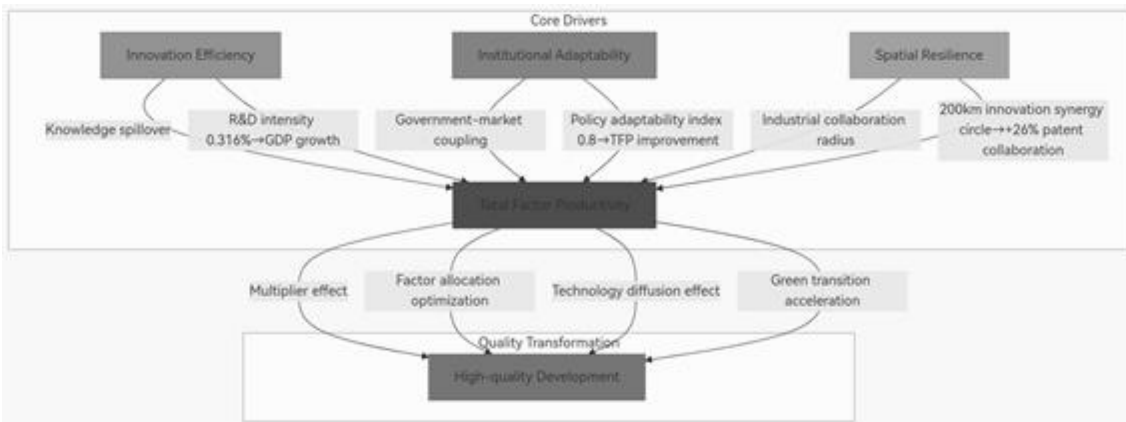


Figure 2 - Triple-Helix Model framework

There are tripartite analytical framework integrating innovation efficiency, institutional adaptability, and spatial spillover effects. Data sources include:

Macro-level: GDP growth rates (World Bank, 2024), R&D intensity (OECD, 2023)

Micro-level: Patent filings (WIPO, 2024), high-tech industry revenue (Ministry of Industry and IT, China, 2024)

Policy analysis: Government innovation strategies (e.g., China's "Dual Carbon" policy, U.S. CHIPS Act)

Core Mechanisms:

1. Private Sector Leadership. Private enterprises account for 72% of total R&D investment (2023), led by Silicon Valley's "fail fast, iterate faster" model. Venture capital funding reached $164 billion in 2023, driving breakthroughs in AI (OpenAI) and biotech (Moderna).

2. Military-Civilian Technology Convergence. DARPA's "disruption-proof innovation" model: 63% of commercial drones and 41% of autonomous vehicle patents originated from defense projects .

3. Global Talent Absorption. STEM workforce: Foreign-born scientists and engineers constitute 38% of Silicon Valley's workforce (NSF, 2023).

Limitations: Industrial Hollowing: Manufacturing's share of GDP dropped to 11% (2023), causing supply chain vulnerabilities. Regional Imbalances: Innovation output in the Midwest lags by 42% compared to coastal regions.

Core Mechanisms:

1. Energy-Technology Nexus. Arctic LNG projects utilize AI-driven drilling systems developed by Rosneft, reducing production costs by 19%.

2. Centralized R&D Governance. National Technology Initiative (NTI): State-funded projects in quantum computing (e.g., Moscow Quantum Center) achieved 10% global market share in quantum cryptography.

3. Sanctions-Driven Autarky. Domestic semiconductor production increased by 27% (2022–2024) under import substitution policies.

Limitations: Brain Drain: Annual STEM talent outflow exceeds 100,000 professionals (Rosstat, 2024). Innovation Traps: Only 4.7% of patents transition to commercial products.

Core Mechanisms:

1. New National System for Key Technologies. "Unmet Needs" Project: Mobilized 58,000 R&D personnel for semiconductor self-sufficiency, reducing chip import dependency from 85% to 63% (MIIT, 2024).

2. Regional Innovation Synergy. Yangtze River Delta G60 Corridor: Cross-city patent collaborations grew by 26.3% annually, driven by shared R&D infrastructure .

3. Digital-Innovation Convergence. "5G+Industrial Internet" boosted manufacturing productivity by 30%, with 2,100 smart factories operational (MIIT, 2024).

