

Government Subsidies and Enterprise Innovation in Chokepoint Technologies: Evidence from China's Advanced Materials Sector

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Abstract. Amid rising global tech competition and supply chain restructuring, advancing chokepoint technologies in the advanced materials sector is vital to China's technological autonomy, yet micro-level evidence on the effectiveness of government subsidies in this domain remains limited. This study develops a two-stage identification model to capture firm-level chokepoint innovation activities, integrating patent complexity, strategic value, and international disadvantage. Using panel data on Chinese A-share listed firms in the advanced materials sector from 2013 to 2021, and employing a fixed effects model (FEM), we examine the direct impact and underlying mechanisms of government subsidies on chokepoint innovation. Our findings reveal that subsidies significantly enhance firm-level chokepoint innovation, partly mediated through increased R&D investment. Heterogeneity analyses further show that the effect is more pronounced in eastern and central regions and among non-state-owned enterprises, while firm lifecycle differences appear marginal. This study proposes a replicable methodology for identifying chokepoint technologies and provides micro-level evidence on the efficacy and boundary conditions of subsidy-driven innovation, offering actionable insights for the design of targeted innovation support policies in the advanced materials sector.

Keywords: Government Subsidy Policy; Chokepoint Technologies; Advanced Materials Industry; Identification Model for Chokepoint Technologies.

1. Introduction

In the context of global industrial chain restructuring and escalating technological competition, overcoming bottleneck ("chokepoint") technologies within the advanced materials sector has emerged as a critical strategic challenge impeding China's development of advanced manufacturing and the autonomy of core technologies. Chokepoint technologies generally refer to strategic technological fields that are heavily reliant on foreign supply, characterized by strong external control, substantial difficulty for short-term substitution, and significant risks to industrial security if disrupted externally [1]. Such technologies typically exhibit high complexity, elevated risk, and substantial investment requirements, thereby creating significant barriers to innovation and demanding robust autonomous innovation capabilities.

Although China has recently achieved certain breakthroughs under its innovation-driven development strategy, allowing for the industrialization of select chokepoint technologies, its progression towards technological autonomy faces renewed and severe challenges amid ongoing US-led trade conflicts and technological embargoes. As a foundational sector supporting modern industry, the advanced materials industry underpins critical fields such as electronics and information technology, aerospace, and renewable energy. However, due to its inherently intensive technological nature, prolonged R&D cycles, and market uncertainties, chokepoint technology innovation within this sector faces severe financial constraints and formidable technological barriers [2]. Firms,

constrained by limited resources, financing challenges, and external technological restrictions, typically find it difficult to independently overcome these innovation bottlenecks.

Within this context, proactive government policy interventions become increasingly indispensable. China's Ministry of Finance, for example, has clearly indicated in its 2025 policy guidelines an intensified effort to enhance national technological innovation capabilities, significantly increasing central-level fiscal spending on critical technological breakthroughs by 12%, specifically targeting strategic domains such as integrated circuits and advanced materials. Concurrently, in 2025, the General Office of the State Council introduced policies aimed at steering venture capital funds toward chokepoint technology breakthroughs, employing mechanisms such as direct fiscal injections and risk compensation schemes to mobilize private capital toward critical technology domains including semiconductors and artificial intelligence. As a pivotal policy tool for fostering chokepoint technology innovation in the advanced materials sector [3], government subsidies directly alleviate corporate R&D funding pressures and additionally generate a signaling effect to attract greater private-sector investment, thereby distributing innovation risk [4] and incentivizing increased corporate R&D expenditure. These policy instruments underscore China's strategic intent to accelerate chokepoint technology breakthroughs [5]. Nonetheless, systematic micro-level empirical validation remains insufficient regarding the effectiveness of government subsidies in facilitating breakthroughs in chokepoint technologies. In particular, the current research lacks clear mechanisms and explicit identification criteria for chokepoint technologies, especially in the context of the strategically crucial advanced materials industry.

From a theoretical standpoint, the relationship between government subsidies and corporate technological innovation constitutes a significant theme within innovation economics and public finance literature. Nelson (1959) [6] argues that technological innovation inherently exhibits positive externalities, suggesting that government interventions through fiscal subsidies are essential for correcting market incentive inadequacies. From the perspective of the resource-based view, Barney (1991) [7] emphasizes that external resources, such as subsidies, play a critical role in enabling firms to build sustainable competitive advantages. Similarly, Romer (1990) [8], through endogenous growth theory, underscores technological advancement as a core driver of sustained economic growth, asserting the necessity for government intervention to cultivate a conducive innovation ecosystem. Nevertheless, existing literature exhibits divergent views on the efficacy of government subsidies in fostering high-quality innovation. Some studies underscore positive incentivizing effects, whereas others highlight the potential for crowding-out effects and inefficiencies arising from subsidy misuse [9]. Moreover, extant research predominantly focuses on general innovation indicators, such as total patent counts or R&D intensity, while largely neglecting specialized identification and empirical investigation into chokepoint technologies. Particularly within the advanced materials industry, there remains a notable research gap regarding the identification of underlying policy mechanisms and the heterogeneity in subsidy effectiveness [10].

Drawing on panel data from Chinese A-share listed firms in the advanced materials sector from 2013 to 2021, this study develops a two-stage identification model to detect firm-level chokepoint innovation activities. We empirically examine the incentive effects and underlying mechanisms of government subsidies, as well as their heterogeneity under different contextual conditions. The objective of this study is to provide micro-level evidence to support China's independent breakthroughs in critical technologies and to inform the optimal allocation of fiscal resources and the design of targeted innovation policies.

This research makes several potential contributions.

First, it introduces an original and replicable framework for identifying chokepoint technologies, integrating three dimensions—patent complexity, strategic value, and international disadvantage—to construct a generalizable method for future studies on strategic technology bottlenecks.

Second, at the empirical level, this study is among the first to focus on the mechanism through which government subsidies influence chokepoint innovation in the advanced materials sector. By incorporating a mediation model, it identifies the transmission pathway from government support to

innovation output via R&D investment, thereby extending the theoretical boundaries of subsidy impact research.

Third, through heterogeneity analyses across regions, ownership structures, and firm lifecycle stages, the study reveals how the effectiveness of subsidies varies across firms and institutional environments, enriching the micro-foundations for more precise and differentiated policy implementation in strategic technology domains.

2. Literature Review and Research Hypothesis

2.1. Chokepoint technologies in the Advanced materials sector

Chokepoint technologies are defined as strategically critical technologies located at key points of the industrial value chain, where domestic capabilities are either weak or absent, resulting in excessive reliance on foreign suppliers and limited substitution capacity in the short run [11]. These technologies can span both emerging fields and legacy domains essential to national industrial security [12].

