

The Impact of Innovation Policy Mix on Innovation Capability of SMEs

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Abstract: Innovation has become an important engine for promoting rapid economic development to high-quality development in the 21st century. Small and medium-sized enterprises (SMEs) are the most important innovation subjects in China, but due to the risk characteristics and positive externalities of innovation, innovation cannot only rely on the spontaneous behavior of enterprises, but also needs the support of national innovation policies. Based on this, this paper takes the listed SMEs from 2015 to 2019 as a sample to study the impact of three types of innovation policies—supply-based innovation policies, demand-based innovation policies, and environmental-based innovation policies on the innovation activities of SMEs. Further, we will explore whether there is synergy between different types of policies from the perspective of policy tool combination. The study found that supply-based innovation policy and environmental-based innovation policy can significantly improve the innovation capability of enterprises, while demand-based innovation policy has no significant impact. In addition, supply-based policies and environmental-based policies are complementary, which can alleviate the inhibitory effect of corporate financing constraints on innovation. This conclusion still holds under different robustness tests. Finally, this paper finds that the single and combined effects of innovation policies show differences in enterprises with different characteristics. For enterprises in the eastern region, high-tech enterprises, and large-scale enterprises, the supply-based innovation policy has a stronger role in promoting innovation. For enterprises in the central and western regions and high-tech enterprises, the environmental innovation policy has a stronger incentive for innovation, and the policy synergies exist only in eastern enterprises, high-tech enterprises and small-scale enterprises.

Keywords: Enterprise innovation, Supply-based innovation policy, Demand-based innovation policy, Environment-based innovation policy, Innovation policy coordination.

1. Introduction

In recent years, Chinese awareness of innovation has been continuously improved. The "Twelfth Five-Year Plan for Small and Medium-Sized Enterprises Growth" shows that about 65% of China's invention patents, more than 75% of enterprise technological innovation, and more than 80% of new product development are provided by SMEs. As of 2019, the proportion of technology-based SMEs in the national high-tech parks reached 63%. SMEs have become the main part of innovation in China. However, SMEs often face strong financing constraints. Enterprise innovation activities are of high risk and uncertainty, and will be unsustainable without sufficient financial support. The government's innovation policy provides financial support for SMEs, and creates a healthy and orderly innovation environment, which effectively relieves the financing constraints of enterprises and has a positive impact on enterprise innovation.

Since China proposed to build an innovative country in 2006, China has successively introduced various innovation policies. As of 2020, there are more than 80 support policies for innovation of SMEs alone. According to the effect of innovation policy, Rothwell[1] divides innovation policy tools into supply-based innovation policy tools, demand-based innovation policy tools, and environment-based innovation policy tools. Among them, supply-based innovation policy tools mainly refer to financial, human and technical support; demand-based innovation policy tools mainly refer to policy tools that directly participate in market creation of demand; and environment-based innovation policy tools mainly refer to policy tools creating an innovation environment and stimulating innovation

enthusiasm. Many scholars have conducted text analysis of the promulgated policies through the content analysis method. From the perspective of the types of policies, supply-based policies and environmental support policies are dominant, accounting for more than 90%, while demand-based innovation policies that directly stimulate the innovation needs of enterprises are very scarce, accounting for less than 10%, and almost for government procurement. It is not difficult to see that there is an overflow of supply-based policies and environmental-based policies, while demand-based policies are seriously insufficient. Therefore, this paper intends to explore whether there are differences in the effects of the three types of policy tools on the innovation activities of SMEs, in order to explain the reasons for the current policy imbalance.

This paper takes the listed SMEs from 2015 to 2019 as a research sample, and analyzes the impact of supply-based, demand-based and environmental-based innovation policies on enterprise innovation activities and the synergistic effect between the three types of innovation policy. The marginal contribution of this paper has two points: First, this paper divides policies into three types: supply-based innovation policies, demand-based innovation policies, and environmental-based innovation policies, and examines the impact of the three types of innovation policies on enterprise innovation activities. Second, while previous studies on the synergies of policy innovation are few and concentrated at the regional and economic level, this paper focuses on SMEs, enriching the research in this field.

