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Has the artificial intelligence innovation and development pilot zone improved regional entrepreneurial activity?

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Abstract. This study systematically examines the impact and mechanism of establishing artificial intelligence innovation development zones on regional entrepreneurial activity. Theoretically, the establishment of such zones significantly promotes local entrepreneurship through three pathways: stimulating digital economy vitality, driving offline experiential economic development, and enhancing regional R&D efficiency. These mechanisms expand market potential and reduce costs for entrepreneurial activities from both supply and demand sides, thereby increasing entrepreneurial dynamism. Empirically, this research uses panel data from 285 prefecture-level cities and above in China between 2009 and 2023, treating the designation of national new-generation artificial intelligence innovation development zones as a quasi-natural experiment. This study measures urban entrepreneurial activity as the number of registered enterprises per ten thousand residents, employing a multi-period difference-in-differences approach. Results show that the promotion effect of AI innovation zones on entrepreneurship exhibits significant regional heterogeneity—policy impacts are stronger in cities with underdeveloped factor markets and well-developed transportation infrastructure. At the city level, various foundational factors differentially affect entrepreneurial activity: higher per capita economic development, internet penetration, and education levels positively boost entrepreneurship, while excessive concentration of financial and fiscal resources exerts a certain inhibitory effect. Furthermore, the establishment of AI innovation zones not only enhances local entrepreneurial activity but also generates spillovers to other regions within the same province. Based on these findings, targeted policy recommendations are proposed to better leverage the demonstration and leadership role of these zones and sustainably unlock regional entrepreneurial vitality.

Keywords: National New Generation Artificial Intelligence Innovation and Development Pilot Zones, entrepreneurial activity level, multi-period DID model, policy impact

1. Introduction

Entrepreneurial vitality is a key indicator of regional economic dynamism and innovation capacity, bearing directly on the quality of national and regional development as well as long-term competitiveness [1]. As China enters a critical stage of high-quality economic development and industrial transformation, stimulating regional entrepreneurial activity has become essential for fostering new drivers of economic growth, expanding employment, and improving resource allocation. Against the backdrop of a global economic slowdown, newly established firms generally face low survival rates and intense homogeneous competition [2]. At the same time, distortions in factor allocation caused by mounting pressures on local economic growth have further constrained the regional entrepreneurial environment. Meanwhile, the latest wave of technological revolution has witnessed rapid breakthroughs and widespread adoption of generative Artificial Intelligence (AI), which has emerged as a core engine of economic and social development. Recognizing its strategic importance, the Chinese government has placed AI at the center of its national innovation agenda. In 2017, the State Council issued the *New Generation Artificial Intelligence Development Plan*, elevating AI development to the national strategic level. In 2019, the Ministry of Science and Technology launched the National New Generation Artificial Intelligence Innovation and Development Pilot Zones, initiating pilot programs in Beijing, Shanghai, Shenzhen, Hangzhou, and other cities and regions. These pilot zones aim to establish demonstration hubs for AI-driven industrial integration through policy experimentation, the concentration of innovation resources, and the opening of application scenarios. Generative AI technologies can substantially lower barriers to entrepreneurship and have penetrated a wide range of business operations and consumer activities [3]. In addition, the establishment of AI pilot zones can reduce institutional transaction costs through policy experimentation, optimize the allocation of innovation resources, create a more favorable business environment, and thereby provide strong momentum for enhancing regional entrepreneurial vitality. Existing studies have confirmed that AI development positively promotes regional entrepreneurial activity by alleviating financing constraints and increasing returns on capital, thereby indirectly stimulating entrepreneurship [4]. Likewise, pilot-zone policies have also been shown to encourage entrepreneurial activities [5].

Although previous studies generally acknowledge the positive effects of AI and related policies on entrepreneurship, several important research gaps remain. As a General Purpose Technology (GPT), artificial intelligence is characterized by strong platform-based and networked features. The productivity gains generated by intelligent technologies, particularly large language models, possess nationwide spillover effects that are not geographically confined to pilot areas. However, few studies have explicitly distinguished between the nationwide benefits of general AI technologies and the policy-specific effects associated with AI pilot zones, leaving it unclear whether localized policy support and resource agglomeration generate additional improvements in regional entrepreneurial vitality. Moreover, current AI applications exhibit considerable structural imbalance. Most applications remain concentrated on the demand side and have yet to achieve deep integration into manufacturing, agriculture, and traditional service industries. Furthermore, major technological revolutions are often accompanied by a Solow Paradox-type lag effect, whereby substantial delays exist between technological investment and measurable improvements in total factor productivity [6]. Whether AI can rapidly empower all industries and comprehensively stimulate entrepreneurial activity across sectors has yet to be adequately verified through empirical evidence.