In the semiconductor industry, chokepoint challenges in advanced materials are particularly salient. Extreme ultraviolet (EUV) lithography, indispensable for manufacturing sub-5nm chips, involves a range of ultra-high-specification materials such as ultra-flat mask blanks, Mo/Si multilayer mirrors, and highly pure photoresists—all of which are extremely difficult to substitute domestically. These materials must maintain stability under high-vacuum, high-energy environments and meet stringent purity, surface roughness, and thermal expansion criteria [13]. The production and intellectual property rights of these materials and related equipment are highly concentrated: ASML (Netherlands) dominates EUV lithography systems, ZEISS (Germany) supplies key mirror components, and Japanese firms such as JSR and Shin-Etsu control key resist formulations. China's lag in these domains is exacerbated by patent blockades, export restrictions, and knowledge opacity.

These cases illustrate several defining characteristics of chokepoint technologies: (1) high entry barriers and process complexity, with nonlinear breakthrough paths; (2) strong path dependency and lock-in effects due to concentrated patent ownership; and (3) monopolistic control embedded in global value chains and IP regimes [14].

R&D in advanced materials typically involves atomic- and molecular-level engineering, making it highly uncertain and costly [15]. The development cycle often spans 10–15 years [16], with innovations exhibiting strong positive externalities and low private returns, thereby disincentivizing private investment [17,18]. Mazzucato [19] underscores the indispensable role of the state in such long-term, high-risk innovation. From a resource-based view [7], breakthrough innovation requires not only sustained investment but also organizational learning and specialized capabilities, which are especially challenging for firms in developing countries [20]. Geopolitical tensions and intensified tech decoupling further increase uncertainty, as technology denial regimes evolve from market actions into deliberate state strategies [21].

While earlier studies have addressed some characteristics of chokepoint technologies and related market failures, few have proposed systematic methods for their identification or examined them in the context of government intervention within the advanced materials sector.

2.2. Government Subsidies in Promoting Technological Innovation

From the perspective of market failure theory, government subsidies are a key policy instrument to correct underinvestment in innovation [6,18]. Empirical studies have highlighted multiple channels through which subsidies can promote innovation. First, they provide direct financial relief for resource-constrained R&D [22]. Second, they send positive signals to capital markets, thereby easing external financing constraints [23,24]. Third, they attract complementary private investment, amplifying the overall innovation effect [25].

Nevertheless, subsidies are not without controversy. Scholars have raised concerns about strategic behavior and rent-seeking, where firms may engage in symbolic or superficial innovation to meet

funding criteria without making substantive technological progress [26,27]. Moreover, information asymmetry between governments and firms can lead to adverse selection and moral hazard. Kimura and Morimitsu [28] argue that governments may lack the technical expertise to accurately screen innovation projects, leading firms to exaggerate their expected returns and underdeliver in execution.

Some studies also highlight the potential crowding-out effects, whereby public funds displace rather than complement private R&D [29,30]. Ye et al. [31] further point out that in high-uncertainty sectors like advanced materials, weak evaluation mechanisms exacerbate subsidy misallocation. In such cases, subsidies may inadvertently encourage low-risk, incremental innovation rather than truly transformative efforts.

Existing literature mostly focuses on general innovation metrics such as patent counts or R&D intensity, lacking dedicated frameworks to identify or evaluate subsidies' effects on chokepoint technologies. Research on the mechanisms and heterogeneity of subsidy impacts within the advanced materials context remains limited.

2.3. The Mediating Role of R&D Investment in the Impact of Government Subsidies on Chokepoint technologies Innovation

Government subsidies affect innovation outcomes primarily through their impact on firm-level R&D investment, which serves as a key mediating variable [32]. In the advanced materials sector, high technological barriers and long development cycles make sustained R&D investment both a prerequisite and a constraint for innovation breakthroughs [33].

Subsidies help alleviate financial constraints in high-risk R&D, enabling firms to invest in long-term, foundational research [34,25]. Policy continuity and institutional stability are particularly important; in a stable policy environment, firms are more willing to pursue ambitious, high-risk projects rather than short-term, incremental improvements [35]. From a signaling perspective, subsidies also enhance firm credibility in capital markets, attracting further external investment into R&D [36].

Empirical studies confirm a significant crowding-in effect, whereby government funding increases total R&D investment—especially in technology-intensive sectors[37].

Based on the above analysis, this study proposes the following research hypotheses:

H1: Government subsidies significantly promote chokepoint innovation in advanced materials firms.

H2: Government subsidies indirectly enhance chokepoint innovation by increasing firms' R&D investment.

To test these hypotheses, this study constructs a two-stage identification model for chokepoint technologies, integrating three dimensions—patent complexity, strategic value, and international disadvantage. We apply this framework to a panel dataset of Chinese A-share listed firms in the advanced materials industry over the period 2013–2021. Using this model, we identify firm-year chokepoint innovation activities and compile a dataset including key variables such as the number of chokepoint-related patents, the amount of government subsidies received, and R&D investment intensity. A fixed effects panel model (FEM) is employed to examine both the direct effects of government subsidies on chokepoint innovation and the mediating role of R&D investment. Furthermore, we explore the heterogeneity of subsidy effects across regions, ownership types, and firm lifecycle stages.

3. Research Design

3.1. A Two-Stage Identification Model for Chokepoint Technologies

To identify whether firms are engaged in chokepoint technologies, this study develops an exploratory two-stage quantitative identification model based on patent data, grounded in the core characteristics of chokepoint technologies. The model first evaluates and screens critical core technologies using a composite index built upon three dimensions: strategic security value,

technological complexity, and market potential. It then assesses the presence of chokepoint risk through constructed indices of chokepoint intensity and chokepoint depth. The full identification process consists of the following two stages:

3.1.1. Stage One: Screening for Critical Core Technologies

(1) Indicator Design

Building on prior research, we expand the evaluation framework by incorporating six indicators across three dimensions—strategic security value, technological complexity, and market potential—to identify critical core technologies.

1) Strategic Security Value:

This dimension assesses whether a given patent spans multiple advanced technology domains within a strategic industry and whether it addresses national security concerns in terms of technology sovereignty. According to Trappey et al. [38] and Lee et al. [39], technology scope reflects the breadth of technical fields covered by a patent, while the number of claims indicates the depth and extensiveness of the disclosed technological solutions. Hence, we adopt two key indicators for this dimension: Technology Scope and Number of Claims.

2) Technological Complexity:

This dimension evaluates whether a patent involves intricate design, breakthrough innovation, and complex technical processes, as reflected in both development and downstream referencing. Following Verhoeven et al. [40], the number of inventors is positively associated with technological complexity, as broader inventor collaboration often corresponds to more sophisticated inventions. In parallel, forward citations capture the influence of a patent on subsequent technological developments. Therefore, we use the following two indicators to measure technological complexity: Number of Inventors and Number of Forward Citations.