2. Theoretical Analysis and Research Assumptions

2.1. Government Innovation Policy and Enterprise Innovation

Enterprise innovation has positive externalities, and the purpose of supply-based innovation policies is to internalize externalities through subsidies to enterprises, encourage enterprises to provide innovative products with positive externalities, and thus improve social benefits. Government subsidies can motivate enterprises to innovate in two ways: one is direct influence, by supplementing the funds that enterprises lack, reducing the financing constraints faced by enterprises. The other is the signal transmission function. Through the government action of subsidies, it transmits a favorable signal to investors, making it easier for enterprises to obtain external financing, thereby reducing the risks faced by enterprises in innovation and promoting enterprise innovation. However, when the government subsidy is large enough, if the subsidy continues to increase, it will crowd out the R&D expenditure of the enterprise itself, resulting in the reduction of the enterprise's own R&D investment, resulting in a crowding out effect. Considering that SMEs generally face greater financing constraints due to low loan quotas and insufficient credit [2]. The scale of government subsidies only accounts for about 20% of the R&D costs of enterprises, which is not enough to crowd out R&D funds. This paper proposes the following hypothesis:

H1: The supply-based innovation policy can effectively promote the innovation of SMEs.

Different from the supply-based policy that directly supports the innovation of enterprises, the impact of environmental-based innovation policies on enterprises is to provide a good environment for innovation, so it also avoids the tendency of government subsidies and the "rent-seeking behavior" of enterprises. Once the environmental-based innovation policy is implemented, enterprises can have stable cash flow expectations. Tax incentives is the most widely used environmental innovation policy. It reduces the risk of enterprise innovation through measures such as super deduction and tax relief, and directly reduces the investment cost of enterprise innovation, thereby achieving the purpose of stimulating innovation. In addition, since there are a series of recognition criteria for tax incentives, this may prompt enterprises to actively cater to external requirements, thereby affecting their own innovation capabilities. This paper proposes the following hypothesis:

H2: Environmental-based innovation policy can effectively promote the innovation of SMEs.

The purpose of demand-based innovation policy is to increase innovation demand, improve innovation transformation conditions, stimulate the emergence of innovation markets or reconstruct new markets. The demand-based innovation policy directly drives the demand for enterprise innovation on the demand side, which helps to form an important and sustainable connection between innovation output and the market, and then encourages enterprises to innovate [3]. In theory, government procurement is the most important demand-based innovation policy in China. On the one hand, it injects funds into enterprise innovation, stimulates enterprise innovation vitality, and reduces innovation uncertainty [4]. On the other hand, through government procurement, the positive signal of government

recognition is transmitted to the outside world, which forms the brand effect of the enterprise and creates a better financing environment for the enterprise. Government procurement can also promote the development of domestic emerging industries through the purchase of foreign advanced technologies, thereby creating a favorable external environment for enterprises to innovate. However, the demand-based innovation policy is to alleviate the problem of market failure by directly intervening in the market. In order to play a real role, there must be a competitive market environment and the timing of intervention must be identified. Without a sound institutional framework and adequate policy experience, these interventions may also lead to new market distortions or crowding out effects that are not conducive to sustainable growth of innovation [5]. In addition, due to information asymmetry and opportunism, corrupt behaviors such as "rent-seeking" are easy to breed in the process of government procurement, resulting in inefficiency of government procurement. Compared with foreign countries, China's government procurement started later, and the procurement system still has imperfections, such as too many procurement levels, weak supervision, and lack of specific requirements for each link, which will affect the effectiveness of government procurement [6]. Based on the above analysis, this paper proposes the following opposing hypotheses:

H3_a: Demand-based innovation policies can effectively promote the innovation of SMEs.

H3_b: Demand-based innovation policies have no impact on SMEs innovation.

2.2. Synergies of Innovation Policies

The coordinated implementation of different innovation policies ensures policy continuity and mobilizes multi-sectoral cooperation. The demand side drives innovation demand, the supply side provides innovation support, and the environment side improves the innovation environment. Abundant policy tools and policy subjects make policies synergistic to some extent. In the context of the increasingly integrated government and society, the use of a single policy tool is often differentiated and time-sensitive, and it is difficult to solve all problems alone. The combination of policies must be used to achieve the best effect. When multiple support policies exist at the same time, it can increase the disposable funds of enterprises, ease the financing constraints faced by enterprises in innovation, increase their willingness to innovate, accelerate the flow of disposable funds to the R&D field of enterprises, improve the efficiency of R&D capital allocation, and ultimately improve the innovation capabilities of enterprises. This paper proposes the following hypothesis:

H4: Different types of innovation policies have certain synergies in promoting the innovation of SMEs.