To address these research gaps, this study investigates three central questions. First, can the National New Generation Artificial Intelligence Innovation and Development Pilot Zone policy effectively enhance regional entrepreneurial vitality, and through what mechanisms does this effect operate? Second, after controlling for the nationwide benefits of general AI technologies, do the location-specific policies implemented within AI pilot zones exert an independent promotional effect on entrepreneurial activity? Third, can the pilot-zone policy mitigate the structural imbalance in AI applications and reduce the lag in technological transformation, thereby promoting simultaneous growth in entrepreneurial vitality across industries? Using the National New Generation Artificial Intelligence Innovation and Development Pilot Zones as a quasi-natural experiment, this study systematically examines these questions. In doing so, it clarifies the independent role of place-based AI policies in the context of platform-based technological diffusion and provides empirical evidence for evaluating the extent to which AI technologies have penetrated and empowered industries as a whole. The findings therefore carry both theoretical significance and practical policy implications.

2. Literature review

Entrepreneurial vitality reflects the intensity of entrepreneurial activities within a region and exhibits multidimensional characteristics in both conceptualization and measurement [7]. In a narrow sense, it is commonly measured by the number of newly established firms and self-employed businesses within a given period, emphasizing the frequency of entrepreneurial entry. In a broader sense, it encompasses the entire entrepreneurial lifecycle—from business establishment and operation to growth—thereby highlighting the sustainability of entrepreneurial activities. This study adopts the narrow definition and uses newly established business entities as the empirical measure of entrepreneurial vitality. Existing literature generally classifies the determinants of entrepreneurial vitality into three categories: human capital, the institutional and business environment, and technological innovation together with digital infrastructure. From the perspective of human capital, entrepreneurs' individual endowments and regional talent agglomeration directly influence entrepreneurial decisions. Personal characteristics such as gender, risk preference, and household wealth shape entrepreneurial intentions. Previous studies have documented significant gender differences in both entrepreneurial participation and entrepreneurial intention [8], with these differences varying across regions at different stages of economic development [9]. At the same time, talent agglomeration generates knowledge spillovers that reduce the costs associated with entrepreneurial experimentation [10]. Conversely, insufficient human capital and household financial constraints significantly suppress entrepreneurial activity, with these constraints exerting stronger effects in less-developed regions [11]. From the perspective of institutions and the business environment, efficient public administration, streamlined regulation, and supportive fiscal and financial policies are conducive to entrepreneurial development [12], whereas cumbersome administrative approval procedures [13], financing constraints, and inadequate supporting services impede entrepreneurial activities [14]. Regarding technological innovation and digital infrastructure, digital technologies [15], industrial agglomeration [16], and new infrastructure development all contribute to entrepreneurship by lowering entry barriers and enhancing productivity, whereas deficiencies in both digital and physical infrastructure increase startup costs and limit entrepreneurial opportunities. Artificial intelligence, in particular, improves resource allocation, expands market boundaries, and reduces entrepreneurial costs, making it an important driver of regional entrepreneurial vitality. Yin Zhichao further finds that new digital infrastructure, including broadband networks and mobile payment systems, exerts a stronger promotional effect on entrepreneurial activities than traditional physical infrastructure, with particularly pronounced benefits in less-developed regions.

At the level of AI pilot policies, artificial intelligence facilitates labor mobility across industries, accelerates industrial transformation and upgrading, and creates entirely new entrepreneurial opportunities, thereby responding to the realities of China's diminishing demographic dividend [17]. AI also optimizes the processes of social reproduction, promotes high-quality economic development, and narrows regional development disparities through technological diffusion [18]. By concentrating innovation resources and entrepreneurial factors through industrial agglomeration, AI pilot zones further stimulate regional entrepreneurial vitality [19]. With respect to digital finance pilot programs, digital finance possesses an inclusive character that alleviates financial exclusion in remote areas [20] and eases financing constraints faced by start-up firms. Under the national strategy of promoting mass entrepreneurship and innovation, its enabling effects exhibit threshold characteristics that further strengthen economic development [21].