3) Market Potential:

This dimension assesses whether a patent occupies a central position in the technological ecosystem and whether it has the potential to be widely commercialized. According to Grimaldi et al. [41], the number of patent family members reflects the breadth of technology dissemination, while the number of jurisdictions in which family members are filed reflects global market penetration. Thus, we select: Number of Patent Family Members and Number of Jurisdictions with Family Members.

(2) Screening Method: Entropy Weight Method

To objectively assign weights to the above indicators, we employ the entropy weight method, which increases the weight of indicators with greater variability and stronger discriminatory power. Assume that there are m patents and n indicators in a given sector. The raw data matrix is first normalized to eliminate scale effects, resulting in a standardized matrix M . Each entry in M corresponds to the normalized value of the i -th patent under the j -th indicator.

$$M = (M_{ij})_{m \times n} \quad (1)$$

Next, we calculate the relative proportion of each patent under each indicator. The share of the i -th patent under the j -th indicator, denoted as e_{ij} , is given by:

$$e_{ij} = \frac{M_{ij}}{\sum_{i=1}^m M_{ij}} \quad (2)$$

Third, we compute the entropy value for each indicator. The entropy of the j -th indicator, denoted as g_j , is calculated as follows:

$$g_j = -\ln(m)^{-1} \sum_{i=1}^m e_{ij} \ln e_{ij} \quad (3)$$

Finally, the weight assigned to each indicator, W_j , is determined by:

$$w_j = \frac{1-g_j}{\sum_{i=1}^m (1-g_j)} \quad (4)$$

Based on the computed weights, a composite score Z is calculated for each patent using all six indicators. Following the ranking approach proposed by Noh et al. [42], we sort the patents by their composite scores and select the top 10% as the critical core technologies identified in Stage One.

Table 1. Patent Evaluation Framework

Dimension	Dimension Weight (%)	Indicator Name	Indicator Weight (%)	Description
Strategic Security Value	16.06	Technology Scope	7.30	The broader the technical fields involved, the higher the strategic value.
		Number of Claims	8.76	Reflects the strength of the patent's technical coverage and protection.
Technological Complexity	40.61	Number of Inventors	6.37	A greater number of inventors implies higher technological complexity.
		Number of Forward Citations	34.24	Higher citation frequency indicates stronger technological influence.
Market Potential	43.33	Number of Patent Family Members	14.24	A larger patent family implies greater potential for commercialization.
		Number of Jurisdictions with Family Members	29.09	Indicates the extent of global market diffusion.

3.1.2. Stage Two: Identification of Chokepoint Technologies

After identifying the critical core technologies in Stage One, we further evaluate whether China faces chokepoint risks in the corresponding technical domains by constructing two key indicators: the Technology Quantity Gap Index (L_i) and the Technology Quality Gap Index (S_i).

This study draws on prior research by Chinese scholars who argue that chokepoint risk can be effectively measured by assessing technological gaps across two dimensions: quantity and quality. Based on this perspective, we develop two metrics—chokepoint intensity and chokepoint depth—to determine whether a given critical technology falls into the category of restricted or externally controlled technologies.

1) Technology Quantity Gap Index (L_i)

This index reflects the extent to which China lags behind the most advanced global competitor in terms of the number of critical core technologies within a specific technical domain. It is calculated as follows:

$$L_i = \frac{\max(N) - N_i}{\max(N)} \quad (5)$$

$$L_i^* = \begin{cases} 1, & \text{if } L_i > 0 \\ 0, & \text{otherwise} \end{cases} \quad (6)$$

Where: N_i denotes the number of critical core technologies held by China in subfield i ; $\max(N)$ represents the maximum number of such technologies held by any global competitor in the same

domain. The value of L_i ranges from 0 to 1, where a higher value indicates a larger quantity-based disadvantage for China in that domain.

2) Technology Quality Gap Index (S_i)

This index measures the relative quality disadvantage of China’s core technologies compared to the global leader, based on a composite patent quality score. It is calculated as:

$$S_i = \frac{\max(V) - V_i}{\max(V)} \quad (7)$$

$$S_i^* = \begin{cases} 1, & \text{if } S_i > 0 \\ 0, & \text{otherwise} \end{cases} \quad (8)$$

Where: V_i denotes the composite quality score of China’s patents in subfield i ; $\max(V)$ indicates the highest quality score held by any global actor in the same field. Patent quality is evaluated based on a weighted combination of forward citations, patent family size, and geographic coverage. The value of S_i also ranges from 0 to 1, with higher values reflecting lower technological influence and innovation sophistication.

In terms of classification criteria, this study adopts a binary decision rule to identify chokepoint technologies. Specifically, if both the Technology Quantity Gap Index (L_i^*) and the Technology Quality Gap Index (S_i^*) are equal to zero, the corresponding technical subfield is classified as non-chokepoint. Conversely, if either index is greater than zero, the subfield is identified as a chokepoint technology.

The underlying logic of this rule is as follows: when China holds some presence in a given critical core technology domain but is not technologically dominant (i.e., quantity disadvantage) and simultaneously lags behind in quality (i.e., lower innovation influence), it suggests persistent dependence on foreign actors. This dual disadvantage indicates the presence of chokepoint risk and warrants the classification of the domain as a chokepoint technology.

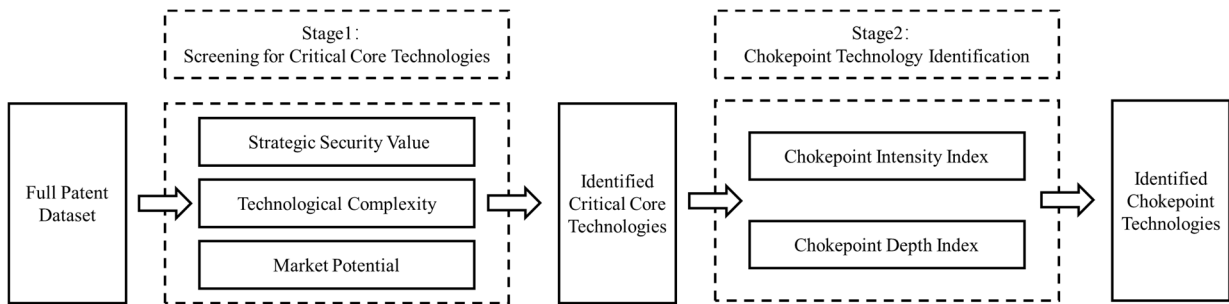


Figure 1. Framework for Identifying Chokepoint Risks in Critical Core Technologies

3.2. Data Collection and Sample Selection

This study focuses on A-share listed firms in China’s advanced materials sector from 2013 to 2021. The initial sample is constructed by retrieving all firms classified under the “Strategic Emerging Industries – Advanced materials” category in the Wind database. Based on the official definition of advanced material categories in the Guidelines for the Development of the Advanced materials Industry (2017), firm-level business descriptions are further analyzed using text mining methods to identify those whose core operations are centered on advanced materials. This results in a final sample of 379 listed firms.