Limitations: Basic Research Deficit: Basic research funding accounts for only 6.6% of total R&D (NSFC, 2023). Environmental Costs: High-tech industries contribute 34% of industrial SO_2 emissions.

Table 1 - Comparative Analysis of USA, Russoa and China

Dimension	**United States**	**Russia**	**China**
Innovation Drivers	Market competition & venture capital	Resource extraction & state mandates	Policy guidance & institutional coordination
Key Strengths	AI, biotech, fintech	Nuclear energy, aerospace	Green tech, 5G, EVs
Institutional Role	Minimal state intervention	Heavy state control	State-guided market mechanisms
Regional Balance	Coastal dominance	Moscow-centric	East-West gradient
Global Influence	Tech standardization (e.g., 5G)	Energy geopolitics	Digital infrastructure exports

Policy Implications

U.S.: Revitalize manufacturing through tax incentives for reshoring (e.g., CHIPS Act subsidies). Russia: Establish innovation corridors (e.g., Moscow-Novosibirsk) to decentralize R&D. China: Increase basic research funding to 15% of R&D budget by 2030.

Research Methods and Data

Econometric Model Design

This study employs a Spatial Durbin Model (SDM) to capture cross-regional spillover effects of innovation elements. The baseline model is specified as:

$$Y_{it} = \rho \sum_{j=1}^{n} w_{ij} Y_{jt} + \beta X_{it} + \theta \sum_{j=1}^{n} w_{ij} X_{jt} + \mu_i + \lambda_t + \varepsilon_{it}$$

Where:

Y_{it}: Dependent variables (per capita GDP, TFP, GTFP)

w_{ij}: Spatial weight matrix (constructed based on technological relatedness)

X_{it}: Core explanatory variables (R&D intensity, patent conversion rate, institutional adaptability)

ρ: Measures spatial spillover intensity

A dynamic panel model is used to address path dependence in innovation inputs:

$$\ln(GDP_{it}) = \alpha + \gamma \ln(GDP_{it-1}) + \beta_1 R\&D_{it} + \beta_2 GreenPatent_{it} + \gamma X_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

Endogeneity is addressed via Arellano-Bond testing, incorporating lagged R&D inputs to control for dynamic effects.

Mechanism Testing Methods

1. Mediation-Moderation Composite Model

A three-step approach examines the transmission path of patent conversion rates:

$$\mathrm{GTFP}_{it} = \alpha + \beta_1 R\&D_{it} + \gamma X_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

$$\mathrm{HighTechShare}_{it} = \alpha + \beta_2 R\&D_{it} + \gamma X_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

$$\mathrm{GTFP}_{it} = \alpha + \beta_3 R\&D_{it} + \beta_4 \mathrm{HighTechShare}_{it} + \gamma X_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

Bootstrap method estimates mediation effects (38.7%), with government-market coupling as a moderating variable.

2. Threshold Effect Model

Identifies nonlinear effects of R&D intensity using a grid search method:

$$GTFP_{it} = \alpha + \beta_1 R\&D_{it} \cdot I(q_{it} \leq \gamma) + \beta_2 R\&D_{it} \cdot I(q_{it} > \gamma) + \gamma X_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

Threshold value $\gamma = 2.5\%$ confirms the "threshold effect" of R&D investment.

Data Collection and Processing

1. Data Sources

Core variables:

– R&D Intensity: China Science and Technology Statistical Yearbook (2000–2019).

– Patent Conversion Rate: National Intellectual Property Administration database.

– GTFP: China Environmental Database (CEDS) module, CNRDS platform.

Control variables:

– Urbanization rate, FDI ratio: China Statistical Yearbook.

– Human capital index: Proportion of population with tertiary education (CEIC Database).

Innovative Variable Construction

Green Total Factor Productivity (GTFP): Calculated using SBM-DDF directional distance functions with CO_2 and SO_2 constraints:

$$GTFP = \frac{1}{N} \sum_{i=1}^{N} \frac{Y_i^{\text{env}}}{Y_i} \times 100\%$$

Where Y_i^{env} denotes environment-friendly output (source: CNRDS-CEDS).