3. Research Design

3.1. Model Design

This paper intends to study the impact of various innovation policies and their combinations on the innovation capabilities of SMEs. According to the above theoretical analysis, the empirical model is constructed as follows:

$$patent_{it} = \alpha_0 + \alpha policy_{it-1} + \beta control_{it-1} + year_t + industry_j + \epsilon_{it}$$

In the above model, patent represents the innovation capability of enterprise, due to the lag in the impact of policies

on enterprise innovation activities, this paper adopts the innovation output of the second year as the explained variable. policy refers to innovation policy, where Supply represents supply-based innovation policy, measured by the government subsidies received. Env represents the environmental-based innovation policy, which is measured by the deduction of the R&D expenses received by the enterprise. Demand represents the demand-based innovation policy. If the enterprise has government procurement, Demand is 1, otherwise Demand is 0. Control represents a series of control variables. This paper controls the time fixed effect and industry fixed effect, which are represented by $year_t$ and $industry_j$, ϵ_{it} represents the random error term.

In order to further explore the synergy between supply-based innovation policies, demand-based innovation policies, and environmental-based innovation policies, the cross terms between policies are introduced in sequence on the basis of the above models: $Supply_{it} * Env_{it}$, $Supply_{it} * Demand_{it}$, $Env_{it} * Demand_{it}$. If the coefficient of the cross term is significantly positive, it indicates that different types of policies are complementary; if the coefficient of the cross term is significantly negative, it indicates that different types of policies are mutually exclusive.

3.2. Variable Description

(1) Explained variable: innovation capability includes innovation input and innovation output, among which innovation output is generally measured by patent application, authorization and new product output value [7]. The number of patent applications of an enterprise directly reflects its

innovation output, which can better reflect the innovation capability of the enterprise. SMEs are an important innovation subject, so this paper selects the total number of patent applications of A-share listed SMEs as the explained variable.

(2) Core explanatory variables: The core explanatory variables of this paper are three types of innovation policy tools. Supply-based policy tools mainly include personnel training, financial support, scientific and technological research and development infrastructure construction, and public services. This paper selects the government subsidy obtained by enterprises as a measure of supply-based innovation policy tools. Demand-based policy tools include government procurement, technology outsourcing, trade controls, and overseas agency management. This paper selects government procurement as a measure of demand-based innovation policy tools. Environmental-based policy tools include tax incentives, laws and regulations, and financial support. This paper selects the deduction of R&D expenses as a measure of environmental innovation policy tools.

(3) Control variables: In order to reduce the estimation error caused by omitted variables, this paper introduces other control variables that may affect the innovation ability of enterprises. Drawing on the practice of previous literature, in order to control the influence of enterprise-level factors on the regression results, the control variables introduced in this paper include enterprise age, asset-liability ratio, return on assets, and the proportion of liquid assets, the proportion of fixed assets, corporate growth, equity concentration. The detailed variable description is shown in Table 1:

Table 1. Variable description

variable type	Variable indicator	variable	Variable calculation instructions
Explained variable	Total number of patent applications	patent	Add 1 to the total number of patent applications of the enterprise and take the logarithm
core explanatory variables	Supply type - government subsidy	Supply	Government subsidies received by enterprises, take the logarithm
	Demand type - government procurement	Demand	Whether the enterprise has government procurement, take 1 if yes, otherwise take 0
	Environmental type - additional deduction for R&D expenses	Env	Additional deductions for corporate R&D expenses, take the logarithm
control variables	Age of enterprise	age	Year of the current year - the year the company was established, take the logarithm
	asset-liability ratio	Lev	Total liabilities/Total corporate assets
	return on assets	ROA	Net Profit/Total Average Assets
	the proportion of liquid assets	Liquid	Liquid Assets/Total Assets
	the proportion of fixed assets	Tangible	Fixed Assets/Total Assets
	corporate growth	Growth	operating income growth rate
	equity concentration	Top1	Shareholding ratio of the company's largest shareholder

3.3. Data Source and Processing

This paper selects A-share listed SMEs from 2015 to 2019 as the research sample, in which all corporate financial data comes from the CSMAR and the company's annual report, patent application data from CNRDS, government procurement data comes from China Government Procurement Network. In order to ensure the integrity of the data and the accuracy and convincing of the empirical results, this paper screened out the SMEs listed before 2015, and exclude ST, *ST and listed companies with missing or abnormal financial data. The continuous variables are truncated by 1% above and below to avoid the influence of

extreme values. A total of 2299 observations were obtained.