Subsequently, applying the two-stage chokepoint technology identification framework developed in this study, we identify 223 firms with observable chokepoint technology innovation activities,

thereby establishing the core sample for mechanism analysis. Financial and patent data for the sample firms are primarily obtained from the CSMAR database.

During data preprocessing, we exclude firms with ST, *ST, or PT status; those that changed their registered location during the study period; and observations with missing values on key variables. To mitigate the influence of outliers, all continuous variables are winsorized at the 1st and 99th percentiles.

3.3. Variable Definitions

1. Dependent Variable: Chokepoint technology Innovation (*Inpat*)

Following the identification framework detailed in Section 3.1, we compute each firm’s annual count of invention patent applications in designated chokepoint technology domains. This measure captures firm-level innovation output under strategic technological constraints. To address skewness in the distribution, the natural logarithm of the patent count is used.

2. Independent Variable: Government Subsidies (*Lnsb*)

Government subsidies are measured by the natural logarithm of the annual amount of fiscal support received by each firm, based on CSMAR’s “Listed Company Government Subsidy Details,” which includes items such as tax rebates, R&D project funding, and co-financing support. To ensure robustness, the subsidy amount is winsorized at the 1% level and log-transformed after adding one.

3. Mediating Variable: R&D Investment (*LnRAD*)

Consistent with resource-based theory [7], R&D investment is considered a key mediating channel through which subsidies influence innovation output. It is measured as the natural logarithm of annual R&D expenditures, as reported in the Wind database. For firms lacking R&D disclosure, missing values are imputed using industry means in accordance with the disclosure requirements of the Guidelines on Information Disclosure by Listed Companies.

4. Control Variables:

This thesis controls for a set of firm-level characteristics that may influence technological innovation, including firm size (*Size*), leverage (*Lev*), growth (*Growth*), operating cost (*Cost*), and ownership type (*Soe*). The specific definitions are as follows: *Size* is measured as the natural logarithm of total assets; *Lev* is defined as the ratio of total liabilities to total assets; *Growth* is measured by the annual growth rate of operating revenue; *Cost* refers to the natural logarithm of total annual operating costs; and *Soe* is a dummy variable equal to 1 if the firm is state-owned and 0 otherwise. Detailed variable descriptions are presented in Table 2.

Table 2. Variable Names and Definitions

Variable Type	Variable Name	Definition
Dependent Variable	Chokepoint technology Innovation (<i>Inpat</i>)	Natural logarithm of the number of invention patents in bottleneck domains plus one
Independent Variable	Government Subsidies (<i>Lnsb</i>)	Natural logarithm of the annual amount of government subsidies received by the firm
Mediating Variable	R&D Investment (<i>LnRAD</i>)	Ratio of R&D expenditure to operating costs for each year
Control Variables	Firm Size (<i>Size</i>)	Natural logarithm of total assets
	Leverage (<i>Lev</i>)	Ratio of total liabilities to total assets
	Firm Growth (<i>Growth</i>)	Annual growth rate of operating revenue
	Operating Cost (<i>Cost</i>)	Natural logarithm of total operating costs
	Ownership Type (<i>Soe</i>)	Dummy variable: 1 for state-owned firms, 0 for non-state-owned firms

3.4. Model Specification

To examine the impact of government subsidies on firm-level technological innovation and to test the proposed mediating mechanism, this study employs a fixed-effects regression model. Industry

and regional fixed effects are included to control for unobserved heterogeneity across sectors and geographic locations. The model is specified as follows:

$$InPat_{it} = \beta_0 + \beta_1 Lusub_{it} + \beta_2 Controls_{it} + Year_i + City_t + \varepsilon_{it} \quad (9)$$

$$LnRAD_{it} = \beta_0 + \beta_1 Subit + \beta_2 Controls_{it} + Year_i + City_t + \varepsilon_{it} \quad (10)$$

$$InPat_{it} = \gamma_0 + \gamma_1 Lusub_{it} + \gamma_2 LnRAD_{it} + \gamma_3 Controls_{it} + Year_i + City_t + \varepsilon_{it} \quad (11)$$

In the above specification, i and t represent the firm and year, respectively; $InPat_{it}$ denotes the quantitative measure of chokepoint technology innovation; β_0 is the intercept term; $Treat \times Post$ is the interaction term serving as the main explanatory variable; $Controls$ refers to the set of control variables; β_1 and β_2 are the coefficients to be estimated; and ε_{it} is the error term. Specifically, Equation (9) captures the direct effect of government subsidies on chokepoint technology innovation among advanced materials firms; Equation (10) examines the effect of government subsidies on the mediating variable—R&D investment; and Equation (11) incorporates R&D investment into Equation (9) to test the mediating pathway.

4. Empirical Results and Analysis

4.1. Descriptive Statistics

Descriptive statistics for the key variables are presented in Table 3. Regarding the primary measure of firm innovation output, the average number of patent applications is 0.57, with a relatively large standard deviation. This suggests substantial variation in innovation capabilities across firms. While a few firms demonstrate strong technological competitiveness, the majority still exhibit low levels of innovation output. In terms of government subsidies, the average value of $Lnsb$ is 12.25, with a standard deviation of 7.12, indicating a highly uneven distribution of fiscal support. Some firms received substantial government funding, whereas others received none. This distributional disparity may be driven by firm size, government policy priorities, and differences in competitive environments across industries.

Table 3. Descriptive Statistics of Variables

Variable	Observations	Mean	Std. Dev.	Min	Max
Lnpat	2007	0.21	0.53	0.00	3.83
Lnsb	2007	12.25	7.12	0.00	22.48
Size	2007	21.76	1.76	15.86	28.64
Lev	2007	0.95	0.03	0.29	1.30
Growth	2007	0.74	8.28	-0.99	20.88
Cost	2007	21.02	1.97	13.60	28.36
Soe	2007	0.18	0.38	0.00	1.00

4.2. Baseline Regression

The Hausman test was conducted, and the results are presented in Table 4. The p -value is 0.0021, which is less than the 0.05 threshold, indicating that the null hypothesis is rejected. This result suggests that the coefficient estimates from the fixed effects and random effects models differ significantly, reflecting firm-level heterogeneity. Considering the presence of unobservable firm-specific characteristics, the fixed effects model is preferred for addressing potential endogeneity and controlling for unobserved heterogeneity. The estimation is based on Model (9), as specified earlier.