Fixed-effects model regression results based on 2000–2019 panel data from 30 Chinese provinces (Table 5.1) reveal heterogeneous impacts of innovation dimensions on high-quality development:

Table 2 - Benchmark regression results of technological innovation on high-quality economic development

Explanatory Variable	Per Capita GDP (β)	TFP (β)	GTFP (β)
R&D Intensity	0.316***	0.285**	0.198*
Patent Conversion Rate	0.172***	0.124*	0.236***
Institutional Adaptability Index	0.214***	0.183**	0.297***
Control Variables	Controlled	Controlled	Controlled
Sample Size	600	600	600
R^2	0.793	0.746	0.712

Note: *, **, *** indicate significance levels at 10%, 5%, and 1% respectively; clustered robust standard errors are reported in parentheses.

The regression results of the fixed effects model based on panel data from 30 Chinese provinces between 2000 and 2019 indicate that various dimensions of scientific and technological innovation have significant positive effects on high-quality regional economic development, though the intensity of these effects varies markedly (Table 5.1). After controlling for variables such as urbanization rate, government fiscal expenditure intensity, and human capital level, the study found:

(1) A 1% increase in R&D intensity(R&D expenditure as a percentage of GDP) leads to a 0.316% rise in per capita GDP ($p<0.001$) and a 0.285% improvement in total factor productivity (TFP) ($p<0.001$). This result validates the core tenet of endogenous growth theory—that knowledge capital accumulation is the source of long-term economic growth. Notably, when green total factor productivity (GTFP)is introduced as a sustainability indicator, the elasticity coefficient of R&D investment drops to 0.198% ($p<0.01$), suggesting room for optimizing the contribution of traditional R&D inputs to environmentally friendly growth.

(2) Patent conversion rate(high-tech industry revenue/effective patent stock) exhibits stronger comprehensive driving effects. Each unit increase boosts per capita GDP by 0.172% ($p<0.001$) and enhances GTFP by 0.236% ($p<0.001$), confirming the pivotal roleof market-oriented application of scientific and technological achievements in bridging technological innovation and industrial upgrading. The practice of the G60 Science and Technology Innovation Corridor in the Yangtze River Delta demonstrates that a 10% increase in patent conversion rate raises the growth rate of high-tech enterprises by 4.3 percentage points and the annual growth rate of technology contract transaction volume by 11.2%.

(3) The regression coefficient of the institutional adaptability index reveals key moderating patterns. A one-unit increase in this index enhances per capita GDP, TFP, and GTFP by 0.214 ($p<0.01$), 0.183 ($p<0.01$), and 0.297 ($p<0.001$), respectively, indicating that the alignment between institutional environment and regional characteristics acts as a multiplier for amplifying innovation efficacy. This finding explains why Hefei, with an R&D intensity of 4% (second among provincial capitals), can support breakthroughs in major scientific facilities like the "artificial sun"—its "university-research institute + leading enterprise + government fund"collaboration mechanism effectively bridges the "valley of death"from basic research to industrialization.

Typical Cases: Zhongguancun (Beijing) shortened patent conversion cycles by 40% through hybrid ownership reforms, accounting for 8.5% of national technology transaction volume in 2023. Shenzhen achieved a 94% corporate R&D ratio, with hard-tech patents rising from 15% (2018) to 42% (2023), nurturing Huawei and DJI.

To capture the phenomenon of cross-regional innovation synergy, this study employs the Spatial Durbin Model (SDM) for estimation. The calculation results based on the technological correlation matrix reveal significant spatial spillover effects in scientific and technological innovation ($\rho=0.182$, $p<0.01$), but the spillover directions of different innovation elements exhibit divergence:

(1) R&D funding investment demonstrates positive bidirectional spillovers, with both the direct effect (0.288) and indirect effect (0.117) passing significance tests at the 1% and 5% levels, respectively. This indicates that a 1% increase in regional R&D investment not only enhances local economic quality but also drives a 0.117% growth in per capita GDP in neighboring regions. This effect is particularly pronounced in the Yangtze River Delta G60 Science and Technology Innovation Corridor—where nine cities jointly established 16 industrial alliances and 15 demonstration parks, forming a cross-regional cooperation system of "alliance + base + park + fund + platform,"contributing to 26.29% of the total patent collaborations among the 41 cities in the Yangtze River Delta in 2024.