Moreover, digital finance generates significant cross-regional spatial spillover effects [22], although the magnitude of these spillovers differs across China's eastern, central, and western regions [23]. Regarding green finance pilot policies, green finance directs capital toward energy-saving and environmentally friendly industries, expands opportunities for green entrepreneurship, and, when combined with environmental regulation, facilitates low-carbon industrial transformation while reducing the risks associated with green entrepreneurship. These policy effects are particularly pronounced in the central and western regions of China [24].

As the core driving force behind the latest technological revolution, artificial intelligence has attracted extensive scholarly attention for its relationship with entrepreneurial activities. Existing studies have thoroughly examined the mechanisms linking AI and entrepreneurship [25], arguing that AI supports entrepreneurial activities through its technological advantages and creates new pathways for entrepreneurial development. In practice, AI empowers entrepreneurship throughout the entire entrepreneurial process. It helps entrepreneurs identify latent market opportunities, improves the efficiency of resource allocation, and ultimately enhances regional entrepreneurial vitality [26]. Leveraging big data analytics, AI uncovers hidden market demand and anticipates shifts in industrial consumption patterns, thereby reducing entrepreneurial uncertainty in a manner consistent with Schumpeter's theory of creative destruction [27]. From the perspective of resource integration, start-up firms typically face shortages of resources and information. AI establishes intelligent matching systems that connect entrepreneurs with capital providers, supply chains, and skilled talent, thereby lowering both financing costs and the costs of resource integration.

In summary, the existing literature has generated substantial theoretical insights into the determinants of entrepreneurial vitality, the economic effects of technology-oriented pilot policies, and the role of artificial intelligence in promoting entrepreneurship, thereby providing an important foundation for this study. Nevertheless, three major limitations remain. First, although previous studies have broadly examined the relationship between AI technologies and entrepreneurship, few have employed the National New Generation Artificial Intelligence Innovation and Development Pilot Zones as a quasi-natural experiment to quantitatively evaluate the policy's impact on urban entrepreneurial vitality. Consequently, empirical evidence from a policy-oriented perspective remains limited. Second, studies on digital finance, green finance, and artificial intelligence pilot programs have generally examined each policy independently, focusing primarily on their effects on macroeconomic performance and industrial transformation. Even when entrepreneurial outcomes are discussed, the transmission mechanisms have rarely been systematically analyzed within a unified analytical framework capable of capturing potential policy synergies. Third, research on AI and entrepreneurship has largely focused on the micro-level enabling effects of technology, with insufficient causal identification from the perspective of policy experimentation. Moreover, existing studies have inadequately examined urban heterogeneity and detailed transmission mechanisms, making it difficult to fully explain how AI pilot zones influence regional entrepreneurial development.

The marginal contributions of this study are threefold. First, it contributes to the literature by extending research on the relationship between artificial intelligence and entrepreneurial vitality. While existing studies on this topic remain limited, empirical evidence evaluating the effects of the National New Generation Artificial Intelligence Innovation and Development Pilot Zone policy on regional entrepreneurial vitality is particularly scarce. By treating the pilot-zone policy as a quasi-natural experiment, this study systematically evaluates its impact on entrepreneurial vitality and broadens the analytical perspective of the existing literature. Second, this study advances mechanism analysis. Previous research has typically examined policy effects on economic development from either the supply side—focusing on policies that affect production—or the demand side—emphasizing policies that stimulate consumption. Moving beyond this dichotomy, this study simultaneously investigates improvements in regional research and development efficiency on the supply side, together with the expansion of the digital economy and the development of the offline experience economy on the demand side, thereby providing a more comprehensive explanation of the mechanisms through which the pilot-zone policy promotes regional entrepreneurial vitality. Third, this study expands the scope of policy evaluation by moving beyond local policy effects to examine spatial interactions. After confirming the policy's impact on local entrepreneurial vitality, it further investigates three distinct forms of spatial spillover—the leading effect, the siphoning effect, and the diffusion effect—thereby enriching the literature on the spatial spillover effects of place-based innovation policies.