Table 4. Hausman Test Results

Variable	Fixed	Random	Difference	Std. err.
Lnsb	0.0068	0.0077	-0.0009	0.0005
Size	0.0059	0.0114	-0.0055	0.0073
Lev	-0.0048	-0.0080	0.0031	0.0041
Growth	0.0290	0.0423	-0.0133	0.0066
Cost	-0.0349	-0.0399	0.00450	0.0089
p=0.0021				

Table 5 reports the baseline regression results assessing the impact of government subsidies on firms' chokepoint technology innovation. Column (1) includes only the core explanatory variable *Lnsb*, while controlling for year and regional fixed effects. The coefficient of *Lnsb* is positive and statistically significant, indicating that government subsidies significantly enhance firms' innovation in critical technological domains.

Columns (2) and (3) introduce control variables without applying fixed effects. The coefficient of *Lnsb* remains highly significant at the 1% level, confirming the robustness of the result. In Column (4), time and regional fixed effects are added to account for unobservable macro-level heterogeneity. The coefficient of *Lnsb* remains statistically significant and stable, suggesting that a one-unit increase in government subsidies is associated with a 0.007 unit increase in *Lnpat*, the proxy for chokepoint technology innovation.

These findings provide strong empirical support for Hypothesis H1, indicating that government subsidies significantly promote firms' innovation in Chokepoint technologies. This result is consistent with the theoretical expectation that such technologies—characterized by high risk, long development cycles, and limited substitutability—often suffer from underinvestment by the private sector. Public subsidies alleviate financial constraints and offer critical support for R&D activities in strategic areas.

Table 5. Baseline Regression Results

Variables	(1)	(2)	(3)	(4)
Lnsb	0.008*** (5.48)	0.010*** (5.83)	0.010*** (5.76)	0.007*** (4.36)
Lnassets		0.042* (1.65)	0.042* (1.65)	0.006 (0.24)
Lnlia		-0.040** (-2.25)	-0.038** (-2.10)	-0.005 (-0.30)
Lnrev		0.140*** (3.20)	0.138*** (3.16)	0.029 (0.81)
Lncosts		-0.098** (-2.52)	-0.099** (-2.53)	-0.035 (-1.00)
Soe		-0.073** (-2.43)		
_cons	0.116*** (6.16)	-0.905*** (-5.79)	-0.925*** (-5.92)	0.213 (1.20)
Year/city	yes	no	no	yes
N	2,007	2,007	2,007	2,007
R ²	0.018	0.044	0.041	0.013

Note: t-values are reported in parentheses, and standard errors are robust. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Soe (state ownership) is a time-invariant firm characteristic and is therefore omitted in the fixed effects model.

Moreover, subsidies serve as a valuable external resource that enhances firms' capabilities in strategic planning and R&D allocation, thereby strengthening their long-term innovation competitiveness [43]. From a signaling perspective, receiving public subsidies conveys a positive signal to external stakeholders regarding a firm's innovation potential and strategic value. This perception facilitates additional resource acquisition from capital markets, forming a positive feedback loop that amplifies the incentive effect of fiscal support.

5. Mechanism Analysis

R&D investment is widely recognized as a key driver of firm-level technological innovation. Upon receiving government subsidies, firms often allocate these funds to expand their research activities, thereby accelerating innovation outcomes. The increase in R&D input typically manifests along two dimensions: greater financial expenditure on R&D and expanded human capital dedicated to innovation [44]. This study focuses on the former dimension and investigates whether public subsidies stimulate chokepoint technology innovation by increasing firm-level R&D expenditure. To empirically test this mechanism, we use the ratio of annual R&D expenditure to operating costs—derived from firms' financial statements—as a proxy for R&D intensity. Column (1) of Table 6 reports the regression results with R&D intensity (*LnRAD*) as the dependent variable. The estimated coefficient of the subsidy variable (*Lnsb*) is 0.002 and statistically significant at conventional levels. This finding suggests that, compared to firms in the control group, subsidy recipients exhibit a significantly higher level of R&D input.

To further examine the mediating role of R&D investment, we include both government subsidies (*Lnsb*) and R&D intensity (*LnRAD*) as independent variables in the regression model. As shown in Column (2) of Table 6, where chokepoint technology innovation (*Lnpat*) is the dependent variable, the coefficient of *LnRAD* is 0.455 and statistically significant at the 1% level ($p < 0.002$), indicating a strong positive association between R&D investment and innovation in strategically constrained technological domains. Notably, after including *LnRAD*, the coefficient of *Lnsb* declines from 0.011 to 0.010, and this change is statistically significant. This result is consistent with theoretical expectations, suggesting that government subsidies foster chokepoint technology innovation both directly and indirectly—by incentivizing greater internal R&D effort. Hence, Hypothesis 2 is empirically supported.

Table 6. Mechanism Test: The Impact of Government Subsidies on Chokepoint Innovation

Variables	Chokepoint Innovation Output (<i>LnPat</i>)	
	(1)	(2)
<i>Lnsb</i>	0.002*** (8.40)	0.010*** (4.94)
<i>LnRAD</i>		0.455*** (3.05)
Size	-0.163*** (-7.13)	1.331*** (8.18)
Lev	-0.482*** (-9.23)	-1.032*** (-2.76)
Growth	0.000 (-0.05)	-0.001 (-0.74)
Cost	0.006 (1.37)	-0.065** (-2.12)
_cons	0.981*** (13.58)	-3.024*** (-5.71)
R ²	0.114	0.051
N	2007	2007

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. t-values are reported in parentheses.

To further evaluate the magnitude of the mediating mechanism, we conduct a Sobel test. As reported in Table 7, the indirect effect is estimated at 0.001, with a Z-value of 2.865, which is statistically significant at the 1% level. This provides additional evidence that R&D investment acts as a statistically significant mediator in the relationship between government subsidies and chokepoint technology innovation. Furthermore, the indirect effect accounts for approximately 9.76% of the total effect, indicating that although R&D investment contributes meaningfully to the transmission mechanism, the direct effect of government support remains dominant. Taken together, these results provide robust empirical validation for Hypothesis 2 and underscore the dual channels—direct and R&D-mediated—through which public subsidies advance chokepoint technology innovation.

