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Incentives, Constraints, and Synergy: How Does the Development of a Social Credit System Drive Corporate Patent Innovation?

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Abstract

Against the backdrop of intensifying global innovation competition, this study adopts PSM-DID method and panel data of listed companies from 2010 to 2023 to explore the impact of the social credit system on corporate patent innovation. The results show that the system affects innovation through "incentive-constraint-synergy" mechanisms: optimizing financing environment, curbing low-quality patents, and reducing technological cooperation costs. Heterogeneity analysis reveals more pronounced effects in western regions, private enterprises, and areas with low marketization, reflecting its compensatory role in formal institutional deficiencies. Further, the system enhances firms' adaptability and value creation efficiency, forming a systemic innovation cycle. Robustness tests verify the reliability of the conclusions. This study clarifies the system's innovation-driving pathways and provides a basis for credit governance's transformation from "regulatory tool" to "innovation infrastructure".

Keywords

Social Credit System, Technological Innovation, Propensity Score Matching, Difference-in-Differences

1. Introduction

China has promoted the innovation and development strategy, and patented technology innovation has become the basis for enhancing core competitiveness (Acemoglu & Restrepo, 2018) [1]. Innovation activities are accompanied by high risks, long cycles and high uncertainties (Hall & Lerner, 2010) [2]. The large differences in resource conditions and drastic market fluctuations in the Asia-Pacific

region make the above problems more obvious. Faced with this challenge, many Asia-Pacific economies are attempting to respond through institutional innovation. The aim is to reduce the systemic risks faced by enterprises in innovation. At the same time, this also seeks to improve the efficiency of innovation resource allocation. Building a policy environment conducive to innovation becomes the focus of economic governance research.

Among the diverse institutional practices in the Asia-Pacific region, China's social credit system has garnered widespread attention. This represents a governance initiative with distinct characteristics of institutional innovation. As the largest developing country, relying on its domestic market and manufacturing base, China's competitiveness in the field of innovation in the world has been constantly improved. To leverage the social credit system as a management tool, the government has rolled out the Outline of the Social Credit System Construction Plan (2020-2025). This plan also helps steer enterprises toward better operations and more efficient resource planning. Through the collection and publication of credit data, this system carries out hierarchical management, rewards and punishments for enterprises, and improves the situation of insufficient market information and high transaction costs. In the field of intellectual property protection and technology and finance, the policy has a positive effect (Kafouros *et al.*, 2024) [3]. Grounded in the actual conditions of China, the social credit system applies reputation evaluation to lower transaction expenses and foster cooperation. This is consistent with international views on the role of trust and institutions for economic development. Examining how this system fosters innovation provides an assessment of institutional practices in China and gives a reference for the world and other emerging economies.

Carrying out the social credit system as a policy has taken more than ten years. Existing literature has largely focused on examining its direct impacts, which include business credit (Zhao *et al.*, 2024) [4], the cost of raising funds for enterprises or regional financial stability (Fang *et al.*, 2024; Tao *et al.*, 2024) [5] [6]. The research focuses on corporate investment efficiency (Zuo *et al.*, 2023) [7], and also examines the promotion effect of total factor productivity (Wen, 2026) [8]. Furthermore, some studies adopt a social trust perspective. This study examined the impact on financial decisions such as dividend policy (Bae *et al.*, 2012; Javakhadze & Sen, 2014) [9] [10], capital cost (Gray *et al.*, 2013) [11], cash holdings (Chen *et al.*, 2017) [12] and investment behavior. With social credit system building deepening over time, the focus of academic research has shifted from the traditional economic function to the field of micro enterprise behavior, focusing on the long-term impact of credit system on enterprise innovation activities.

With regard to innovation quality, Hu *et al.* (2023) [13] drew on data from China's Supreme People's Court on individuals subject to enforcement for breaking their word, and concluded that a shortage of social credit causes patent quality to drop. The research of Yu *et al.* (2022) [14] shows that a good level of social credit helps enterprises enter new technology fields. Such an effect is more pro-

nounced among high-tech firms and those featuring innovative management. Several studies illustrate the channels through which social credit affects innovation. Zuo *et al.* (2023) [7] confirmed that social credit supports enterprises to innovate by alleviating financing difficulties, reducing agency costs and enhancing information transparency.

Tao *et al.* (2024) [6] pointed out that when enterprises make venture capital, good social credit level can improve the risk-bearing capacity of enterprises, and the above effect is more obvious in regions with opaque information and low degree of marketization. Song and colleagues (2024) [15] looked into corporate ESG performance and held that once the social credit environment improves, enterprises will see a corresponding rise in their level of sustainable development. This effect is particularly pronounced in two types of firms: first, high-tech enterprises; and second, firms with management possessing a spirit of risk-taking, which reflects that the credit system promotes enterprises to fulfill social responsibility. The negative impact of social dishonesty also cannot be ignored. Yu *et al.* (2023) [14] found that social faithlessness led to a decline in local total factor productivity, which was affected by economic ties between regions, and this kind of problem also restricted the improvement of production efficiency in surrounding areas. These studies show the effect of a good credit environment on economic efficiency from the opposite side, and offer a point of reference for exploring how social credit relates to innovation efficiency.

When it comes to how the social credit system affects patent technology innovation, existing studies have three main gaps. First, the current research mostly describes the action process as reducing transaction costs or alleviating financial difficulties, but lacks specific analysis of how credit policies affect enterprise innovation decisions, and the actual implementation process of credit information disclosure and reward and punishment systems is not clear enough. Second, this influence is restricted by the nature, scale, industrial competition and regional marketization level of enterprises, which is manifested in different results. Third, the social credit system's build-out is still underway, so its influence on corporate innovation might not involve a simple, head-to-head comparison, but there may be a threshold, and the impact will change with time. These aspects need in-depth investigation.

The current study looks into how the social credit system influences patent applications filed by enterprises, studies its internal process, and discusses the intermediate role between enterprise strategic adjustment ability and market value. Based on institutional theory, dynamic capability theory and signal theory, this paper establishes an analytical framework of institutional environment, enterprise capability, market signal and innovation performance, and selects samples of Chinese listed companies for empirical analysis. This paper extends the research scope of social credit system from the overall governance to the level of enterprise innovation, and improves the theoretical details of the connection between system and innovation. This paper analyzes the two intermediate variables of enterprise

strategic adjustment ability and market value, and explains how the external institutional environment affects enterprise innovation, so as to improve the lack of existing research on the role process. These findings could serve as a reference for government efforts to refine social credit system policies, while also offering lessons for global innovation governance as it supports the building of national innovation systems.

2. Theoretical Analysis and Research Hypotheses

2.1. The Intensity of Social Credit System Policy Implementation and the Level of Corporate Patent-Based Technological Innovation

The social credit system can alter the information asymmetry and moral hazard problems, and reduce the cost of innovation cooperation. The new institutional economics believes that the role of institutions is to provide a stable rule system, reduce market transaction costs and the uncertainty of economic behavior, and change the decision-making mode of economic agents to provide guarantee for technological innovation (Monteiro & Miranda, 2025; North, 1990) [16] [17]. Building China's social credit system is part of modernizing the institutional landscape. As transaction environments become more certain and trustworthy, firms grow more inclined to put resources into R&D and innovation (Acemoglu & Robinson, 2019) [18]. The social credit system reduces transaction costs and uncertainty, and provides basic support for enterprise technological innovation.

The social credit system optimizes the allocation of financial resources and helps enterprises reduce the financing burden. Technological innovation often involves multi-party collaboration, contract terms are uncertain, and market information circulation is not completely transparent (Ding *et al.*, 2023) [19]. The social credit system establishes a unified record, and in the process of selecting partners, negotiating contracts and performing contracts, the cost of checking information and internal management is reduced (Guo *et al.*, 2025) [20]. It is difficult to predict the income of intangible assets obtained from R&D investment, and it is difficult for banks to issue loans only based on financial statements. A good credit record makes the loan conditions loose, the scale of corporate borrowing increases, and the financing interest decreases (Zhu & Song, 2025; Brown *et al.*, 2017) [21] [22]. Credit data supplements the lack of financial information, reduces the cognitive bias of banks on enterprises, financial resources begin to concentrate in the field of enterprise research and development, intellectual property protection is pivotal to innovation activities, and the social credit system punifies infringement, resulting in the increase of illegal costs. With the strengthening of the binding force of the patent system, the profits of enterprises after innovation are guaranteed, and the motivation of enterprises to innovate is enhanced (Tong *et al.*, 2026; Yang *et al.*, 2001) [23] [24].

Institutional change varies across countries in the Asia-Pacific region, and government-driven experimentation and reform characterize local development.