3. Research hypotheses

The relationship between artificial intelligence and regional entrepreneurship remains a subject of debate in the existing literature, with studies presenting both positive and negative perspectives. Nevertheless, the prevailing evidence suggests that AI has an overall positive effect on entrepreneurial activity. As a core driver of technological transformation, the deployment of AI technologies and the establishment of AI pilot zones can enhance the urban entrepreneurial ecosystem through multiple channels, thereby stimulating regional entrepreneurial vitality. At the industrial level, AI breaks down traditional industry boundaries, creates new business models, and expands entrepreneurial opportunities. At the firm level, AI reduces information asymmetry, lowers entrepreneurial costs, and mitigates business risks. At the institutional level, supporting policies and infrastructure improvements associated with AI pilot zones optimize the business environment and reduce institutional transaction costs. More specifically, AI pilot zones promote entrepreneurial vitality primarily through two mechanisms: the government incentive effect and the entrepreneurial climate spillover effect.

The first mechanism is the government incentive effect. As designated National New Generation Artificial Intelligence Innovation and Development Pilot Zones, pilot cities typically demonstrate strong policy initiative and implementation capacity in advancing AI-related development. This proactive approach is primarily reflected in the extensive use of policy instruments to attract AI enterprises to invest and establish businesses locally. Such government activism is driven by the dual incentives of political advancement and economic development under China's institutional framework [28]. The first incentive arises from political promotion. Within a performance evaluation system that places considerable emphasis on economic growth and innovation, local government officials are motivated to achieve visible policy outcomes within a relatively short period. Consequently, they employ measures such as fiscal subsidies, tax incentives, and infrastructure investment to attract AI enterprises and rapidly establish the city's reputation as a successful AI innovation pilot zone. Notably, these political incentives are often sufficiently strong that local governments may willingly accept short-term declines in fiscal revenue and substantial increases in public expenditure in exchange for industrial agglomeration. Under such circumstances, political performance frequently takes precedence over immediate economic returns. The second incentive is economic in nature. Local governments seek to attract high value-added AI enterprises in order to stimulate employment growth and facilitate industrial upgrading. At the same time, designation as a national pilot zone provides local governments with opportunities to negotiate greater regulatory flexibility from the central government in related policy areas, thereby expanding their autonomy in pursuing regional economic development. More importantly, many of the preferential policies introduced to attract AI enterprises—such as improvements in the business environment and investments in public infrastructure—are not exclusive to the AI industry. Instead, they generate substantial spillover benefits for entrepreneurs across a wide range of sectors. By fundamentally reducing the overall cost of entrepreneurship, these inclusive policy measures directly enhance regional entrepreneurial vitality.

The second mechanism is the entrepreneurial climate spillover effect. AI enterprises are representative high-technology firms that are typically founded by teams possessing substantial human capital and strong innovative capabilities. As dynamic market participants, they not only introduce advanced technologies and capital into pilot regions but also reshape the surrounding entrepreneurial environment. On the one hand, the success of AI enterprises and their promising financial returns create powerful demonstration effects that encourage potential entrepreneurs to pursue entrepreneurial opportunities. On the other hand, the new ideas, business models, and management practices introduced through their day-to-day operations diffuse rapidly throughout the region via labor mobility, informal knowledge exchange, and commercial collaboration [29]. Consequently, the agglomeration of AI enterprises represents more than an expansion of industrial scale; it also serves as a catalyst for a vibrant regional entrepreneurial culture. Through the diffusion of entrepreneurial norms, innovative mindsets, and demonstration effects, AI enterprise clusters stimulate entrepreneurial activities across industries and significantly enhance regional entrepreneurial vitality.

Hypothesis 1: The establishment of National New Generation Artificial Intelligence Innovation and Development Pilot Zones enhances regional entrepreneurial vitality.

The establishment of National New Generation Artificial Intelligence Innovation and Development Pilot Zones represents a strategic policy initiative deployed by the central government, with the primary objective of promoting regional development through institutional empowerment and demonstration effects. First, the pilot zones generate strong policy demonstration effects that inject new momentum into regional economic development. Compared with non-pilot regions, pilot zones enjoy preferential policy support, including targeted fiscal subsidies, tax incentives, and greater access to open data resources. These policy advantages send positive signals to the market, increasing both the attention paid to and participation in the digital economy by market participants. Through this demonstration effect, expectations regarding returns in the digital economy improve substantially, encouraging broader adoption of digital technologies and accelerating the incubation of new digital business models, thereby directly enhancing the vitality of the regional digital economy.