Table 7. Sobel Test Results

Test Component	Coefficient	Z-value
Sobel	0.001***	2.865
Coefficient a	0.002***	8.340
Coefficient b	0.455***	3.048
Indirect Effect	0.001***	2.865
Direct Effect	0.010***	4.942
Total Effect	0.011***	5.553
Proportion of Indirect Effect (%): 9.76%		

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

6. Robustness Checks

6.1. Endogeneity Tests

6.1.1. Instrumental Variable Approach

In the context of firm-level behavior, a potential bidirectional causality may exist between government subsidies and technological innovation [45]. Firms with stronger innovation capabilities are more likely to attract policy attention and receive preferential resource allocation [5]. At the same time, public subsidies may further incentivize these firms to pursue additional innovation activities, thereby giving rise to a classic endogeneity issue [46].

Moreover, when designing subsidy policies, governments may condition funding decisions on firms' existing patent performance, which could introduce selection bias and exacerbate the non-randomness of subsidy allocation.

To effectively address the potential endogeneity concerns outlined above, this study employs a two-stage least squares (2SLS) estimation strategy, utilizing two instrumental variables that are both exogenous and strongly correlated with the endogenous regressor:

(1) *Treat1*: the one-period lag of government subsidies received by the firm. Due to administrative and disbursement delays typically associated with public funding processes, lagged subsidies can serve as a plausibly exogenous predictor of current innovation input. This approach is widely adopted in policy evaluation and innovation economics literature (Howell, 2017; Li et al., 2021).

(2) *Post1*: a policy dummy indicating whether a provincial government issued a targeted subsidy policy related to the advanced materials sector in a given year (coded as 1 if issued, 0 otherwise). The data are collected from official websites of provincial finance bureaus, departments of industry and information technology, and science and technology bureaus. Relevant documents issued between 2013 and 2021 were identified through keyword searches including “advanced materials subsidy,” “patent support,” “chokepoint technology breakthrough,” and “critical technology self-reliance program.”

The rationale behind the construction of the variable *Post1* lies in the assumption that the announcement of targeted industrial policies exerts a signaling effect, shaping local firms'

expectations regarding government support and influencing their actual willingness to apply for subsidies. Importantly, *Post1* is determined by region-specific policy arrangements and is not directly driven by firm-level innovation decisions, thereby satisfying the exogeneity condition required for a valid instrumental variable.

To ensure the statistical validity of the instrument design, Table 8 reports the descriptive statistics for both instrumental variables.

Table 8. Descriptive Statistics of Instrumental Variables

Variable Name	Description	Mean	Std. Dev.	Min	Max
Treat1	Government subsidy amount received in the previous year	8.41	2.16	0.00	15.78
Post1	Whether a special subsidy policy for advanced materials was issued	0.52	0.50	0	1

Both instrumental variables exhibit favorable distributional characteristics and demonstrate a strong linear correlation with the endogenous regressor, *Lnsb*. To establish the validity of the instruments, we evaluate them along two dimensions: relevance and exogeneity. Regarding instrument relevance, the results from the first-stage regression of the 2SLS model indicate that the instruments possess strong explanatory power for *Lnsb*. The R-squared value is 0.24, with a partial R-squared of 0.19 and an adjusted R-squared also at 0.24. The corresponding F-statistic reaches 212.99, which far exceeds the conventional Stock-Yogo threshold of 10 for weak instruments. These results confirm a statistically significant association between the instruments and the endogenous variable, thereby ruling out concerns related to weak instrumentation.

To assess the validity of the exogeneity assumption, we conduct a Sargan overidentification test to examine whether the instruments are correlated with the model's error term. The test yields a p-value of 0.139, indicating that we fail to reject the null hypothesis of instrument orthogonality. This result suggests that the instruments satisfy the exogeneity condition required for valid inference. Taken together, both *Treat1* and *Post1* meet the requirements of valid instruments from both a theoretical and empirical perspective, providing strong support for the identification strategy employed in the 2SLS model. Compared to ordinary least squares (OLS), the use of two-stage least squares (2SLS) mitigates endogeneity bias and improves the consistency and interpretability of the coefficient estimates. The corresponding regression results based on the 2SLS estimation are reported in Table 9.

Table 9. Second-Stage 2SLS Regression Results

Variables	Coefficient	Std. Error	z-value
Lnsb	0.02***	0.004	4.28
Size	0.02	0.027	0.87
Lev	-0.03*	0.019	-1.70
Growth	0.14***	0.047	2.94
Cost	-0.08**	0.043	-1.97
Soe	-0.08***	0.026	-3.00
_cons	-0.96***	0.195	-4.91
R ²		0.146	
N		2007	

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

As shown in the 2SLS estimation results, the coefficient of government subsidies (*Lnsb*) on firm-level bottleneck patent output (*Lnpat*) is 0.02 and statistically significant at the 1% level ($p < 0.001$). This finding indicates that, even after accounting for endogeneity concerns, government subsidies continue to exert a significantly positive impact on chokepoint technology innovation. From an

economic perspective, although the magnitude of the estimated coefficient appears modest, its stability and statistical significance affirm the robustness of the effect. The positive and directionally consistent result suggests that public subsidies indeed play a catalytic role in stimulating innovation activities in technologically constrained domains. Given the inherent time lags associated with innovation outputs, it is plausible that the long-term effects of government support may be even more pronounced.

In addition, firm growth (*Growth*) is positively and significantly associated with chokepoint technology innovation, with a *p*-value of 0.003. This suggests that high-growth firms are more capable of pursuing technological breakthroughs. By contrast, both operating costs (*Cost*) and leverage (*Lev*) exert negative effects on innovation output, indicating that resource constraints can hinder firms' investment in innovation.

Taken together, these findings further validate the positive effect of government subsidies on chokepoint technology innovation after addressing endogeneity concerns. They underscore the important role of policy intervention in guiding technological advancement in strategically critical areas of China's industrial development.

6.1.2 Heckman Two-Step Procedure

To further assess potential endogeneity, we employ the Durbin-Wu-Hausman test. The results indicate that the *p*-values for the robust score chi-squared test and the robust regression F-test are 0.0761 and 0.0763, respectively—both above the conventional 5% significance level. These results suggest that the government subsidy variable is not significantly correlated with the error term, thereby providing no statistical evidence of endogeneity.

6.2. F-Test for Joint Significance

To control for unobserved firm-level heterogeneity, we estimate a fixed effects model and conduct an F-test to assess the overall significance of the regression specification. The results indicate that the model passes the joint significance test at the 1% level, suggesting that the explanatory variables collectively account for a statistically meaningful portion of the variation in firms' chokepoint technology innovation.

Although the model yields an R-squared value of 0.037, which appears low at first glance, this is a common outcome in empirical research on innovation—particularly when employing panel data at the firm level. This is largely attributable to the multifaceted nature of innovation, which is shaped by a wide range of external factors, such as industry technology cycles, supply chain dynamics, international competition, and organizational culture—many of which are difficult to quantify and incorporate fully into the model [47].