China's effort to build its social credit system is an attempt at modernizing social management, demonstrating the Asia-Pacific approach of first experimenting, then promoting, and finally legislation. Different from the practice of Western countries that rely on the spontaneous change of the market, China's social credit system relies on government coordination and departmental cooperation, relying on the way that local governments take the lead and the upper levels plan and follow up, so as to build a system covering the whole country with a clear division of labor. The above measures are in line with the tradition of attaching importance to government capacity and management efficiency in the Asia-Pacific region, and realize the inter-connectivity of credit data across regions and departments, providing a stable and transparent institutional space for enterprises. In the context of the Asia-Pacific region, enterprise behavior is broadly shaped by the social credit system, which is also vigorously enforced and clearly boosts technological innovation among firms.

Drawing on the preceding analysis, this study puts forward the hypothesis stated below:

H1: The development of a social credit system can significantly promote enterprises' patent-based technological innovation. That is, the higher the level of social credit system development, the higher the output of patent-based technological innovation (including the number of applications and grants) among enterprises in the region.

2.2. Theoretical Deconstruction of the Mediating Mechanism

2.2.1. Mediating Pathways of Firm Adaptability

The theory of dynamic capabilities puts forward the following perspective: in a dynamically changing external environment, firms must possess specific core capabilities to maintain a competitive advantage (Teece, 2018) [25]. The social credit system has improved the market operation rules and business environment, and the adaptability of enterprises has changed the constraints and incentives of external systems into internal management changes, promoting innovation behaviors (Helfat & Peteraf, 2015) [26]. A large amount of credit data in the credit system helps enterprises to improve their understanding of the external environment, judge market opportunities, evaluate the reputation of partners, identify risks and opportunities, and provide support for innovation decisions (Guo *et al.*, 2025) [20]. After implementing the reward system for upholding trustworthiness and the sanction framework for breaching trust, enterprises need to carry out dynamic adjustment and resource reorganization, optimize the internal process and external cooperation relationship, obtain the value brought by trust, and enter the innovation space based on trust (Geng & Wen, 2025) [27]. The social credit system makes enterprises more adaptable, and this adaptability becomes transformed into continuous patent innovation. These enterprises use good credit qualifications to obtain external innovation resources and achieve efficient innovation (Wang *et al.*, 2026) [28]. On the contrary, when facing the same policy support,

enterprises with weak adaptability are accustomed to the old working mode due to internal reasons of their own organization, which makes it difficult to effectively respond to institutional changes and miss innovation opportunities (Gilbert, 2025) [29]. As it backs the growth of innovation, the social credit system also encourages firms to act in a conforming manner and speeds up the rise in innovation output.

Therefore, the following hypothesis is put forward:

H2a: In the mechanism through which the social credit system fosters patent-based technological innovation, enterprise adaptability acts as a mediator.

2.2.2. Mediating Transmission Pathways of Corporate Value

When the social credit system improves, it influences how the capital market is valued and also shapes firms' choices regarding innovation. This system affects the market value of enterprises in different ways, and the improvement of the system reduces regional systemic risk and operational uncertainty, and investors reduce risk premium requirements and increase enterprise valuation (Xie *et al.*, 2024) [30]. With the increase of enterprise value, enterprises can obtain sufficient and low-cost funds from the market to provide financial support for long-term R&D innovation. The credit records of enterprises have become important resources, showing the management level, operation stability and contract performance ability to the market, narrowing the information gap between investors and management, and reducing the financing cost of equity and debt of enterprises (Gomber *et al.*, 2018) [31]. The favorable conditions provided by the system include reducing financing costs, increasing business opportunities and government support, improving enterprises' profitability and growth expectations, and stabilizing the value foundation (Zhu & Song, 2025) [21].

The improvement of enterprise value supports patent innovation, which is reflected in two levels: resource input and management norms. Firms with high market capitalization have stronger financing ability, more access to external funds, and lower financing costs. Financial support ensures technology R&D activities with long cycle, high risk and large capital expenditure (Flammer & Kacperczyk, 2019; Brown *et al.*, 2017) [22] [32]. The growth of enterprise value Narrows the interest difference between managers and shareholders, and the assessment based on market value and stock incentive make the management focus on competitive advantage and future growth, reducing short-term behavioral interference (Pfeffer *et al.*, 1979) [33]. The enterprise has good credit and high market value. The enterprise has sufficient capital and is willing to take the initiative to invest in long-term innovation. Enterprise value provides an operating environment for social credit policies, transforming the convenience brought by policies into resources and power to promote technological innovation.

Therefore, the following hypothesis is put forward:

H2b: Enterprise value serves a mediating role in the mechanism whereby the establishment of the social credit system drives patent innovation.

2.3. Moderating Effects of Spatial Distribution and Ownership Structure

According to the theory of institutional change, the specific impact of institutional adjustment on the economy depends on the original institutional basis (Acemoglu & Robinson, 2019) [18]. When the original institutional environment is perfect, the economic growth effect brought by the new institution will be reduced. When the foundation is weak, the same institutional adjustment can play a greater role in promoting. In the eastern region, the marketization started early, the rule of law and the financial system are relatively mature, and the market development alleviates the problem of information opacity. The way the social credit system is put into practice stays largely confined to the original framework for fixes, and its role in promoting innovation is relatively limited. In contrast, the marketization degree in the western region is low, the rule of law and financial system are not yet perfect, and enterprises face more financing difficulties and transaction costs. Introducing fresh institutional setups as the social credit system evolves may yield clearer economic gains.

Therefore, the following hypothesis is put forward:

H3a: In western regions, the social credit system's beneficial impact on innovation is stronger than it is in eastern ones.

The theory of property rights points out that the type of property rights determines the connection between the organization and the institutional environment, and the speed of the organization's response to external institutional changes is also affected by this (Coase, 2013; Demsetz, 1974) [34] [35]. As China undergoes economic transformation, State-owned and private firms differ when it comes to who owns property rights and how resources are distributed, which determine how enterprises adjust their credit system.

According to the theory of resource dependence, state-owned enterprises can obtain financing support by virtue of their property rights relationship with the government even if their business performance is not good, they can obtain funds in the credit market through administrative channels (Pfeffer *et al*., 1979) [33]. These enterprises rely less on the market-oriented credit evaluation system, and the social credit system has little effect on the financing restriction of these enterprises. Because of the lack of government credit support, private enterprises mainly rely on market-oriented credit mechanism for financing. By turning corporate credit records into concrete information, the social credit system lessens the information gap between banks and firms, thereby enhancing the financing conditions for private enterprises. According to the signal transmission theory, credit records are the basis for financial institutions to evaluate enterprises (Spence, 1973) [36].

Therefore, the following hypothesis is put forward:

H3b: Private enterprises experience a stronger positive innovation effect from the social credit system than state-owned ones do.

3. Research Design

3.1. Sample Selection and Data Sources

Since 2010, China's social credit system policy has entered a stage of systematic

advancement. The continuous refinement of its institutional framework creates a sound institutional setting to evaluate the policy's long-term economic consequences. This study initially takes all A-share listed firms on the Shanghai and Shenzhen Stock Exchanges from 2010 to 2023 as the raw sample. We exclude financial enterprises, special treatment (ST) listed firms, and observations missing core variable values, yielding an unbalanced panel dataset.

For data robustness, all continuous variables are winsorized at the 1% and 99% percentiles. Natural logarithm transformations are applied to mitigate heteroskedasticity. After the above data cleaning procedures, the final baseline sample contains 2340 firm-year observations. Notably, variations in sample size across regression specifications stem solely from data availability of corresponding variables rather than subjective adjustments to sample screening rules. Specifically, regressions for the baseline effect and firm value (measured by Tobin's Q) rely on the full sample (N = 2340). We measure firm adaptability using the coefficient of variation of R&D spending, advertising expenditure and capital expenditure. Since valid non-missing data for all three expenditures are required simultaneously, the sample size drops to 1893-1894 observations. For the innovation efficiency variable (InnoEff), we further exclude firm-years with zero R&D investment, leaving a sample of 2326 observations. To ensure the cross-coefficient comparability of mediation paths within identical subsamples, all mechanism tests incorporating the adaptability mediator estimate both the baseline and mediation effects on the restricted subsample with complete mediator data (N = 1893). This empirical design avoids comparability bias in mediation tests induced by inconsistent sample thresholds across regressions.

3.2. Variable Definitions

For a precise evaluation of how the social credit system affects corporate patent innovation, our research design lays out the dependent variable, main explanatory variables, mediating variables, plus a number of control variables. What follows is a detailed definition and description for each one.