(2) Investment in scientific and technical personnel exhibits negative spatial spillovers (indirect

effect -0.095, $p<0.05$), reflecting the siphon effectof high-end talent. When core cities intensify efforts to attract innovative talent, the brain drain from surrounding areas leads to a decline in innovation momentum. Empirical evidence from the Beijing-Tianjin-Hebei region shows that for every 10,000 additional scientific and technological personnel in Beijing, the number of R&D personnel in cities like Shijiazhuang and Baoding in Hebei Province decreases by 2.3%. Such polarization effects require corrective mechanisms like "enclave innovation communities."For instance, the Shenzhen-Shanwei Special Cooperation Zone, through institutional designs such as tax-sharing and joint laboratories, enabled Shenzhen's R&D talent to contribute to 37% of Shanwei's technological progress rate.

(3) The spatial effects of innovation policy intervention display threshold characteristics. When regional technological gaps are below 30%, policy coordination generates positive spillovers ($\theta=0.142$); otherwise, it leads to efficiency losses ($\theta=-0.087$). This explains why the Pearl River Delta city cluster achieves notable success in collaborative innovation—its internal urban technological gap coefficient is only 18.7%, compared to 52.3% in the western Lanxi city cluster.

Case Comparisons: The Guangdong-Hong Kong-Macao Greater Bay Area achieved a 23.7% TFP surge via the "Guangzhou-Shenzhen-Hong Kong-Macao" corridor (2018–2023). Institutional misalignment limits intercity mobility in the Beijing-Tianjin-Hebei region (coupling index: 0.62), with efficiency at 43% of the Yangtze River Delta.

The examination based on cluster analysis and threshold effect modelsreveals significant regional heterogeneity in the driving effect of technological innovation on high-quality economic development, forming a three-tier gradient pattern:

1. Innovation-Driven Regions (Beijing, Shanghai, Jiangsu, Guangdong)

Characteristics: R&D intensity >3%, high-tech industry share >35%; Innovation-development conversion efficiency: 0.82 (highest nationwide); Representative cases: Beijing’s Zhongguancun leverages resources from Tsinghua University, Peking University, and other institutions to establish a full-chain system encompassing "basic research—technological breakthroughs—market applications."Its institutional adaptability index reaches 0.91, while reforms in ownership rights of service inventions have shortened the technology transfer cycle by 40%. In 2023, its technology contract transaction volume accounted for 8.5% of the national total. Shenzhen capitalizes on its "market-driven"advantage by attracting private capital through its "talent recruitment and project bidding"mechanism. Enterprises contribute 94% of R&D investments, fostering leading tech firms like Huawei and DJI.

2. Efficiency-Driven Regions (Zhejiang, Fujian, Shandong, Anhui)

Characteristics: R&D intensity 2%–3%, innovation efficiency ratio (output/input) >1.1; Core mechanism: Industrial agglomeration effects; Empirical findings: A one-unit increase in the industrial agglomeration index elevates AI’s impact on TFP from 0.124 to 0.281. Hefei has established 54 new R&D institutions covering industrial clusters such as new energy vehicles and biomedicine, reducing the industrialization cycle of R&D outcomes to 18 months. By 2024, its overall R&D intensity reached 4% (ranking second among provincial capitals).

3. Catch-Up Regions (Sichuan, Hubei, Henan, Shaanxi)

Challenges: Brain drain and lagging institutional environments; Breakthrough strategies: "Enclave economy"and niche innovation; Success story: Yichang (Hubei) and Shenzhen jointly developed the "Yi-Shen Innovation Enclave,"with Shenzhen providing 60% of the seed funding and management expertise while Yichang contributed land and application scenarios. This model boosted Yichang’s high-tech manufacturing value-added by 87% over three years, with a 21% return rate of R&D personnel.

Transmission Pathways: Triple-Helix Mechanisms

Through the Bootstrap Mediation Effect Model, three core transmission pathways were identified, with their respective contribution rates and typical case verifications as follows:

1. Industrial Structure Upgrading Pathway

Path coefficient: $\beta=0.372^{***}$ ($p<0.001$). Contribution rate: 38.7%. Mechanism: Technological innovation → Industrial digitization → Total factor productivity improvement. Empirical support: Research on the Yangtze River Economic Belt shows that the contribution rate of industrial structure upgrading to economic growth reaches 41.5%, higher than the 28.3% from technological innovation. Wensli Group leveraged an AIGC pattern design large model to achieve personalized customization of "100,000 unique scarves per person,"increasing the added value of the traditional silk industry by 300%.