6.3. Autocorrelation Test

To further mitigate potential estimation bias arising from model misspecification, we conduct an autocorrelation test on the regression residuals. Specifically, we apply the Wooldridge test for first-order autocorrelation in panel data, with the null hypothesis being that no autocorrelation exists in the residuals. The test yields an F-statistic of 0.28 with a corresponding *p*-value of 0.60, which exceeds the conventional 5% threshold. As such, we fail to reject the null hypothesis, indicating that the model residuals do not exhibit significant first-order autocorrelation and thus satisfy the independence assumption underlying classical regression models.

Taken together, the robustness of our findings is supported by a comprehensive validation strategy, which includes the construction and relevance of instrumental variables, the strength of the first-stage regression, overidentification testing, autocorrelation diagnostics, and the joint significance and theoretical plausibility of the model's R-squared. These combined results lend strong empirical credibility to the conclusion that government subsidies exert a statistically robust and positive effect on chokepoint technology innovation among advanced materials firms in China.

7. Heterogeneity Analysis

7.1. Regional Heterogeneity

Given the significant differences across regions in resource endowments, institutional environments, and innovation capacity, the effectiveness of government subsidies in promoting chokepoint technology innovation may vary substantially by location [48]. To better capture these boundary conditions and improve the precision of policy targeting and resource allocation, we conduct a heterogeneity analysis based on regional divisions. Specifically, we divide the full sample into three major economic zones—eastern, central, and western—according to firms' registered locations, and perform separate regressions for each subgroup. The regression results are reported in Columns (1), (2), and (3) of Table 10.

The results reveal that government subsidies have a significantly positive impact on chokepoint technology innovation in both the eastern and central regions, with estimated coefficients of 0.015 and 0.029, respectively, significant at the 5% level. This suggests that subsidies are more effectively converted into technological outcomes in regions with stronger industrial foundations or greater innovation agglomeration effects. By contrast, although the subsidy coefficient in the western region is positive, it is not statistically significant, indicating a relatively weaker incentive effect of fiscal support in less developed areas. With regard to the control variables, firm size in the central region shows a significantly positive effect on innovation output, implying that larger firms may be more capable of integrating resources and utilizing subsidies efficiently. In the western region, both leverage and revenue growth are significantly negatively associated with innovation, reflecting the constraining effects of financial pressure and weaker market conditions. Interestingly, R&D cost shows a significantly negative association in the eastern region but a significantly positive one in the west, indicating a pronounced difference in cost sensitivity toward innovation investment across regions. Three factors may explain these regional disparities. First, the concentration of innovation factors varies. The eastern region benefits from high-density innovation ecosystems—encompassing R&D institutions, skilled labor, and integrated industrial chains—that facilitate a virtuous cycle of “subsidy → R&D input → innovation output.” In contrast, central and western regions face challenges related to limited technological accumulation and fragmented innovation resources. Second, regional differences in policy implementation and institutional support may play a role. The eastern region generally has stronger capabilities in fiscal execution, intellectual property protection, and industry–academia collaboration, enhancing the effectiveness of government subsidies [49]. Meanwhile, the central and western regions suffer from institutional frictions such as delayed policy diffusion and weaker governance infrastructure. Third, firm-level R&D capabilities diverge across regions [50]. Eastern firms tend to possess superior R&D efficiency and innovation commercialization capacity. While central firms exhibit some responsiveness to policy incentives, their innovation outputs remain volatile. Western firms, by contrast, often rely on subsidies to maintain basic R&D activities and lack the endogenous capacity to produce breakthrough innovations.

7.2. Firm Age Heterogeneity

Firms at different stages of their life cycle often differ in terms of resource endowments, risk preferences, and innovation behavior. Theoretically, more mature firms—with greater managerial experience and stronger risk-bearing capacity—may be more inclined to allocate government subsidies toward high-risk chokepoint technology development and achieve higher levels of innovation output. In contrast, younger firms, while limited in accumulated resources, may exhibit greater agility and responsiveness to policy incentives [51].

To test whether the effectiveness of government subsidies varies by firm age, we introduce a dummy variable (*age_group*), which equals one if the firm's age is above the sample median and zero otherwise. The regression results show that government subsidies overall exert a significantly positive effect on chokepoint technology innovation (*coefficient* = 0.016), while the *age_group* variable itself

is statistically insignificant ($coefficient = -0.022$). This suggests that the incentive effect of subsidies does not significantly differ across firms at different stages of maturity.

One possible explanation is that although older firms benefit from superior resource integration and more stable R&D investment patterns, younger firms, with their greater strategic flexibility and innovation dynamism, are equally capable of leveraging policy incentives. Overall, the findings imply that firm age does not significantly influence sensitivity to government subsidies, and that subsidy policies are broadly applicable across firms at different stages of their life cycle.

7.3. Ownership Heterogeneity

Ownership structure may also shape how firms respond to government subsidies in their innovation activities. Compared to private firms, state-owned enterprises (*SOEs*) differ substantially in governance structures, risk tolerance, and incentive mechanisms, which may affect their innovation efficiency and responsiveness to external support.

To explore this heterogeneity, we introduce an interaction term between state ownership (*Soe*) and government subsidies (*Lnsb*) into the baseline regression model. The results, reported in Column (5) of Table 10, indicate that government subsidies have a significantly positive effect on chokepoint technology innovation overall. However, the coefficient of the interaction term (*Soe_Lnsb*) is negative and statistically significant, implying that SOEs are significantly less responsive to subsidies compared to non-SOEs.

This divergence may be attributed to structural differences in institutional environments and operational behavior. On the one hand, SOEs are typically subject to multiple constraints—such as performance assessments, budget ceilings, and policy mandates—that drive their managers toward more conservative and risk-averse innovation strategies. On the other hand, private firms, which are more reliant on external financing to sustain their innovation activities, tend to be more sensitive to fiscal incentives. For them, government subsidies often serve as a critical external resource to overcome technological bottlenecks [52].