3.2.1. Dependent Variable

The level of firms' patent-based technological innovation is the core outcome variable examined in this study. It is measured as the natural logarithm of one plus the number of patents granted to the firm (denoted as Patent_C), *i.e.*, Patent_C = ln (1 + number of patents granted). This measurement specification retains observations with zero patent grants and avoids sample loss arising from the undefined mathematical property of ln (0).

The number of patents granted can authentically reflect firms' effective innovation outcomes introduced to the market. Compared with the number of patent applications, patent grants better capture the output quality of technological achievements and the substantive innovation level of enterprises.

3.2.2. Key Explanatory Variables

This paper studies the influence degree of the social credit system policy to analyze

the policy effect, referring to the practice of Guo *et al.* (2025) [20]. The DID model is used to establish indicators to calculate the situation of each region affected by the pilot policy, and the calculation formula is DID_{it} = Treati * Timet. Where Treati represents the city, which is assigned a value of 1 when city i enters the pilot and 0 when it does not. Timet represents time and is assigned a value of 1 in the year and after the implementation of the policy, and a value of 0 before. When Treati and Timet are both 1, the value of the interaction term DID_{it} is 1, indicating that the city is affected by the policy in the current year, and 0 in other cases. This variable captures how much patent innovation differs between pilot cities and non-pilot cities, and it serves as a measure of the implementation intensity behind the social credit system's construction.

3.2.3. Mediating Variables

To study how policy affects patent innovation, the study listed enterprise adaptability and enterprise value as mediating variables. Referring to the research methods of Xie *et al.* (2024) [30] and Gomber *et al.* (2018) [31], the enterprise's resilience is determined by the coefficient of variation of R&D investment, advertising expenditure and capital expenditure. The smaller the coefficient value is, the more stable the enterprise's resource allocation is, and the higher the coping level in market fluctuations is.

3.2.4. Control Variables

To reduce estimation errors from omitted variables, the research team added firm-level control indicators. These include firm size, measured as the natural log of total assets; financial leverage, calculated as total liabilities divided by total assets; and cash flow ratio, defined as net operating cash flow over total assets. Board size is taken as the natural log of the total number of directors. The share of independent directors equals unity under the scenario of role duality, defined as the general manager also serving as the board chairman, and zero otherwise. Ownership concentration is the shareholding ratio of the top five shareholders, and the years of establishment of the enterprise is the natural logarithm of the years of establishment. Meanwhile, the study incorporates year fixed effects and province fixed effects to control for region-invariant time shocks and time-invariant provincial heterogeneity. Detailed definitions of all variables are provided in **Table 1**. Notably, the social credit system pilots are implemented at the city level. In the baseline model, the study controls for province fixed effects and clusters standard errors at the firm level. The robustness check that refines fixed effects to the city level is reserved for future research extensions.

Table 1. Definitions of the variables.

	Variable Symbol	Variable Name	Variable Definition
Dependent variable	Patent_C	Level of technological innovation in patents	Natural logarithm of the number of patents granted

Continued

Replace the dependent variable	Patent_A	Number of patent applications	Logarithm of patent applications, used for robustness testing
	RDsz	R&D Expenditures	R&D expenditure as a percentage of total assets
	InnoEff	Innovation efficiency	the number of patents granted, and the absolute value of the natural logarithm of R&D expenditure
Explanatory variable	DID	Implementation of the social credit system policy	Interaction term between the dummy variables (*Treat*) and (*Time*)
	Treat	Experimental Dummy Variable	Dummy variable: 1 if the city is a pilot city, 0 otherwise
	Time	Time-specific dummy variable	Dummy variable: 1 if the year is no later than the policy year; 0 otherwise
Instrumental variable	TobinQ	Enterprise Value	Tobin Q ratio
	Adaptability	Adaptability	Coefficient of Variation for Corporate R&D, Advertising, and Capital Expenditures
Control variables	Size	Enterprise size	Natural logarithm of total assets
	Level	Financial Leverage Ratio	Total Liabilities/Total Assets
	Cash Flow	Cash Flow Ratios	Net Cash Flow from Operating Activities/Total Assets
	Board	Board Size	Natural logarithm of the number of directors
	Indep	Proportion of Independent Directors	Number of Independent Directors/Total Number of Directors
	Dual	Dual role	General Manager and Chairman are the same person: 1; otherwise: 0
	Top 5	Shareholding Structure	Shareholding Ratios of the Top Five Shareholders
	Firm Age	Years since establishment	Natural Log of Years Since Incorporation
	Province	Dummy variable	Province fixed effect
	Year	Dummy variable	Time fixed effects

3.3. Econometric Model

Using the difference-in-differences method, we construct the following model:

$$\text{Patent\_C}_{it} = \beta_0 + \beta_1 \text{DID}_{it} + \beta_2 \text{Control}_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

In the above equation, 'i' denotes the firm, and 't' denotes the year; 'Patent_C_{it}' represents the number of patents granted to listed firm i in year t, and 'DID_{it}' is the core explanatory variable in this study, measured by the product of the group

dummy variable ‘ $TREAT_i$ ’ and the time dummy variable ‘ $TIME_t$ ’. The coefficient of primary interest in this study is β_1. If it is significantly positive, it indicates a positive effect between the implementation of social credit system policies and firms' innovation capabilities in patent technology; if it is significantly negative, the opposite holds. $Control_{it}$ represents the set of control variables, μ_i represents provincial fixed effects, λ_t represents year fixed effects, and ε_{it} denotes the random error term. Additionally, to address heteroskedasticity, cluster-robust standard errors at the individual level have been incorporated into the model.

4. Empirical Analysis

4.1. Descriptive Statistics

Table 2 gives descriptive statistics for all variables. For the dependent variable, which is the level of corporate patent-based technological innovation (Patent_C), measured as the natural logarithm of the number of granted patents (average 2.210, ranging from 0 to 6.368), the data show that most firms have relatively few patent achievements, a handful stand out, and some hold no patents at all. As for the main independent variable—the development of the social credit system (DID)—it is represented by a dummy indicator (pilot regions = 1).

Enterprise value averages 2.559, with a range spanning 0.802 to 16.65, revealing a clear disparity in how different firms are valued by the market. The mean value of adaptive capacity is −0.720, and the numerical range is −1.392 to −0.041, indicating that most enterprises have insufficient strength to cope with environmental adjustment. There are differences in the innovation level, scale, corporate debt and board structure of the sample enterprises, and most of them have a low level of patent technology innovation.

Table 2. Descriptive statistics (N = 2340).

Variant	N	Median	Stand	Min	Max
Patent_C	2340	2.210	1.255	0	6.368
Patent_A	2340	2.412	1.308	0	6.317
RDsz	2340	0.0310	0.0380	0	0.538
InnoEff1	2326	0.132	0.0680	0	0.338
TobinQ	2340	2.559	1.632	0.802	16.65
Adaptability	1894	−0.720	0.285	−1.392	−0.041
DID	2340	0.206	0.405	0	1
Size	2340	21.94	0.976	19.93	24.39
Level	2340	0.300	0.176	0.0470	0.820
Cashflow	2340	0.0650	0.0680	−0.155	0.247
Board	2340	2.133	0.180	1.609	2.639

Continued

Indep	2340	37.07	4.704	33.33	50
Dual	2340	0.338	0.473	0	1
Top5	2340	0.531	0.148	0.208	0.878
FirmAge	2340	2.957	0.304	2.079	3.497

The boxplots in Figure 1 depict the dynamic characteristics of patent activities among Chinese enterprises from 2010 to 2023, as well as the impacts of the credit policy on such activities. Under the "policy instrument–firm response" framework, Patent_C exhibits a sensitive response to policy implementation, which is consistent with the pattern of Patent_A. As shown in the figure, following the implementation of the Planning Outline for the Construction of a Social Credit System (2014-2020) in 2014, the medians of both patent indicators display an overall upward trend, with the overall position of the boxes shifting upward. The distribution of granted patents has a narrower dispersion than that of patent applications, which aligns with the findings presented later: while the social credit system expands patent output, it also imposes higher requirements on the quality of patent grants. The median level of patent activities maintained a sustained upward trend over the sample period, and the fluctuations around 2020 may be attributed to external environmental shocks and the adaptive adjustment of credit instruments. It should be emphasized that the boxplots and kernel density plots (Figure 1 and Figure 2) only present the descriptive characteristics of patent output distribution before and after the policy implementation. The upward shift of the median and the rightward shift of the distribution are merely intuitive indications. Whether these patterns remain valid after controlling for firm characteristics, time fixed effects and regional fixed effects relies on the difference-in-differences (DID) causal identification reported in subsequent sections. Accordingly, this paper does not draw inferences regarding statistical significance based solely on these graphical results. The aforementioned stylized facts only provide intuitive support for the subsequent causal identification analysis. The specific heterogeneity across regions, property rights and marketization will be rigorously tested via subsample regressions in Section 3.6.