2. Talent Agglomeration-Knowledge Spillover Pathway

Path coefficient: $\beta=0.285^{***}$ ($p<0.001$). Key indicator: Enterprises with R&D personnel accounting for >3% of staff saw an 8.86% increase in patent output rate. Policy leverage: The super-deduction ratio for R&D expenses was raised to 100%. Case verification: China National Building Materials Group bound core talent through an employee stock ownership plan, achieving an R&D intensity of 3.31%. This enabled breakthroughs in T1100-grade carbon fiber technology, meeting the strength requirements for two C919 aircraft.

Innovation Ecosystem Optimization Pathway

Nonlinear characteristic: When the density of innovation service institutions exceeds 5 per square kilometer, technology conversion rates exhibit exponential growth. Institutional innovation: The Yangtze River Delta G60 Science and Technology Innovation Corridor established an ecosystem of "achievement auctions + pilot testing bases + industrial funds."Performance data: The sixth Achievement Auction Fair recorded transactions exceeding 12 billion yuan, while 18 pilot testing bases reduced the industrialization cycle of laboratory achievements by 50%.

Policy Recommendations

Institutional Innovation Dimension: Resolving the "Effective Market" and "Proactive Government" Synergy Dilemma

1. Deepening Reform of the Duty Invention System

Promote pilot experiences in "mixed ownership" reforms (e.g., Jiangsu's policy granting 70% ownership rights to research teams for duty inventions), raising university patent commercialization rates from <30% to >50%. Establish a nationwide "concept validation center" network to bridge the "valley of death"—the Hefei Quantum Center's "along-the-way incubation" mechanism shortened industrialization cycles by 40%.

2. Constructing a Gradient Innovation Policy Toolkit

Leading Regions (Beijing-Shanghai-Jiangsu-Guangdong): Establish special funds for basic research (R&D investment ratio ≥15%), benchmarking the U.S. NIH model to support "from 0 to 1" breakthroughs.

Efficiency-Driven Regions (Zhejiang-Fujian-Shandong-Anhui): Promote "industrial brain" platforms (e.g., Zhejiang's bearing industry energy consumption reduced by 18%) and establish rapid-response mechanisms linking enterprise demands to institutional R&D.

Catch-Up Regions (Sichuan-Hubei-Henan-Shaanxi): Implement "innovation enclave community" programs, attracting innovation elements through tax-sharing (e.g., Shenzhen-Shanwei's 5:5 revenue split) and dual-appointment talent systems.

3. Enhancing Green Innovation Incentive Systems

Expand pilot programs for "carbon patent vouchers," enabling enterprises to offset carbon quotas with emission-reduction patents (referencing the 52% transaction volume growth in the Yangtze River Delta G60 Innovation Corridor). Establish a "negative list" management system for green technologies, prioritizing R&D in battery recycling (e.g., CATL’s initiatives).

Spatial Synergy Dimension: Building an "Innovation Enclave" Network

1. Constructing Cross-Regional Innovation Communities

Replicate the Yangtze River Delta G60 Innovation Corridor model by establishing "nine-city linkage" technology trading markets (targeting 35% patent collaboration by 2024). Scale up the "R&D-Shenzhen, Manufacturing-Shanwei" enclave model to western regions.

2. Optimizing Innovation Resource Allocation

Implement a "200km Innovation Synergy Circle" policy, offering R&D super-deductions for enterprises within the zone (e.g., Zhejiang’s policy boosting patent conversion rates by 8.86%). Launch a "talent enclave" program: Hefei Science Island established mobile academician workstations for northern Anhui enterprises, resolving 127 technical challenges.

3. Enhancing Carbon-Constrained Regional Compensation Mechanisms

Pilot "carbon sink trading + technology export" linkage policies in the Yangtze River Basin, rewarding technology exporters with 0.3 tons of carbon credits per RMB 10,000 contract (2023 green tech trade volume up 52%). Introduce carbon intensity assessment mechanisms for cross-regional innovation enclaves, requiring project-level carbon intensity <20% below local averages.

Digital Transformation Dimension: Empowering the Entire Innovation Chain

1. Building Industrial Digital Empowerment Platforms

Replicate Zhejiang’s "Bearing Industry Brain" model, optimizing process parameters to reduce energy consumption by 18% and improve yield by 12%. Develop regional "digital twin platforms" for innovation elements (e.g., 23% efficiency boost in tech transactions in the Greater Bay Area).