4. Empirical Results Analysis

4.1. Descriptive Statistics

The variable descriptive statistics are shown in Table 2. The average number of patent applications is 3.209, and the minimum and maximum values are 0 and 8.185, indicating that there is a large gap in the level of innovation among different enterprises. From the perspective of innovation policy tools, there is a large difference between the maximum and minimum value of government subsidies and R&D

expenses plus deduction, indicating that there are significant differences in the implementation of supply-based and environment-based innovation policies among enterprises. The median of government procurement is 0, which indicates

that the current situation of SMEs' procurement in China is not optimistic, and many enterprises have not yet participated in the market competition of government procurement.

Table 2. Descriptive Statistics of Main Variables

variable	observations	average	standard deviation.	minimum	maximum	median
patent	2299	3.209	1.495	0	8.185	3.295
Supply	2299	16.447	1.349	7.616	21.568	16.389
Env	2299	15.094	1.385	6.225	19.978	15.148
Demand	2299	0.181	0.385	0	1	0
age	2299	2.956	0.246	2.485	3.989	2.944
Lev	2299	0.372	0.173	0.009	0.916	0.361
ROA	2299	0.047	0.068	-0.602	0.455	0.044
Liquid	2299	0.569	0.153	0.130	0.982	0.572
Tangible	2299	0.215	0.125	0.001	0.672	0.198
Growth	2299	0.275	2.214	-0.801	84.992	0.134
Top1	2299	0.320	0.140	0.041	0.850	0.301

4.2. The Influence of Innovation Policy on the Innovation Capability of Enterprise

Table 3 shows the impact of supply-based innovation policy, demand-based innovation policy, and environmental-based innovation policy on enterprise innovation output. The regression controls the year fixed effect and the industry fixed effect, and the enterprise clustering effect is used to correct the standard error in the regression model.

Analysis (1) shows that the coefficient of supply-based policy tools is significantly positive, indicating that supply-based innovation policies have a significant positive effect on enterprise innovation output. Analysis (2) shows that the

coefficient of environmental-based policy tools is significantly positive, indicating that environmental-based innovation policies have a significant positive effect on enterprise innovation output. Analysis (3) shows that the demand-based policy tool coefficient is not significant, indicating that the demand-based innovation policy has little impact on the innovation output of enterprises. In the analysis column (4), the coefficient of supply-based policy tools is 0.233, and the coefficient of environmental-based policy tools is 0.278, both of which are significant at the 1% level, indicating that the impact of environmental-based innovation policies is greater. H1, H2, H3 are verified.

Table 3. Basic regression results

	patent						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Supply	0.324*** (9.830)			0.233*** (6.818)	0.226*** (6.244)	0.234*** (6.719)	-0.370 (-1.558)
Env		0.353*** (9.292)		0.278*** (7.461)	0.277*** (7.399)	0.283*** (7.918)	-0.372 (-1.539)
Demand			0.110 (1.005)	-0.053 (-0.525)	-0.855 (-0.849)	0.390 (0.374)	-0.059 (-0.588)
Supply*Demand					0.048 (0.799)		
Env*Demand						-0.029 (-0.422)	
Supply*Env							0.039*** (2.645)
age	-0.303 (-1.635)	-0.366** (-2.010)	-0.379* (-1.946)	-0.314* (-1.747)	-0.316* (-1.759)	-0.313* (-1.743)	-0.301* (-1.682)
Lev	1.039*** (3.779)	1.282*** (4.666)	2.013*** (6.641)	0.736*** (2.783)	0.743*** (2.816)	0.730*** (2.758)	0.732*** (2.760)
ROA	3.263*** (5.452)	3.067*** (4.964)	4.949*** (7.327)	2.253*** (3.847)	2.230*** (3.787)	2.258*** (3.845)	2.209*** (3.775)
Liquid	0.513 (1.346)	0.332 (0.812)	0.335 (0.823)	0.459 (1.190)	0.451 (1.166)	0.466 (1.201)	0.421 (1.095)
Tangible	-0.183 (-0.411)	-0.020 (-0.044)	-0.315 (-0.658)	0.013 (0.029)	0.018 (0.040)	0.010 (0.022)	0.015 (0.033)
Growth	0.015* (1.712)	0.023** (2.252)	0.026** (2.117)	0.016* (1.937)	0.016* (1.947)	0.016* (1.930)	0.014** (1.975)
Top1	0.064 (0.203)	0.095 (0.308)	0.210 (0.607)	0.014 (0.048)	0.018 (0.061)	0.010 (0.033)	-0.006 (-0.022)
Constant	-2.034** (-2.289)	-1.880** (-2.267)	3.134*** (4.413)	-4.534*** (-5.111)	-4.396*** (-4.746)	-4.623*** (-5.045)	5.374 (1.391)
Year	yes	yes	yes	yes	yes	yes	yes
Industry	yes	yes	yes	yes	yes	yes	yes
Observations	2,289	2,289	2,289	2,289	2,289	2,289	2,289
R-squared	0.382	0.396	0.320	0.425	0.425	0.425	0.429