Figure 2 Kernel density estimation results indicate a significant difference in the distribution patterns of firms' patent grants before and after the implementation of the social credit system policy. Before the execution of the policy (DID = 0), the innovation output gap of enterprises is small, and the number of patents granted is concentrated at a single level. After the implementation of the policy, DID = 1, the distribution curve shifts to the right and the long-tail feature increases. The number of patents granted has spread to a high level, the efficiency of innovation resource allocation has been improved, enterprises have broken through technological bottlenecks, and technology diffusion has accelerated.

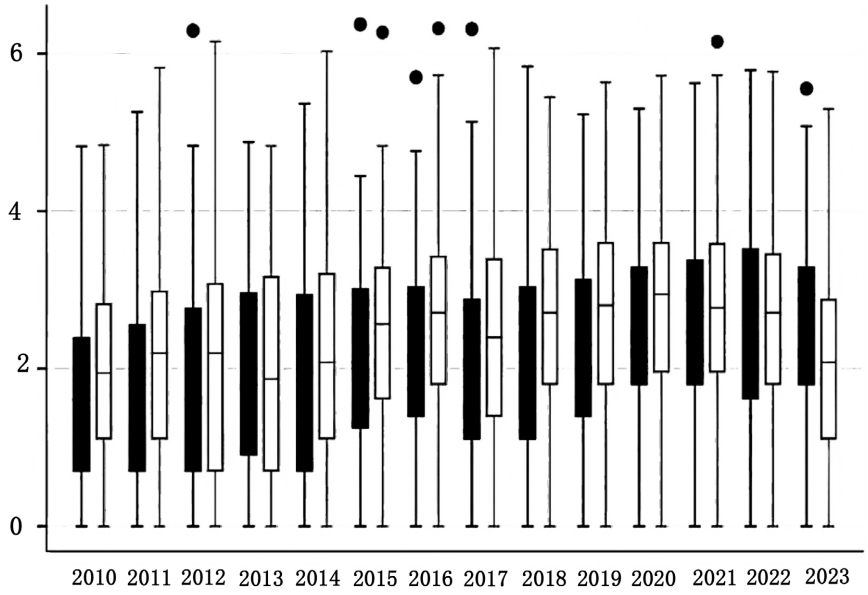

Figure 1. Box Plot of patents granted and patent applications.

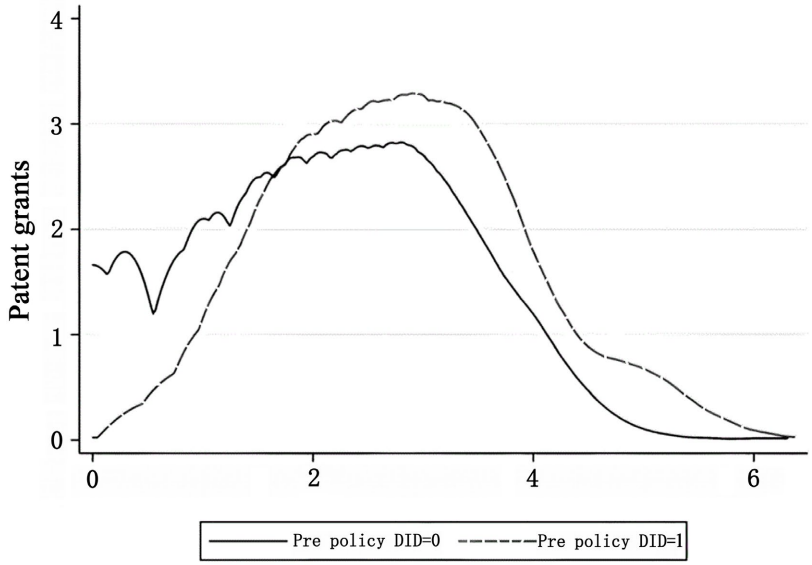

Figure 2. Kernel density plot of sample patent grants before and after policy implementation.

4.2. Baseline Regression Analysis

Table 3 regression findings offer the study's conclusions. This model confirms that building the social credit system promotes patent technology innovation, and the data confirm hypothesis H1. Combined with the theoretical framework of policy instruments, transmission paths, and innovation responses, the specific analysis is as follows.

As shown in Model M1, the social credit system policy (DID coefficient = 0.8144, T = 11.23, $p < 0.01$) significantly enhances firms' patent-based technological innovation, providing preliminary support for Hypothesis H1. In the full model incorporating control variables and two-way fixed effects (presented in

subsequent sections), the transmission mechanism through which the credit policy exerts effects by optimizing the financing environment (Cashflow) and strengthening firms' resource base (Size) is also verified.

After firm characteristic variables are introduced into Model M2, the policy effect coefficient decreases to 0.3268 (T = 4.42) and remains significant at the 1% level, indicating that the policy leverage effect remains robust. The functioning mechanisms of key control variables show clear divergence. The positive effect of firm size (Size, $\beta = 0.6223$) corroborates the resource-based view: large firms are more likely to access innovation resources under the credit policy context. The coefficient of financial leverage (Level) is significantly positive, suggesting that the credit system effectively improves firms' willingness and capacity for risk-taking by alleviating financing constraints. Corporate governance structure (Dual) consistently exerts a negative effect ($\beta = -0.1766$, T = −3.97). Role duality may inhibit the efficiency of innovation decision-making, which indirectly corroborates the practical necessity of improving corporate governance structure based on the credit evaluation system.

After province-year two-way fixed effects are incorporated into Model M3, the DID coefficient converges to 0.4892 (T = 7.42) with high statistical significance ($p < 0.01$), indicating that the policy effect holds spatial and temporal generalizability. The coefficient of firm age (FirmAge) is significantly negative ($\beta = -0.2155$, T = −2.62), implying that mature firms, constrained by path dependence, have relatively weaker adaptability to the credit policy, which calls for the deepening of differentiated policy design.

Table 3. Baseline regression results.

	(1) Innovation Level	(2) Innovation Level	(3) Innovation Level
DID	0.8144***	0.3268***	0.4892***
	(11.23)	(4.42)	(7.42)
Size		0.4015***	0.6223***
		(5.28)	(24.27)
Level		0.0118	0.5446***
		(0.05)	(3.80)
Cashflow		−0.4260	1.7824***
		(−1.15)	(5.47)
Board		−0.2399	0.1935
		(−0.93)	(1.28)
Indep		0.0002	0.0069
		(0.02)	(1.31)
Dual		−0.0083	−0.1766***
		(−0.10)	(−3.97)

Continued

Top5		0.2331	−0.1020
		(0.52)	(−0.63)
FirmAge		0.8996***	−0.2155***
		(3.60)	(−2.62)
Constant term	2.0423***	−8.9154***	−11.7411***
	(136.41)	(−6.00)	(−18.69)
Sample Size	2340	2340	2340
Year fixed effect	No	No	Yes
Province fixed effect	No	No	Yes
R^2	0.0895	0.2304	0.3944

Notes: T statistics in brackets. *, ** and *** indicate significance at the levels of 10%, 5% and 1%.

4.3. Endogeneity Tests

4.3.1. Parallel Trends Test

As shown in Figure 3, the parallel trend test indicates that from 2010 to 2014—before the policy took effect—the two groups showed little difference, so the parallel trend assumption underlying the DID model holds. After the Framework of the Social Credit System Construction Plan was carried out in 2014, the coefficient of the policy treatment effect in the experimental group begins to deviate from zero and also shows an expanding trend, which demonstrates that the policy measure exhibits a dynamic cumulative effect. Setting up a credit information sharing network helps raise technical cooperation efficiency and reduce information asymmetry, forming a continuous driving force for the improvement of innovation level.

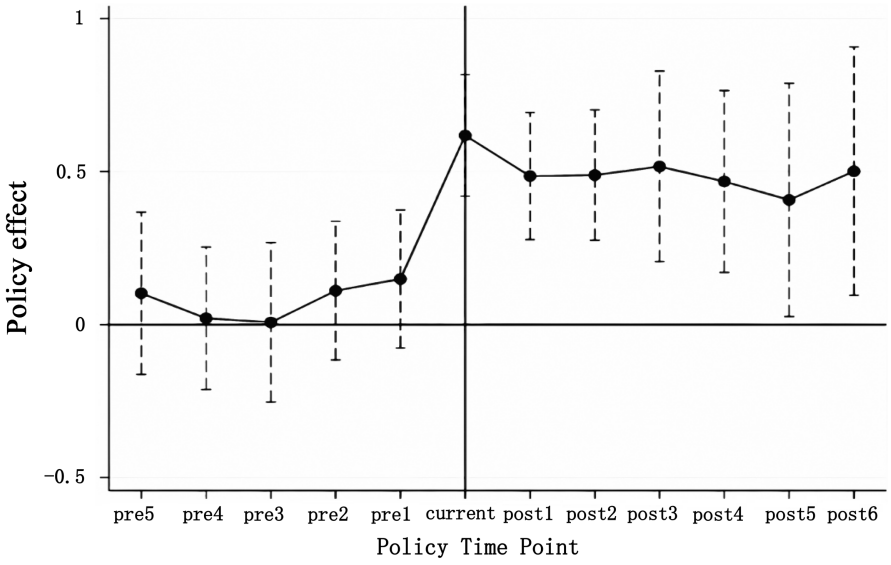

Figure 3. Parallel trends test and dynamic effects test.