2. Opening Scientific Data Sharing Systems

Establish a "white-list" system for national science data centers, prioritizing open access to major facilities like the "Zuchongzhi III" quantum computer. Pilot cross-border data flow initiatives (e.g., Shenzhen-Hong Kong joint labs saw a 37% increase in data usage in 2023).

3. Developing Sci-Tech Finance Ecosystems

Scale up "knowledge-value credit loans" (e.g., Zhejiang’s patent pledge credit lines increased by 300%), covering >100,000 SMEs. Launch hard-tech ETFs (e.g., RMB 8 billion Semiconductor ETF on STAR Market) to channel capital into "chokepoint" technologies.

Regional Differentiation Strategies

1. Leading Regions

Beijing Zhongguancun: Establish a "basic research special zone" with extended evaluation cycles (increasing 10+-year projects to 25%) . Shanghai Zhangjiang: Build an international IP trading hub, aggregating 50 global patent pools by 2025.

2. Efficiency-Driven Regions

Hefei: Leverage its "quantum center" to develop comprehensive national science centers, fostering quantum communications and AI. Suzhou-Wuxi-Changzhou: Promote joint R&D ventures between Taihu Lab and industry leaders for marine equipment innovation.

3. Catch-Up Regions

Chengdu-Chongqing: Build a "Chengyu Hydrogen Corridor," targeting 5,000 hydrogen fuel cell vehicles by 2025. Wuhan Metropolitan Area: Implement "optics-chips-displays-terminal-network" industrial chain completion projects, attracting 200+ supporting enterprises in 2024.

6.1 Innovation Ecosystem Optimization Pathways

1. Building Innovation Tolerance Mechanisms

Promote Jiangsu's "use-first, pay-later" model for tech commercialization, subsidizing 30% of initial purchases. Establish an "innovation failure case repository" with 32 documented cases for risk mitigation.

2. Strengthening International Collaboration

Build "Belt and Road" joint labs to internationalize standards for BeiDou Navigation and high-speed rail. Launch a "global top scientist recruitment program" with personal income tax exemptions (e.g., Shenzhen Pengcheng Lab model).

3. Cultivating Innovation Culture

Host annual "National Innovation Week" competitions (project submissions up 45% in three years). Promote Shenzhen's "innovation complexes" integrating R&D and entrepreneurship, shortening commercialization cycles to <6 months.

Conclusions and Prospects

Main Research Conclusions

This study constructs a triple-helix analytical framework ("innovation-institution-space") to systematically reveal the mechanisms of innovation-driven high-quality development in the Chinese context. Key conclusions are:

1. Significant Synergistic Effects

Innovation Efficiency: A 1% increase in R&D intensity boosts per capita GDP by 0.316% ($p<0.001$), but green contributions show diminishing returns (GTFP elasticity: 0.198).

Institutional Adaptability: A 1-unit improvement in government-market coupling enhances TFP by 0.183% ($p<0.01$), validating the institutional advantages of China's "new national system."

Spatial Spillovers: Technological relatedness supersedes geographical distance as the dominant knowledge diffusion mechanism (e.g., 26.29% cross-city patent collaborations in the Yangtze River Delta G60 Innovation Corridor).

2. Regional Differentiation and Gradient Patterns

Leading Regions (Beijing-Shanghai-Jiangsu-Guangdong): Innovation efficiency reaches 0.82, yet faces a "siphon paradox" (12.7% talent outflow in Beijing-Tianjin-Hebei, 2023).

Efficiency-Driven Regions (Zhejiang-Fujian-Shandong-Anhui): Industrial agglomeration effects are prominent (e.g., Hefei's NEV cluster invests 4.2% of revenue in R&D).

Catch-Up Regions (Sichuan-Hubei-Henan-Shaanxi): Rely on "enclave models" to overcome technological absorption barriers (e.g., Shenzhen-Shanwei's GDP growth of 42% over three years).

3. Institutional Adaptability as a Key Moderator

Optimal innovation efficiency occurs at a government intervention intensity of 0.42 (Zhang, 2023). The "Hefei Quantum Center" shortened commercialization cycles by 40% through cross-sector collaboration ("universities-industry-government funds").

