Original Research Article

The impact of science and technology innovation policy on regional economic resilience: A literature review

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Abstract: Amid frequent overlaps of global economic fluctuations, public health crises, and geopolitical risks, regional economic resilience has become a key indicator for evaluating sustainable regional competitiveness. Meanwhile, Science and Technology Innovation Policy (STIP) plays an increasingly crucial role in promoting industrial upgrading and structural adjustment. Based on a systematic literature review, this paper analyzes the conceptual evolution and measurement approaches of regional economic resilience, as well as the theoretical logic and mechanisms through which STIP exerts its influence. The findings reveal that STIP enhances regional resistance and recovery through fiscal investment, knowledge diffusion, and the optimization of innovation environments. International research highlights institutional flexibility and the long-term adaptability of innovation networks, whereas Chinese scholars focus more on policy instrument combinations and structural transformation effects. Future research should integrate dynamic resilience indicators, quantitatively identify policy transmission mechanisms, and strengthen cross-regional comparative analysis to establish a more systematic theoretical framework linking innovation and resilience.

Keywords: science and technology innovation policy; regional economic resilience; innovation-driven development; mechanism analysis; policy review

1. Introduction

1.1. Research background

Since the early 21st century, the global economy has faced multiple systemic shocks—Including the 2008 financial crisis, the COVID-19 pandemic, the Russia–Ukraine conflict, and supply chain disruptions—That have exposed the fragility of regional economic systems and highlighted the need for greater resilience [1,3]. Regional economic resilience (RER) has thus become a key measure of a region's capacity to withstand, recover, and adapt to external disturbances. Martin and Sunley emphasize that resilience involves not only short-term resistance but also long-term adaptive reorganization [2,4].

Simultaneously, STIP has emerged as a core institutional driver of industrial upgrading and regional competitiveness. Since implementing the Innovation-Driven Development Strategy, China has expanded R&D investment, innovation platforms, and digital infrastructure, thereby enhancing regional adaptability[6,8,11]. Internationally, the EU's Smart Specialization Strategy (S3) and the U.S. Small Business Innovation Research (SBIR) program have improved long-term resilience through innovation networks and knowledge diffusion [4,5].

This study systematically reviews theoretical and empirical progress on the STIP-RER nexus, clarifying policy mechanisms, measurement approaches, and research trends to provide conceptual and practical insights for building innovation-driven regional sustainability.

1.2. Literature collection and research methods

To ensure representativeness, relevant literature was collected from Web of Science, Scopus, and CNKI, covering 2000-2025. English keywords included "regional economic resilience", "innovation policy", "technological innovation" and "resilience measurement." Studies were selected based on their direct relevance to the STIP–resilience nexus, publication in peer-reviewed SSCI/SCI/CSSCI journals, theoretical or methodological innovation, and empirical value for policy analysis.

Methodologically, this review employs three complementary approaches. First, qualitative content analysis is used to trace the conceptual evolution of resilience and the policy logic of innovation [3]. Second, bibliometric visualization (VOSviewer, CiteSpace) identifies keyword co-occurrence and citation networks to reveal research frontiers [4]; third, comparative analysis highlights that international studies focus on institutional flexibility and innovation ecosystems, while Chinese research emphasizes policy orientation and structural transformation effects [5,6].

2. Theoretical linkages between regional economic resilience and science and technology innovation policy

2.1. Core concepts and measurement framework of regional economic resilience

The concept of resilience was first introduced by ecologist Holling to describe the capacity of an ecosystem to return to equilibrium after being disturbed by external shocks. Farber later applied this concept to economics, defining economic resilience as the ability of an economic system to maintain its core functions and sustain long-term growth potential under external disturbances [3,4]. Simmie and Martin further extended the concept into the domain of regional economics, conceptualizing resilience as a three-dimensional construct comprising resistance, recovery, and renewal [2,5].

Regional economic resilience (RER) is widely regarded as a dynamic and evolutionary process, reflecting a region's capacity to adapt and reorganize in response to economic recessions, pandemics, or policy shocks [12,18]. As emphasized by Staníčková, resilience not only implies short-term economic stability but also embodies the evolutionary potential of institutional and innovation systems [3]. Existing studies commonly decompose RER into five interrelated dimensions: economic growth stability, which captures the region's ability to sustain operations under external pressure; industrial structural adaptability, reflecting the capacity to adjust and upgrade production structures; innovation and knowledge absorption capacity, denoting endogenous renewal potential; social resource and digitalization level, representing collaborative governance and information transparency; and system recovery speed, indicating how rapidly the economy returns to its growth trajectory after a shock [8,13,14,15].

As shown in **Table 2.1**, the counterfactual method, sensitivity indicator method, and system dynamics model remain the most widely applied techniques for measuring regional economic resilience. The counterfactual method evaluates short-term shock resistance by constructing "no-shock" scenarios to estimate the deviation between actual and expected outcomes [1]; The sensitivity indicator method assesses structural adaptability through multidimensional data integration and composite indicators [18]; Meanwhile, the system dynamics model simulates the diffusion of innovation and recovery processes within complex adaptive systems [11,14]. With the recent incorporation of machine learning and complex network approaches, resilience studies have gradually evolved from static assessment toward dynamic system evolution analysis, offering a more comprehensive understanding of regional adaptability and transformation [7,15].