4.3.2. Placebo Test

The study used the Bootstrap repeated sampling technique to establish a counterfactual analysis framework for the data after 1000 iterations, and the results are shown in Figure 4. Most of the effect coefficients of the policies in the pilot cities are around zero, within the 95% confidence interval [−0.032, 0.041], which is significantly different from the estimated value of the real policy effect. The statistical results of random samples show that only 3.7% of the samples pass the significance level of 5%, which is lower than the theoretical type I error threshold of 5%. Furthermore, the distribution of placebo estimation coefficients derived from 1000 rounds of random sampling exhibits a mean of −0.0007 and a standard deviation of 0.0187. The true estimate of 0.4892 deviates from the mean of this random distribution by approximately 26 standard deviations and lies at the extreme tail of the distribution. This evidence is more intuitive and compelling than the approach relying on the proportion of statistically significant estimates. Taken together, these results confirm that no systematic correlation in technological innovation levels is observed between pilot and non-pilot cities under the counterfactual scenario, which strengthens the credibility of the evaluation conclusions on the effects of the social credit system policy.

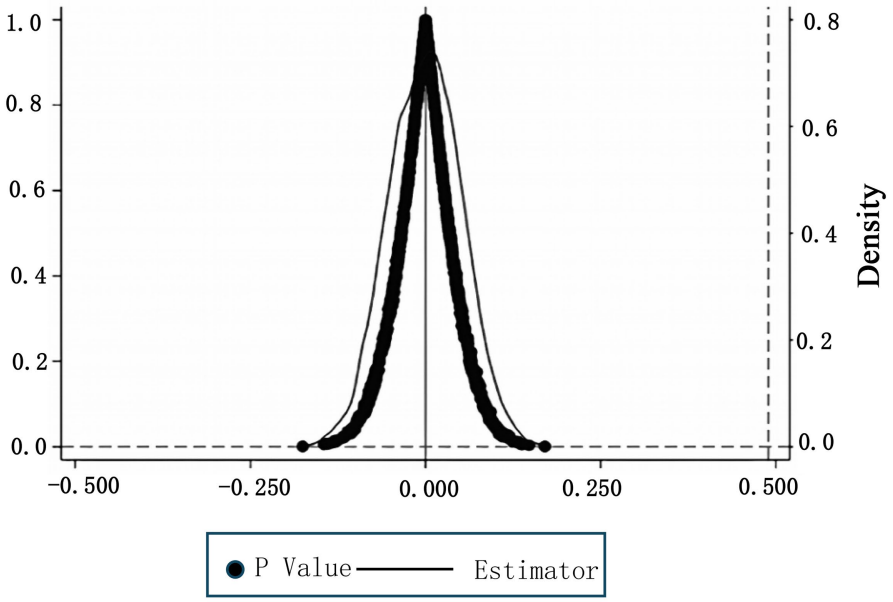

Figure 4. Placebo test results.

4.4. Robustness Tests

4.4.1. Propensity Score Matching

To enhance the robustness of causal inference, this study employs the propensity score matching (PSM) method.

First, covariates X_i are selected from the previously defined control variables. These are firm-level characteristics that may simultaneously affect a firm's exposure to the pilot policy and its patent-based technological innovation level, includ-

ing firm size (Size), financial leverage (Level), cash flow ratio (Cashflow), board size (Board), proportion of independent directors (Indep), role duality (Dual), ownership concentration (Top5), and firm age (FirmAge). Given that firms' pilot status is time-varying in the panel dataset, this study adopts a year-by-year matching strategy to avoid introducing "future information" through pooled matching. Specifically, propensity scores are estimated via the logit model and cross-group matching is conducted separately within each calendar year. The matched samples across all years are then pooled for subsequent estimation. Second, four matching approaches are applied to match the treatment group with the control group, namely one-to-one nearest neighbor matching, radius matching, kernel matching, and Mahalanobis matching, as specified in Equation (2).

$$P_i(X) = P\left(f_p = 1 \middle| X_i\right) = F\left[f\left(X_i\right)\right] \tag{2}$$

where X_i represents a set of independent variables influencing FDI. $f\left(X_i\right)$ is a linear function; in this study, the Logit model is employed to compute the probability that sample I serves as a consumption hub city, *i.e.*, the propensity score $P_i(X)$. A covariate balancing test was performed with the results shown in Figure 5. The matched samples exhibit significant differences only in the outcome variable and show no significant differences in other aspects.

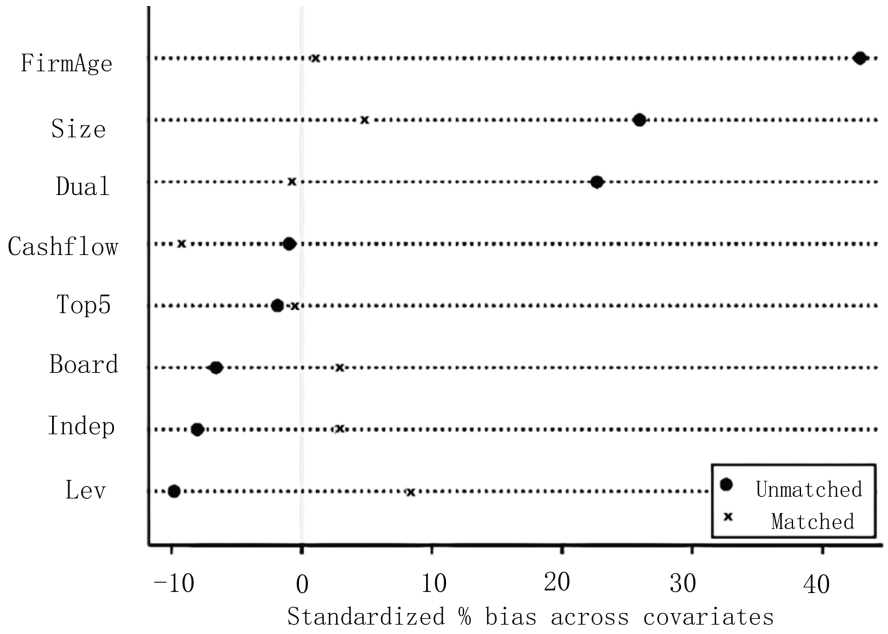

Figure 5. PSM propensity score matching balance test.

Table 4 lists the average treatment effect obtained by using the PSM model, and the resulting data of each matching are all positive. This shows that compared with the control group, the experimental group performs better in promoting enterprise patent innovation.

Table 4 presents the numerical values of the average treatment effects. This paper proposes four remedies to address sample selection bias.: first-order nearest

neighbor matching, radius matching, kernel matching and Mahalanobis estimation, so as to compare whether the policy effect is stable under different strategies. Data analysis shows that in the test of the four methods, the level of patent innovation of enterprises in pilot areas is between 2.79 and 2.80, and that of enterprises in non-pilot areas is between 2.14 and 2.18. The difference between the two is statistically obvious, and the t-test statistics are greater than 2.58 and $p < 0.01$. The estimated value of the first-order nearest neighbor matching is 0.66 and the t-value is 7.49, indicating that the implementation of the policy has increased the innovation capability of enterprises by 30.9%. The mean value of the control group is 2.1375, the estimated value of radius matching is 0.61, and the t-value is 9.91. The t-value of kernel matching reaches 10.38, and the standard deviation is 0.051, indicating that the sample balance is the best, and the estimated value of 0.63 is the most stable. The estimated value of Markovian matching is 0.61, and the t-value is 9.1.

Table 4. Average treatment effect from propensity score matching.

ATT	Treatment Group	Control Group	Treatment effect	Standard deviation	T-value
Nearest Neighbor Matching Method	2.7975	2.1375	0.6600	0.0881	7.49
Radius Match	2.7975	2.1861	0.6113	0.0617	9.91
Core Match	2.7975	2.1698	0.6277	0.0605	10.38
Mahalanobis distance	2.7913	2.1786	0.6128	0.0673	9.1

Our analysis shows a clear link between implementing social credit system policies and enterprises' patent output. Such policies help boost firms' reputations and encourage R&D spending, thereby strongly influencing the volume of patented technology output. Based on multiple data checks, firms in pilot regions have more patents than those in non-pilot ones, suggesting the policy indeed fosters tech innovation.