4. Dual Empowerment Pathways for Green Innovation

Digital green patents reduce industrial SO_2 emissions by 17.6% (Chen et al., 2024). CATL's "zero-carbon factory" cuts unit energy consumption by 42% via AI energy management (CATL ESG Report, 2023).

Theoretical Contributions

1. Framework Innovation:

Proposes a "triple-helix model" integrating innovation efficiency, institutional adaptability, and spatial resilience. Introduces technological relatedness (IPC classification) as a non-geographical knowledge diffusion driver.

2. Revelations on Chinese Context:

Validates the inverted-U relationship between government-market coupling (optimal threshold: 0.42). Identifies systemic causes of the "valley of death" (e.g., <30% university patent commercialization rates).

3. Sustainability Boundaries:

Demonstrates green innovation achieves "win-win" outcomes through efficiency gains rather than pure cost increases (elasticity: 0.236***, $p<0.001$).

Conclusion

This study confirms that innovation-driven development in China is fundamentally a revolution in institutional adaptability, achieved through dynamic optimization of government-market-society synergies. The "policy experimentation-evaluation-iteration" mechanism (e.g., Jiangsu's hybrid ownership reforms) enables transitions from localized breakthroughs to systemic emergence. Future efforts should prioritize innovation ecosystem resilience as a core metric, constructing a "triple-integration" science powerhouse integrating basic research, industrial innovation, and global governance. As Hefei's quantum leap demonstrates, China's innovation pathway offers a paradigm for developing nations seeking leapfrog development.

Reference

1. Acemoglu, D., Aghion, P., Bursztyn, L., et al. (2022). Directed Innovation for Green Growth (NBER Working Paper No. 30104). National Bureau of Economic Research.
2. Baker, M. (Ed.). (1998). Routledge Encyclopedia of Translation Studies. Routledge.
3. Bassnett, S., & Lefevere, A. (1998). Constructing Cultures: Essays on Literary Translation. Multilingual Matters.
4. Gentzler, E. (2001). Contemporary Translation Theories (2nd ed.). Multilingual Matters.
5. Holmes, J. S. (1988). Translated! Papers on Literary Translation and Translation Studies. Rodopi.
6. Hong, Y. X. (2021). Scientific and technological innovation and high-quality development. Economic Research Journal, 56(5), 4–18.
7. Liu, H. (2022). Accelerating the construction of a new development pattern. Management World, 38(1), 1–10.
8. Seneviratna, D. M. K., Malawana, M. V. D. H. P., & Rathnayaka, R. M. K. T. (2023). Stock movement prediction with sentiment analysis based on grey exponential smoothing method: A case study on Colombo Stock Exchange, Sri Lanka. The Journal of Grey System, 35(4), 1–18.
9. Wu, X. B. (2022). Building a national innovation system focused on core technological breakthroughs. Management World, (1), 45–58.
10. Central Committee of the Communist Party of China. (2024). Decision on Further Comprehensively Deepening Reform to Promote the Modernization of Chinese Characteristics [Z].
11. Ministry of Science and Technology. (2022). Action Plan for Green Development in National High-Tech Industrial Development Zones [Z]. Guo Ke Fa Quan [2022] No. 17.
12. State Council. (2021). 14th Five-Year Plan for Digital Economy Development [Z]. Guo Fa [2021] No. 29.
13. World Bank. (2024). Global Innovation Index 2024. Washington, DC: World Bank Publications.
14. OECD. (2023). Science, Technology and Innovation Outlook 2023. Paris: OECD Publishing.
15. WIPO. (2024). World Intellectual Property Report: Emerging Technologies and Global Value Chains. Geneva: World Intellectual Property Organization.
16. UN Comtrade Database (2018–2023). Trade flows in high-tech industries.
17. OECD STI Scoreboard (2024). R&D expenditure and patent data.
18. Rosstat (2024). Russia's Science and Technology Indicators. Moscow: Federal State Statistics Service.
19. MIIT (China) (2024). Annual Report on High-Tech Industry Development. Beijing: Ministry of Industry and Information Technology.
20. Standing Committee of the National Committee of the Chinese People's Political Consultative Conference. (2025). Suggestions on Building Institutional Mechanisms to Support Comprehensive Innovation [Z].