Note: t values are in parentheses, * means $p < 0.10$, ** means $p < 0.05$, *** means $p < 0.01$. The table below is the same.

4.3. Analysis of the Synergistic Effect of Innovation Policies

Based on the results of the basic regression, the intersection of supply-based and demand-based innovation policies, the intersection of environmental-based and demand-based innovation policies, and the intersection of supply-based and environment-based innovation policies are introduced in turn, and the synergy effect between different types of innovation policies is examined. The regression results are shown in the last three columns of Table 3. Only the intersection of supply-based and environmental-based innovation policies has a significant positive impact on innovation output. The interaction terms between demand-based innovation policy and other policies are not significant. H4 is partially validated. The reasons for the insignificant impact of demand-based innovation policies on enterprise innovation and the insignificant synergies with other policies, on the one hand, the current government procurement tends to favor products that already exist in the market, so there is insufficient incentive for the research and development of new products, on the other hand, government procurement has problems such as supervision and implementation, and it is difficult to avoid the emergence of rent-seeking problems, which in turn affects the incentive effect of policies on enterprise innovation. The combination of supply-based and environment-based innovation policies promotes enterprise innovation with both ex-ante subsidies and ex-post subsidies.

4.4. Mechanism Test Based on Financing Constraints

SMEs generally have the problem of insufficient funds, which is also an important reason for restricting their innovation. The supply-based innovation policy and the environment-based policy reduce the innovation cost of enterprises in two ways: pre-subsidy and post-subsidy. Existing literature has studied the relationship between single policy and firm innovation from the perspective of financing constraints. In order to further test whether the synergistic effect of the government's supply-based innovation policy and environmental-based innovation policy alleviates the financing constraints of enterprises and promotes enterprise innovation. This paper draws on the practice of Hadlock and Pierce [8] to construct the SA financing constraint index: $-0.737 \times \text{Size} + 0.043 \times \text{Size}^2 - 0.04 \times \text{Age}$, among them, Size is the logarithmic value of assets in millions, and Age is the age of the enterprise. The SA calculated by this method is a negative value, which is taken as an absolute value in this paper. The larger the absolute value, the greater the financing constraints imposed on the enterprise. The test model is as follows:

$$\text{Innovation}_{it+1} = \alpha_0 + \alpha_1 \text{Supply}_{it} + \alpha_2 \text{Env}_{it} + \alpha_3 \text{Supply} \times \text{Env} + \beta_1 \text{Control}_{it} + \text{Year}_t + \text{Industry}_j + \epsilon_{it} \quad (1)$$

$$\text{SA}_{it+1} = \gamma_0 + \gamma_1 \text{Supply}_{it} + \gamma_2 \text{Env}_{it} + \gamma_3 \text{Supply} \times \text{Env} + \beta_2 \text{Control}_{it} + \text{Year}_t + \text{Industry}_j + \delta_{it} \quad (2)$$

$$\text{Innovation}_{it+1} = \phi_0 + \phi_1 \text{SA}_{it+1} + \phi_2 \text{Supply}_{it} + \phi_3 \text{Env}_{it} + \phi_4 \text{Supply} \times \text{Env} + \beta_2 \text{Control}_{it} + \text{Year}_t + \text{Industry}_j + \epsilon_{it} \quad (3)$$