4.4.2. PSM-DID

Table 5 provides the regression results of the propensity score matching method combined with the DID method. When the nearest neighbor matching is used, the regression coefficient of the DID method is 0.6028, the T value is 5.71, and p is less than 0.01. The regression coefficient under the radius matching method is 0.4708, the T value is 7.11, and p is less than 0.01. The regression coefficient under the kernel matching method is 0.4743, the T value is 7.19, and p is less than 0.01. The regression coefficient under the Mahalanobis matching method is 0.5101, the T value is 6.64, and p is less than 0.01. The above regression coefficients are positive. This suggests that stronger policy intensity of the social credit system goes hand in hand with higher output of patented technological innovation from enterprises. Hypothesis H1 is verified.

Table 5. PSM-DID regression results.

	(1)	(2)	(3)	(4)
	Innovation Level Nearest Neighbor Matching	Innovation Level Radius Matching	Innovation Level Kernel matching	Innovation Level Martian Matching
DID	0.6028***	0.4708***	0.4743***	0.5101***
	(5.71)	(7.11)	(7.19)	(6.64)
Size	0.6270***	0.6245***	0.6212***	0.5844***
	(16.02)	(23.80)	(23.95)	(19.22)
Level	0.4438*	0.5440***	0.5544***	0.7196***
	(1.94)	(3.73)	(3.82)	(4.09)
Cashflow	2.1165***	1.8462***	1.8737***	2.3850***
	(4.41)	(5.54)	(5.63)	(6.18)
Board	0.4827*	0.2238	0.2446	0.3467*
	(1.90)	(1.44)	(1.59)	(1.87)
Indep	0.0118	0.0072	0.0077	0.0089
	(1.33)	(1.32)	(1.42)	(1.31)
Dual	−0.1859***	−0.1649***	−0.1693***	−0.2367***
	(−2.60)	(−3.66)	(−3.79)	(−4.39)
Top5	−0.2896	−0.1119	−0.1149	−0.2271
	(−1.13)	(−0.69)	(−0.71)	(−1.19)
FirmAge	−0.1217	−0.2461***	−0.2539***	−0.2097**
	(−0.93)	(−2.85)	(−2.96)	(−2.00)
Constant term	−12.8172***	−11.7592***	−11.7286***	−11.2948***
	(−12.27)	(−18.11)	(−18.24)	(−14.25)
Sample Size	764	2265	2273	1543
Year fixed effect	Yes	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes	Yes
R^2	0. 4390	0. 3939	0. 3940	0. 3939

Note: 1) Values in parentheses are T-values; 2) * indicates $p < 0.10$, ** indicates $p < 0.05$, *** indicates $p < 0.01$.

4.4.3. Exclusion of Samples from Municipalities Directly under the Central Government and National Central Cities

Special circumstances apply to Beijing, Shanghai, Tianjin, Chongqing, other municipalities directly under the central Government, and national central cities, and this paper is not included in the scope of analysis. Table 6 presents the results of the study for both cases, with column 1 for the data after excluding municipalities. Column 2 shows the data after excluding the national central cities, based on which we observe the innovation impact of the social credit system in different ranges. Looking at Table 6, columns (1) and (2), after dropping municipalities from the sample, the DID regression coefficient is 0.5253, with a T value of 7.15 and $p < 0.01$. Exclud-

ing national central cities gives a coefficient of 0.5014 (T = 6.57, p < 0.01). Even when we remove provincial-level municipalities or national hub cities, the social credit system policies still have a positive effect on enterprise innovation. This suggests that implementing the social credit system has a nationally consistent impact.

Table 6. Eliminate special samples, lag effects, and replace the dependent variable.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Innovation level Excluding municipalities directly under the central government	Innovation Level Excluding central cities	Innovation Level DID lagged by 1 year	Innovation Level DID lagging by 2 years	Innovation Level Patent_A	Innovation Level RDsz	Innovation Level InnoEff
DID	0.5253***	0.5014***	0.3754***	0.3681***	0.3084***	0.0072**	0.0156***
	(7.15)	(6.57)	(4.80)	(3.75)	(4.28)	(2.53)	(3.99)
Size	0.6385***	0.5979***	0.6419***	0.6305***	0.6528***	−0.0014	0.0287***
	(23.14)	(21.11)	(22.93)	(20.69)	(23.83)	(−1.44)	(18.84)
Level	0.3703**	0.2565	0.5836***	0.7283***	0.4307***	0.0143	0.0243***
	(2.38)	(1.60)	(3.73)	(4.26)	(2.97)	(1.49)	(3.00)
Cashflow	1.5687***	1.4441***	1.6059***	1.6709***	1.8445***	−0.0770***	0.0881***
	(4.39)	(3.91)	(4.36)	(3.98)	(5.12)	(−3.51)	(4.45)
Board	0.2390	0.2454	0.2940*	0.3127*	0.1682	0.0099**	0.0074
	(1.44)	(1.43)	(1.75)	(1.65)	(1.08)	(2.47)	(0.87)
Indep	0.0009	0.0053	0.0094	0.0120*	0.0024	−0.0004*	0.0001
	(0.16)	(0.91)	(1.63)	(1.94)	(0.44)	(−1.85)	(0.42)
Dual	−0.1898***	−0.1882***	−0.1368***	−0.1715***	−0.1436***	0.0067***	−0.0085***
	(−3.99)	(−3.81)	(−2.82)	(−3.23)	(−2.95)	(4.17)	(−3.15)
Top5	−0.1089	−0.3030*	−0.1495	−0.1728	−0.0087	0.0233***	−0.0040
	(−0.61)	(−1.69)	(−0.83)	(−0.88)	(−0.05)	(2.61)	(−0.42)
FirmAge	−0.1555*	−0.0895	−0.2932***	−0.2858***	−0.2256**	−0.0283***	−0.0101*
	(−1.68)	(−0.93)	(−3.12)	(−2.62)	(−2.49)	(−6.48)	(−1.96)
Constant term	−12.0627***	−11.4186***	−12.1588***	−12.0432***	−11.9498***	0.1232***	−0.5001***
	(−17.48)	(−16.25)	(−17.66)	(−15.78)	(−18.42)	(5.44)	(−14.09)
Sample Size	2005	1861	1972	1657	2340	2340	2326
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.3952	0.3669	0.3963	0.4004	0.3780	0.2374	0.3016

Note: 1) T-values are shown in parentheses; 2) * indicates p < 0.10, ** indicates p < 0.05, *** indicates p < 0.01.

4.4.4. Examining Lags

Considering that the policy effects of pilot cities may exhibit a time lag on firms' technological innovation, this study constructs one-year and two-year lagged versions of the core explanatory variable DID. Specifically, for cities that launched the policy in 2015, the one-year lagged DID variable takes a value of 1 starting from 2016, and the two-year lagged DID variable takes a value of 1 starting from 2017, while the timing of patent output variables remains unchanged. The corresponding regression results are detailed in Columns (3) and (4) of Table 6.

The one-year lagged DID variable (Column 3) yields a regression coefficient of 0.3754 ($t = 4.80$, $p < 0.01$), and the two-year lagged DID variable (Column 4) yields a regression coefficient of 0.3681 ($t = 3.75$, $p < 0.01$). Both coefficients are statistically significant, indicating that the effects of the social credit system policy materialize gradually over time. This time lag aligns with the inherent pattern of innovation activities. It typically takes 1 to 3 years for firms to convert R&D investment into patent grants, and there is also a natural time lag for improvements in the institutional environment to transmit to patent output through channels such as financing, collaboration, and expectation adjustment. Accordingly, the significantly positive coefficients of the one- and two-year lagged variables are consistent with the temporal characteristics of innovation output, and provide a reference for policymakers to grasp the cycle over which the policy takes effect.

4.4.5. Replacing the Dependent Variable

Estimation outcomes derived from Columns (5) through (7) in Table 6 deliver clear statistical evidence. Column (5) generates a DID regression coefficient of 0.3084; this statistical outcome comes with a t-statistic of 4.28 and significance at the 1% level. Such numerical evidence indicates that the introduction of social credit regulatory policies can effectively raise the number of patent applications submitted by businesses. Moving on to Column (6), the estimated coefficient capturing policy effects on corporate research spending hits 0.0072. A t-statistic of 2.53 shows statistical significance at the 5% level, illustrating that this institutional arrangement can guide business entities to expand their internal research spending scale. When looking at selected control variables, larger board sizes are associated with higher R&D spending levels. Meanwhile, enterprise scale shows no statistical significance in this regression setting, which implies firm scale barely shapes corporate spending decisions on innovative research projects. As shown in Column (7), the computed DID coefficient regarding innovative efficiency equals 0.0156, alongside a t-statistic of 3.99 and significance under the 1% threshold. It can be inferred that this credit-related institutional rule helps businesses expand patent application volumes and increase research spending input, while bringing visible improvements to overall innovative operational efficiency.