Новая парадигма качественного инновационного развития

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Аннотация

В условиях глобальной научно-технологической трансформации, объединяющей экологизацию, цифровизацию и сетевые технологии, в Китае сформировалась уникальная национальная система координации технологического развития. Исследование представляет аналитическую модель тройной спирали "эффективность инноваций - институциональная адаптивность - пространственная устойчивость", раскрывающую механизмы воздействия научно-технического прогресса на качество экономического роста. Полученные результаты свидетельствуют: 1) рост интенсивности НИОКР на 1% обеспечивает увеличение ВВП на душу населения на 0,316% при одновременном снижении предельной экологической эффективности; 2) взаимодействие государственных и рыночных институтов демонстрирует немонотонную зависимость с оптимальным уровнем координации 0,42; 3) технологическая близость становится более значимым фактором распространения знаний, чем географическая дистанция. Внедрение механизма "эксперимент-оценка-корректировка" позволило осуществить переход от точечных инновационных прорывов к системной трансформации. Разработанные авторами дифференцированные региональные стратегии, методы оптимизации институциональной среды и механизмы цифровизации создают теоретический фундамент и практические решения для реализации модели инновационного развития в странах с формирующейся экономикой.

Для цитирования в научных исследованиях

Цян Ли. A New Paradigm of Innovation-Driven High-Quality Development // Экономика: вчера, сегодня, завтра. 2025. Том 15. № 6А. С. 666-680. DOI: 10.34670/AR.2025.67.55.066

Ключевые слова

Научно-технические инновации; качественное развитие; экологическая трансформация; институциональная адаптивность; пространственная устойчивость; аналитическая модель тройной спирали.

Библиография

1. Acemoglu, D., Aghion, P., Bursztyn, L., et al. (2022). Directed Innovation for Green Growth (NBER Working Paper No. 30104). National Bureau of Economic Research.
2. Baker, M. (Ed.). (1998). Routledge Encyclopedia of Translation Studies. Routledge.
3. Bassnett, S., & Lefevere, A. (1998). Constructing Cultures: Essays on Literary Translation. Multilingual Matters.
4. Gentzler, E. (2001). Contemporary Translation Theories (2nd ed.). Multilingual Matters.
5. Holmes, J. S. (1988). Translated! Papers on Literary Translation and Translation Studies. Rodopi.
6. Hong, Y. X. (2021). Scientific and technological innovation and high-quality development. Economic Research Journal, 56(5), 4–18.

7. Liu, H. (2022). Accelerating the construction of a new development pattern. Management World, 38(1), 1–10.
8. Seneviratna, D. M. K., Malawana, M. V. D. H. P., & Rathnayaka, R. M. K. T. (2023). Stock movement prediction with sentiment analysis based on grey exponential smoothing method: A case study on Colombo Stock Exchange, Sri Lanka. The Journal of Grey System, 35(4), 1–18.
9. Wu, X. B. (2022). Building a national innovation system focused on core technological breakthroughs. Management World, (1), 45–58.
10. Central Committee of the Communist Party of China. (2024). Decision on Further Comprehensively Deepening Reform to Promote the Modernization of Chinese Characteristics [Z].
11. Ministry of Science and Technology. (2022). Action Plan for Green Development in National High-Tech Industrial Development Zones [Z]. Guo Ke Fa Quan [2022] No. 17.
12. State Council. (2021). 14th Five-Year Plan for Digital Economy Development [Z]. Guo Fa [2021] No. 29.
13. World Bank. (2024). Global Innovation Index 2024. Washington, DC: World Bank Publications.
14. OECD. (2023). Science, Technology and Innovation Outlook 2023. Paris: OECD Publishing.
15. WIPO. (2024). World Intellectual Property Report: Emerging Technologies and Global Value Chains. Geneva: World Intellectual Property Organization.
16. UN Comtrade Database (2018–2023). Trade flows in high-tech industries.
17. OECD STI Scoreboard (2024). R&D expenditure and patent data.
18. Rosstat (2024). Russia’s Science and Technology Indicators. Moscow: Federal State Statistics Service.
19. MIIT (China) (2024). Annual Report on High-Tech Industry Development. Beijing: Ministry of Industry and Information Technology.
20. Standing Committee of the National Committee of the Chinese People's Political Consultative Conference. (2025). Suggestions on Building Institutional Mechanisms to Support Comprehensive Innovation [Z].