The models (a), (b), and (c) are regressed in turn, and the results are shown in Table 4: In column (1), the Supply*Env coefficient of the interaction term of government subsidies and R&D expenses super deduction is 0.04 and is significant, indicating that there is a synergy between supply-based innovation policies and environmental-based innovation policies, which can significantly promote the innovation output of enterprises. In the regression results of column (2), the Supply*Env coefficient is significantly negative, indicating that the synergy of supply-based policies and environmental-based policies can reduce the financing constraints faced by enterprises. After adding the mediating variable SA in column (3), the size of the Supply*Env coefficient becomes 0.036, indicating that the mediating effect of financing constraints exists. To a certain extent, the synergy of supply-based policies and environmental-based policies promotes the innovation output of enterprises by easing financing constraints.

Table 4. Policy Synergy Mechanism Test Based on Financing Constraints

	Financing Constraints		
	patent (1)	SA (2)	patent (3)
SA			-0.367* (-1.802)
Supply	-0.382 (-1.629)	0.173*** (3.266)	-0.318 (-1.355)
Env	-0.387 (-1.621)	0.194*** (3.477)	-0.315 (-1.310)
Supply*Env	0.040*** (2.749)	-0.012*** (-3.432)	0.036** (2.440)
Lev	0.737*** (2.788)	-0.010 (-0.176)	0.734*** (2.764)
ROA	2.190*** (3.713)	0.113 (1.028)	2.232*** (3.833)
Liquid	0.395 (1.023)	0.024 (0.330)	0.404 (1.044)
Tangible	-0.047 (-0.105)	0.143 (1.489)	0.005 (0.012)
Growth	0.015** (2.201)	-0.004*** (-4.884)	0.014* (1.962)
Top1	0.016 (0.053)	-0.027 (-0.349)	0.006 (0.019)
Constant	4.700 (1.236)	1.014 (1.171)	5.072 (1.369)
Observations	2,289	2,289	2,289
R-squared	0.426	0.116	0.429
Year	yes	yes	yes
Industry	yes	yes	yes

5. Conclusions and Policy Recommendations

This paper takes the listed SMEs in China from 2015 to 2019 as a research sample, discusses the impact of three types of innovation policies on the innovation capability of enterprises, and further explores whether there is a synergistic effect between the three types of innovation policies. The main conclusions of this paper are: (1) The supply-based innovation policy and the environment-based innovation policy have a significant positive effect on the innovation activities of SMEs. On the whole, the effect of environmental-based innovation policy is better than that of supply-based innovation policy. The impact of demand-based innovation policies is not significant. The main reason is that China has not yet established an effective competitive government

procurement system. Provincial governments prefer to purchase enterprises in their own provinces. In addition, the rent-seeking behavior of enterprises makes government procurement ineffective. (2) Supply-based innovation policies and environmental-based innovation policies are complementary, have a synergistic effect on the innovation of SMEs, and can alleviate the inhibitory effect of corporate financing constraints on innovation.

The research conclusions of this paper have certain reference significance for the formulation of national innovation policy. First, current demand-based innovation policies in China are lacking and single, with the total policy accounting for less than 10%, and the impact of demand-based innovation policies on enterprise innovation is not significant. On the one hand, China needs to establish a practical and effective procurement system, form a nationwide fair competition, and improve open and transparent procurement processes and procurement standards. On the other hand, the government should enrich the demand-based innovation policy, not only rely on government procurement, but also reduce the risk loss of its own research and development by promoting enterprises to outsource technology research and development to schools and scientific research institutions, and carry out the combination of production, education and research to achieve the cluster effect of innovation. Second, when the government formulates policies, it should strengthen the combination of supply-based policies and environmental-based policies, give full play to the synergistic effect between the two, supervise the effect of policy implementation, and dynamically adjust the policy combination. Third, according to the innovation status of different regions, different industries and different enterprises, the formulation of China's innovation policies should be tailored to local conditions and cannot be

generalized. The government should focus on building a multi-level and systematic innovation support system for SMEs including countries, regions, industries and enterprises.

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