Table 10. Heterogeneity Analysis Results

Variables	Regional Heterogeneity			Firm Age Heterogeneity(4)	Ownership Heterogeneity (5)
	Eastern Region (1)	Central Region (2)	Western Region (3)		
<i>Lnsb</i>	0.015** (0.005)	0.029** (0.008)	0.005 (0.008)	0.016*** (4.36)	0.017*** (4.44)
<i>Size</i>	-0.005 (0.032)	0.226* (0.097)	0.061 (0.071)	0.025 (0.33)	0.023 (0.85)
<i>Lev</i>	-0.018 (0.020)	-0.105 (0.067)	-0.118** (0.058)	-0.031* (-1.67)	-0.035* (-1.78)
<i>Growth</i>	0.239** (0.094)	-0.025 (0.044)	-0.166** (0.063)	0.133*** (2.87)	0.136*** (2.91)
<i>Cost</i>	-0.164** (0.082)	-0.022 (0.047)	0.198** (0.066)	-0.083* (-1.94)	-0.081* (-1.89)
<i>age_group</i>				-0.022 (-0.80)	
<i>Soe_Lnsb</i>					-0.007*** (-3.54)
<i>_cons</i>	-1.139** (0.263)	-1.822* (0.491)	0.529** (0.201)	-0.985*** (-5.01)	-0.959*** (-4.92)
<i>Year & City</i>	yes	yes	yes	yes	yes
<i>N</i>	1458	342	207	2,007	2,007
<i>R²</i>	0.0419	0.064	0.106	0.034	0.012

Note: Robust standard errors in parentheses for (1)-(3); t-values are reported in parentheses for (4)-(5).*, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

8. Conclusion and Policy Implications

Chokepoint technology innovation among firms in the advanced materials sector plays a critical role in upgrading China's industrial structure and advancing high-end manufacturing. It is also essential for enhancing national competitiveness in the global high-tech arena. As a key policy instrument, government subsidies are expected to incentivize firms to overcome technological bottlenecks. Therefore, a rigorous evaluation of the effectiveness of such subsidies is of strategic importance for optimizing policy design and promoting high-quality development in the advanced materials industry.

This thesis utilizes panel data on A-share listed firms in the advanced materials sector from 2013 to 2021 and employs a fixed effects model to investigate the impact and mechanisms of government subsidies on chokepoint technology innovation. Additionally, we conduct heterogeneity analyses based on firm location, life cycle stage, and ownership type. The main findings are as follows:

First, the baseline regression results show that government subsidies have a significantly positive effect on chokepoint technology innovation among advanced materials firms, indicating that subsidies serve as an effective stimulus for critical technological breakthroughs.

Second, the heterogeneity analysis reveals substantial regional disparities in the effectiveness of subsidy policies. In the eastern region, where R&D resources are concentrated and institutional support is stronger, government subsidies yield significant innovation returns. Market incentives amplify R&D investment, while R&D costs exert a negative effect. In the central region, the subsidy effect is even more pronounced. Larger firms are more capable of translating subsidies into innovation outputs, as indicated by the significantly positive effect of firm size. Leverage and R&D costs, however, show no significant impact. In contrast, subsidies in the western region fail to significantly affect patent output, likely due to limited market demand, low innovation efficiency, and financial constraints. In this region, revenue growth negatively correlates with innovation, while R&D costs have a positive association—suggesting that firms may rely more heavily on external support to sustain R&D.

Third, heterogeneity by firm age shows no significant difference in responsiveness to government support, implying that subsidy policies are broadly applicable across firms at different life cycle stages. By contrast, ownership-based heterogeneity reveals that non-state-owned enterprises (non-SOEs) are more responsive to subsidies than their state-owned counterparts. This suggests that private firms may rely more on external funding to enhance their innovation capacity, whereas SOEs—subject to performance constraints and institutional rigidity—are less sensitive to fiscal incentives.

Fourth, the mediation analysis confirms that R&D investment serves as a partial transmission channel through which subsidies affect bottleneck innovation. However, the direct effect of government subsidies remains the dominant mechanism, indicating the central role of public funding in driving critical innovation efforts.

Based on the above empirical findings, this study proposes the following policy recommendations to enhance the effectiveness of fiscal support and promote chokepoint technology innovation in the advanced materials sector:

First, clarify subsidy priorities and strengthen targeted support for Chokepoint technologies. The results confirm that government subsidies significantly promote innovation in high-barrier technological domains. Fiscal authorities should continue prioritizing strategic core technologies but avoid overly broad, undifferentiated support (“flood irrigation”). Instead, targeted funding should be guided by technology roadmaps and “chokepoint technology lists” that identify critical areas where China lags behind global frontiers but holds breakthrough potential. A performance-based subsidy evaluation system centered on patent quality and commercialization rate should be established to ensure that public funds are channeled into high-quality innovation processes.

Second, promote region-specific fiscal strategies to address regional disparities and strengthen local innovation ecosystems. The analysis reveals substantial regional heterogeneity in subsidy effectiveness. In the eastern region, current support levels should be maintained while improving the precision of fund allocation to high-potential firms and strategic technologies. In the central region,

efforts should focus on improving financing conditions and institutional incentives to channel resources toward capable firms. In the western region, where subsidy effects are weaker due to low innovation capacity, policies should focus on strengthening innovation absorption capacity through investment in research infrastructure, intellectual property protection, and the cultivation of regional champions. Additionally, a regional coordination mechanism should be established to facilitate the diffusion of eastern technological achievements to the central and western regions, enhancing interregional innovation synergy.

Third, promote life-cycle-neutral subsidy design to prevent inefficient, quantity-driven innovation. The analysis finds no significant difference in subsidy responsiveness across firms of different ages, suggesting broad policy applicability. However, to avoid low-quality innovation driven by application volume, fiscal policy should incorporate quality-oriented evaluation metrics—such as the share of bottleneck patents, R&D persistence, and commercialization rate—to dynamically assess firm performance. Simultaneously, firms should be encouraged to diversify their funding sources and reduce dependency on subsidies by committing to sustained investment in long-term technological goals.

Fourth, optimize innovation incentives and accountability mechanisms for state-owned enterprises (SOEs) to enhance the effective use of public funds. As SOEs demonstrate lower responsiveness to subsidies, a differentiated support mechanism is recommended, including: (1) establishing a results-based linkage between subsidies and innovation performance, emphasizing technical breakthroughs and commercialization outcomes; (2) involving third-party institutions in fund evaluation and monitoring to increase transparency and accountability; and (3) advancing SOE governance reforms to embed innovation-oriented incentives into managerial systems, encouraging proactive engagement in chokepoint technology development.

Fifth, coordinate direct subsidies with R&D-based policy instruments to strengthen systemic impact. While direct financial support plays a primary role in promoting bottleneck innovation, its indirect effect through R&D investment is less pronounced. To enhance policy synergy, it is recommended that direct subsidies be complemented by mechanisms that guide and incentivize firm-level R&D behavior. These may include establishing targeted R&D guidance funds linked to enterprise R&D expenditures, stage-based disbursement mechanisms, tax incentives, and intellectual property-backed financing tools. Together, these measures would help form a virtuous cycle of “fiscal guidance – enterprise investment – innovation output,” improving the sustainability and systemic coherence of China’s subsidy system.

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