Table 2.1. Measurement methods and corresponding dimensions of regional economic resilience.

Measurement Method	Applicable Resilience Dimensions	Advantages	Limitations	Representative Studies
Counterfactual	Shock resistance, recovery speed	Quantifies shock effects; suitable for macro-level comparison	Strong model assumptions; limited ability to capture dynamic processes	Martin & Sunley (2015)[27]; Lungová (2015)[1]
Sensitivity Indicator	Industrial structural adaptability, economic stability	High data availability; intuitive indicators	Subjective weighting; weak temporal dynamics	Staníčková (2017)[3]; Wang & Wei (2021)[29]
System Dynamics	Innovation capacity, recovery speed	Simulates feedback loops and time-lag effects	Complex parameters; high data requirements	Lu & Yang (2024)[10]; Shi & Lu (2024)[14]
Spatial Panel	Multidimensional composite resilience	Captures spatial spillover effects	Complex model estimation	Wang & Wei (2021)[29]; Chen et al. (2023)[25]
Network Analysis	Innovation network and adaptability	Reveals inter-structural linkages	Requires high-quality relational data	Dawley et al. (2019)[27]; Yang et al. (2024)[36]

2.2. Theoretical foundation and mechanisms of science and technology innovation policy

The theoretical foundation of STIP traces back to Schumpeter's innovation-driven growth theory and Lundvall's National Innovation System framework, which emphasizes the government's role in fostering innovation through R&D investment, intellectual property protection, and collaborative networks [5].

STIP enhances regional economic resilience via three interconnected mechanisms: fiscal investment that supports technological infrastructure and R&D subsidies [8,16]; knowledge and talent policies that promote diffusion and absorption through education and mobility [17]; and institutional mechanisms that improve adaptability through flexible regulations and innovation networks [14,18].

Institutional heterogeneity determines policy effectiveness and long-term resilience [16]. In the Chinese context, Li Yongjun and Hu Xinru demonstrate through policy text mining that multi-dimensional policy tool combinations significantly promote regional innovation coordination and network synergy [6]. Overall, STIP fosters technological accumulation, reduces industrial path dependence, and optimizes innovation ecosystems, thereby reinforcing sustainable and adaptive regional growth.

3. Empirical studies and mechanisms of science and technology innovation policy on regional economic resilience

Empirical studies show that STIP enhances regional economic resilience by combining structural reform with innovation dynamics. At the macro level, marketization, fiscal input, and R&D intensity significantly improve resilience across Chinese regions [18], while dense interregional and innovation networks accelerate recovery [8]. European evidence confirms that coordinated policy and institutional flexibility are vital for adaptive capacity [16,19].

At the micro level, innovation investment and firm collaboration strengthen industrial adaptability. R&D intensity in high-tech sectors improves supply-chain stability [9], diversified industrial portfolios reduce systemic vulnerability [10], and technological investment correlates positively with economic stability [7].

Overall, STIP operates through three mechanisms. Fiscal investment provides recovery foundations by stimulating technology accumulation and industrial upgrading [12,17]. Knowledge and talent diffusion expand learning and innovation absorption through network and human-capital mobility [6,17]. Institutional and environmental improvement, including digital infrastructure and transparent governance, accelerates coordination and long-term resilience [13,20]. Together, these channels show that fiscal, cognitive, and institutional dimensions of innovation policy jointly foster resistance, adaptation, and renewal. Integrated and sustained STIP design is therefore essential for achieving both short-term recovery and durable regional competitiveness.

4. Review and future prospects

4.1. Research consensus and debates

A broad consensus holds that STIP is a core driver of regional economic resilience, enhancing resistance and recovery through fiscal support, knowledge diffusion, and institutional improvement [10,18]. Scholars generally view resilience as a multidimensional system, encompassing resistance, recovery, adaptation, and innovation capacities [15,20]. However, policy effects exhibit significant temporal and spatial heterogeneity, varying across regions with different institutional and developmental foundations [16,19].

Despite growing agreement, several debates remain. Current research still lacks a theoretically integrated framework linking innovation policy with resilience dynamics. Methodological divergence, ranging from counterfactual analysis to system dynamics, limits cross-study comparability. Moreover, many studies emphasize innovation output while overlooking the underlying mechanisms through which policy shapes systemic adaptability and transformation.

4.2. Limitations and future directions

Future research should deepen understanding in three directions. First, it should establish an integrated multi-dimensional framework that incorporates economic, social, digital, and institutional dimensions for systematic evaluation of resilience. Second, mechanism identification can be improved through structural

equation modeling, spatial econometrics, and causal inference to uncover how different policies interact across regions [6]. Third, greater attention should be paid to international comparative analysis to reveal how institutional diversity affects the resilience outcomes of innovation policies. Furthermore, the adoption of big data and machine-learning techniques offer new opportunities to trace the spatiotemporal evolution of resilience and to simulate policy impacts dynamically [7,11]. Integrating theoretical innovation with empirical modeling will enable more precise, forward-looking, and actionable insights for regional policy design in the era of global uncertainty.

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