Taken together, improvements brought by the social credit institutional arrangement can benefit corporate innovative patent activities across different dimensions. These empirical findings solidify the statistical validity and logical support for the proposed Hypothesis H1.

4.5. Analysis of Mediating Effects

4.5.1. Adaptability

The conventional three-step approach suggested by Baron and Kenny (1986) [37] suffers from endogeneity issues, and this study employs the two-step approach to examine. The findings in Table 7 reveal that Column (1) suggests that the social credit system policy fosters enterprise technological innovation. Column (2) shows that the policy is negatively correlated with the adaptive capacity of enterprises. The adaptability of firms is a negative indicator, which means that the policy improves the adaptability of firms. Improving this adaptive capability helps the social credit system indirectly foster stronger innovation capacity among firms, thereby providing support for Hypothesis H2a.

4.5.2. Firm Value

Results from Column (3) in Table 7 indicate that the estimated DID coefficient stands at 0.4892, with a t-statistic of 7.42 and significance at the 1% level. The rollout of the social credit system policy effectively drives corporate technological innovation, leading to notable rises in both patent applications and R&D expenditures. As reported in Column (4), the corresponding DID coefficient is 0.2250, accompanied by a t-statistic of 2.00 and statistical significance at the 5% level. By strengthening corporate innovation capabilities, the social credit system also contributes to higher firm value, providing empirical support for Hypothesis H2.

Table 7. Mechanism analysis: Adaptation capability, corporate value.

	(1)	(2)	(3)	(4)
	Innovation level	Adaptability	Innovation level	Corporate Value
DID	0.4544***	−0.0636***	0.4892***	0.2250**
	(6.38)	(−3.02)	(7.42)	(2.00)
Size	0.6038***	−0.0198**	0.6223***	−0.4096***
	(20.55)	(−2.47)	(24.27)	(−7.27)
Level	0.5913***	0.1125**	0.5446***	−0.1227
	(3.63)	(2.54)	(3.80)	(−0.49)
Cashflow	1.8308***	−0.0453	1.7824***	3.6275***
	(5.00)	(−0.44)	(5.47)	(6.38)
Board	0.4056**	0.2912***	0.1935	−0.4796**
	(2.37)	(7.36)	(1.28)	(−2.38)
Indep	0.0117**	0.0020	0.0069	−0.0227***
	(1.97)	(1.34)	(1.31)	(−2.89)
Dual	−0.2005***	−0.0345***	−0.1766***	−0.0369
	(−4.11)	(−2.62)	(−3.97)	(−0.55)

Continued

Top5	−0.1947	−0.0335	−0.1020	−0.4064*
	(−1.04)	(−0.68)	(−0.63)	(−1.72)
FirmAge	−0.2986***	0.0570*	−0.2155***	0.9312***
	(−3.13)	(1.94)	(−2.62)	(7.05)
Constant term	−11.6394***	0.3085*	−11.7411***	10.6374***
	(−16.85)	(1.66)	(−18.69)	(9.36)
Sample Size	1893	1893	2340	2340
Year fixed effect	Yes	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes	Yes
R^2	0.3972	0.1554	0.3944	0.2332

Note: 1) T-values are shown in parentheses; 2) * indicates $p < 0.10$, ** indicates $p < 0.05$, *** indicates $p < 0.01$.

4.6. Heterogeneity Test

The policy's influence on patent innovation isn't uniform—it differs along multiple dimensions. Firm attributes and regional institutional environments vary widely in intensity and path. Drawing on theories from institutional economics and innovation management, this paper further investigates how spatial layout, property right attributes, and marketization degree shape the above mechanism.

4.6.1. Regional Heterogeneity

According to relevant theories of regional innovation system, the impact of social credit system on patent innovation varies in different regions (Chung, 2002) [38]. The eastern region has a perfect factor market and a rapid knowledge transfer network, so the effect of credit policy in this region is better (Guo *et al.*, 2025) [20]. The degree of credit information sharing and the ability of innovation resource allocation are not uniform in different regions, so the construction of credit system should cooperate with the innovation and development of the region. The regional division follows the official classification criteria for China's three major geographic zones (eastern, central and western) issued by the National Bureau of Statistics of China. As shown in **Table 8**, the eastern region comprises 10 provinces including Beijing, the central region comprises 6 provinces including Shanxi, and the western region consists of the remaining 12 provinces.

The social credit policy exerts a more pronounced impact in the western region compared to its effects in the eastern and central regions. Empirical results reveal that the DID coefficients for the western, eastern, and central regions stand at 1.0007, 0.4045, and 0.4054, respectively—with these coefficient values showing a gradual downward trend from the western to the eastern regions. The development of credit information sharing mechanism in the western region is slow, and there are difficulties in corporate loans. Policy intervention alleviates the problem of information opacity and brings economic value. The eastern region has a high

degree of marketization, and policies are mainly used to optimize the current innovation environment; these analyses confirm Hypothesis H3a. Based on the above conclusions, it is suggested that the western region should focus on the construction of cross-regional credit information sharing platform and patent pledge financing system. The eastern region introduced credit rating into the technology trading market and established credit certification and innovation alliance mechanism. Use these measures to improve the level of patent commercialization.

4.6.2. Heterogeneity in Property Rights

From the perspective of property rights theory, the intensity of policy response of state-owned enterprises is higher than that of private enterprises (Han & Chen, 2024; Ji *et al*., 2025) [39] [40]. State-owned enterprises enjoy the financing advantage and policy support brought by the credit system by virtue of institutional connection, and the first-mover advantage is obvious (La Porta *et al*., 2000) [41]. Private enterprises are subject to strong credit constraints, and their decision-making is deeply affected by the reputation incentive mechanism of market-oriented credit evaluation, and the marginal effect is more obvious.

Subsample regression results show that the promoting effect of the social credit system on the technological innovation capacity of private enterprises ($\beta = 0.4836$) is significantly more pronounced than that on state-owned enterprises (SOEs) ($\beta = 0.2992$). It should be noted that the sample sizes differ between SOEs (612 firms) and private enterprises (1728 firms), and the aforementioned cross-group comparison is based on an intuitive judgment of coefficient magnitudes. This phenomenon can be interpreted from the perspectives of institutional linkage and resource dependence. When confronted with credit rationing constraints, private enterprises become more reliant on credit signaling. The implementation of the social credit system has effectively improved the financing conditions of private enterprises and enhanced their innovation capacity. In contrast, subject to the dual effects of soft budget constraints and preferential allocation of policy resources, the marginal incentive effect of credit evaluation on the innovation behavior of SOEs is relatively limited. Building on the above conclusions, the policy design requires further improvement. For private enterprises, to strengthen market-based incentives, a dynamic linkage mechanism between credit points and R&D subsidies can be established. For SOEs, it is necessary to embed credit assessment into the management performance evaluation system to advance innovation-oriented governance structure reform.

4.6.3. Marketization Heterogeneity

The theory of institutional complementarity shows that the market operation mechanism is related to the credit system, and this kind of relationship can promote innovation. Zuo *et al*. (2026) [42]. support this view, in regions with high marketization degree, credit policy improves the efficiency of resource pricing and contract execution, and enterprises make more accurate R&D investment decisions. The credit system compensates for the defects through reputation constraints and promotes innovative activities.

The data summarized in Columns (6) and (7) of Table 8 show that the policy effect in low marketization areas is 0.7240, and that in high marketization areas is 0.4153. The value of the low marketization area is 1.74 times that of the high marketization area, indicating that the system has a complementary effect. When the efficiency of contract enforcement is low, enterprises tend to rely on informal constraints such as reputation to deal with business, which complements the deficiency of formal systems. In regions characterized by strong marketization, enterprises tend to use policies and digital technologies to promote the development of supply chain by using credit data. Low-marketization regions should focus on credit infrastructure construction, while high-marketization regions should focus on the combination of credit data and industry demand.

Table 8. Heterogeneity test.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Level of innovation in the eastern region	Level of innovation in the central region	Level of innovation in the western region	Level of innovation in state-owned enterprises	Level of innovation of private enterprises	Level of innovation with a high marketization index	Level of innovation with a low marketization index
DID	0.4054***	0.4045**	1.0007***	0.2992**	0.4836***	0.4153***	0.7240***
	(5.33)	(2.01)	(4.69)	(2.14)	(6.49)	(5.31)	(3.53)
Size	0.5572***	0.7139***	0.6272***	0.5531***	0.6095***	0.5609***	0.6958***
	(18.45)	(11.31)	(8.84)	(7.51)	(20.17)	(17.15)	(17.86)
Level	0.7311***	−0.0807	0.7514*	−0.3271	0.6342***	1.0385***	0.0770
	(4.20)	(−0.23)	(1.92)	(−1.03)	(3.63)	(5.31)	(0.37)
Cashflow	2.1756***	1.2090	−0.2719	0.6029	1.7519***	2.6589***	0.3258
	(5.71)	(1.55)	(−0.29)	(0.75)	(4.85)	(6.85)	(0.58)
Board	0.3640*	−0.3944	0.3118	0.3042	0.0190	0.2428	0.3339
	(1.95)	(−1.35)	(0.65)	(0.83)	(0.11)	(1.14)	(1.61)
Indep	0.0217***	−0.0494***	0.0287*	0.0026	0.0079	0.0215***	−0.0083
	(3.65)	(−3.98)	(1.84)	(0.23)	(1.22)	(3.18)	(−1.03)
Dual	−0.1825***	−0.0991	−0.2292*	0.2227**	−0.2157***	−0.1765***	−0.1690**
	(−3.37)	(−0.95)	(−1.87)	(2.04)	(−4.25)	(−3.04)	(−2.49)
Top5	−0.1299	−0.0717	−0.2822	−0.2529	0.0423	−0.1252	−0.2223
	(−0.65)	(−0.15)	(−0.84)	(−0.66)	(0.23)	(−0.58)	(−0.91)
FirmAge	−0.0373	−0.6944***	−0.7409***	0.2466	−0.3982***	−0.0270	−0.6328***
	(−0.39)	(−3.03)	(−3.22)	(0.68)	(−4.36)	(−0.27)	(−4.53)
Constant term	−11.7737***	−8.6850***	−11.4027***	−11.1155***	−10.7267***	−11.6834***	−11.6324***
	(−16.37)	(−4.66)	(−5.88)	(−7.44)	(−13.83)	(−15.04)	(−11.43)

Continued

Sample Size	1433	527	380	612	1728	1170	1170
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.4075	0.3426	0.4753	0.4093	0.3963	0.4141	0.3772

Note: 1) Values in parentheses are T-values; 2) *indicates $p < 0.10$, **indicates $p < 0.05$, and (***) indicates $p < 0.01$.

5. Conclusions

5.1. Research Conclusions

Drawing on panel data from 310 listed firms spanning the period 2010–2023, this study employs a PSM-DID model to systematically examine the policy effects of social credit system construction. Key findings from this research are summarized below.

1) The social credit system serves to enhance the level of technological innovation in patents among enterprises. Subsequent to the deployment of the policy, the number of patents granted by enterprises has steadily increased, which reflects that the credit system encourages enterprises to make long-term R&D investment and guides innovation activities to the direction of high quality. The results show that credit policy improves external financing conditions, plays the role of reputation mechanism to enhance patent quality, and uses cooperation advantages to reduce communication costs in technical cooperation. Influenced by these factors, the innovation achievements of enterprises achieve growth. This finding shows that the social credit system with reputation mechanism as the core provides a feasible innovation management way for emerging economies in the Asia-Pacific region.

2) Policy impacts vary across firms and regions. The data show that the number of innovations in the western region, private enterprises and regions with lower marketization degree grows faster. The social credit system is instrumental in filling the institutional gap and boosting enterprise innovation when the institutional environment is weak. The eastern region and state-owned enterprises are relatively less affected by the policy, and the institutional background and resource conditions affect the effect of credit policy.

3) The role of the social credit system can be realized by improving the adaptability of enterprises and strengthening the value creation. The enhancement of the institutional setting strengthens the capacity of firms to adapt to market fluctuations and interdepartmental coordination.

4) The utilization efficiency of R&D capital and human capital of enterprises is improved, and the operation efficiency of enterprises in the links of technology transformation and patent output is increased. The change of enterprise value index shows the positive impact of system construction on resource allocation and long-term incentive.

The research shows that the social credit system has the functions of guiding, restricting and assisting. This system makes up for the shortcomings of previous policies in terms of technological progress of enterprises and increases their development capabilities. These results improve the understanding of China's institutional design, and also provide reference for other countries to study how to combine institutional building and technology management.

5.2. Policy Recommendations

1) Promote deep integration of credit and financial resources, and smooth the channel for converting institutional dividends into innovation outcomes.

The social credit system can reduce the information gap between the two parties in a transaction. To reduce costs and improve resource utilization efficiency whether the benefits brought by the system can be turned into new technologies of enterprises depends on whether enterprises can get resources. Policy should guide firms to turn credit into a financial resource. Some departments should popularize credit loans, and banks and other financial institutions can provide products with low interest rates and no collateral according to the credit score. Improve the channel of credit asset securitization, turn the future cash income of enterprises into tradable assets, combine credit with finance, reduce the difficulty of enterprises to borrow money, and improve the role of credit system in promoting technological innovation.

2) Establish a dynamic and differentiated credit incentive system to form a virtuous cycle of "R&D-credit-innovation".

The purpose of the credit system is to prevent risks and take into account the process of enterprise innovation. Relevant departments can include the innovation of enterprises into credit evaluation and establish a method combining dynamic evaluation and specific reward. The department can adjust the credit rating of the enterprise according to changes in the number of patents and the amount of R&D investment of the enterprise, implement measures such as tax reduction and exemption, priority participation in government procurement, and provision of R&D funding support. These practices can improve the credit score of R&D investment, fully utilize the credit system's role in supporting R&D, promote the common development of the two, and improve the enthusiasm of enterprises for technological innovation.

3) Strengthen the adaptation mechanism of institutional dividends to regional and ownership differences, and amplify the incentive effects on weak links.

It is observed that the social credit system works better in western China, private enterprises and regions with low marketization levels. This indicates that the system can play a complementary role when the formal institutional environment is insufficient. Policy-making departments should identify and expand this difference in effect, improve the construction of credit facilities in areas with insufficient relevant facilities, improve the level of information collection and sharing, and issue regional credit support policies. For private enterprises, relevant studies

suggest linking credit scores with R&D subsidies, linking credit performance with resource acquisition, relying on segmentation management measures to improve the actual effect of system construction, and promoting the general improvement of innovation ability.

5.3. Limitations and Outlook

The research content of this paper has two points, focusing on the impact of social credit system on enterprise patent technology innovation. Based on the analysis of the quantity and quality of patent output, social credit is a basic system with diverse and complex policy impacts. This paper does not involve the role of corporate social responsibility, business model transformation, supply chain collaboration and other fields, and other impacts of social credit system can be studied in the future. This paper uses enterprise patent application and authorization data to illustrate the level of technological innovation, which is objective but limited. Future research can combine various indicators and methods such as R&D investment efficiency, new product revenue ratio, and text analysis to systematically and comprehensively show the actual content and effects of enterprise innovation activities.

This study also has several limitations in terms of identification strategy and variable measurement, which provide avenues for improvement in future research. First, the social credit system pilots were rolled out in batches, with policy initiation years varying across cities. The standard difference-in-differences (DID) specification employed in this study may thus be affected by heterogeneous treatment effects. Future studies can adopt the staggered DID estimator proposed by Callaway and Sant'Anna (2021) to more robustly characterize the average treatment effect. Second, the social credit system is a city-level policy. Although firm-level variables, along with province and year fixed effects, are controlled for in the baseline model, city-level economic and institutional disparities—including urban GDP, urban financial development, regional intellectual property protection strength, and industry competition intensity—may still lead to omitted variable bias. Subsequent research can incorporate city-level control variables and apply city fixed effects with standard errors clustered at the city level. Third, due to space constraints, the first-stage results of propensity score matching (including logit regression coefficients, statistical significance, and AUC values) and the standardized bias of each covariate after matching are presented via balance test graphs in this paper. Future work can supplement full first-stage regression tables and standardized bias tables to improve the replicability of the matching procedure. Fourth, innovation efficiency (InnoEff) is constructed as the ratio of the number of patents granted to the natural logarithm of R&D expenditure (scaled by total assets). Since the two indicators have different units of measurement, their economic interpretation requires caution. This study only treats it as an auxiliary proxy indicator for robustness checks. Future research can adopt more standardized input-output efficiency measures, such as Data Envelopment Analysis (DEA) or Stochastic Frontier Analysis (SFA), for further substitution and verification.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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