As one of the most dynamic sectors within the digital economy, the e-commerce industry is among the first to achieve large-scale expansion and business model innovation. The continued growth of the digital economy significantly increases demand for e-commerce and its upstream and downstream industrial chains. This expanding derived demand not only creates growth opportunities for existing firms but also generates numerous low-entry-barrier, high-potential entrepreneurial opportunities in specialized market segments, providing strong demand-side support for regional entrepreneurship. On the one hand, the expansion of e-commerce and related industries reduces market uncertainty for entrepreneurs, allowing start-ups to connect more efficiently with market demand through a mature digital ecosystem and thereby increasing the likelihood of entrepreneurial success. On the other hand, the extension and specialization of industrial value chains create a wide range of niche entrepreneurial opportunities, encouraging greater specialization and differentiation among new ventures while enriching the diversity of entrepreneurial entities and business models within the region. Meanwhile, the demonstration effect of the pilot-zone policy also attracts key entrepreneurial resources—including capital and skilled talent—to the digital economy, reinforcing the expansion of demand and generating a virtuous cycle that further stimulates regional entrepreneurial vitality.

Hypothesis 2: The establishment of National New Generation Artificial Intelligence Innovation and Development Pilot Zones enhances regional entrepreneurial vitality by stimulating the digital economy through policy demonstration effects.

The establishment of AI pilot zones provides comprehensive policy support, industrial infrastructure, and open application scenarios for the research, testing, and commercialization of AI-based products. Consequently, innovative AI products and devices—including service robots, intelligent interactive terminals, and immersive smart experience equipment—are commercialized and launched in pilot zones ahead of other regions. Owing to their technological novelty, distinctive user experiences, and disruptive functionality, these products transform the traditional product-centered consumption model and give rise to a new form of demand centered on experiential consumption. Consumers increasingly shift from purchasing physical products to actively engaging with intelligent scenarios, interactive experiences, and AI-enabled services. This structural transformation in consumer demand directly contributes to both the expansion and upgrading of total retail sales of consumer goods, creating new consumption growth driven by offline experiential activities and substantially promoting the development of the offline experience economy.

The emergence of the offline experience economy, reflected primarily in the growth of total retail sales of consumer goods, promotes entrepreneurial vitality through two principal channels: demand creation and cost reduction. First, the market enthusiasm generated by the launch of AI products creates entirely new consumer markets. Entrepreneurial opportunities rapidly emerge in specialized areas such as intelligent experience store operations, robotic application services, smart scenario design, and customized after-sales services for AI products. These opportunities provide entrepreneurs with clear market prospects and effectively stimulate entrepreneurial intentions among individuals and small businesses. Second, the expansion of the offline experience economy drives the extension and specialization of upstream and downstream industries—including retail, services, and technical support—forming an integrated entrepreneurial ecosystem encompassing AI product development, offline scenario construction, and consumer service provision. This integrated ecosystem substantially lowers both technological and market entry barriers to entrepreneurship. Moreover, sustained growth in retail sales reflects the increasing vitality and potential of the regional consumer market, strengthening the confidence of entrepreneurs and investors alike, reducing market uncertainty during the early stages of entrepreneurship, and attracting key entrepreneurial resources such as talent and capital to the pilot zones, thereby further improving the entrepreneurial environment.

Hypothesis 3: The establishment of National New Generation Artificial Intelligence Innovation and Development Pilot Zones enhances regional entrepreneurial vitality by promoting the development of the offline experience economy.

The approval of National New Generation Artificial Intelligence Innovation and Development Pilot Zones represents an important national policy initiative aimed at strengthening the AI industry and enhancing regional innovation capacity. From the supply-side perspective, the policy provides critical support for improving regional innovation systems and optimizing the allocation of production factors. Leveraging the institutional advantages of policy experimentation, pilot zones actively promote the construction of new digital infrastructure, including computing centers, open data platforms, industrial public service platforms, and intelligent R&D facilities. At the same time, through targeted policy support, innovation ecosystem development, and talent attraction programs, pilot zones facilitate the agglomeration of AI enterprises, research institutions, and innovation-oriented teams. The combined effects of improved infrastructure and concentrated innovation resources lead to more efficient allocation of R&D resources, continuous optimization of technological innovation processes, and enhanced commercialization of research outcomes, thereby systematically improving regional R&D efficiency. Higher R&D efficiency directly affects the supply of productive resources available to entrepreneurs. By improving access to technology, reducing the costs of R&D experimentation, shortening the commercialization cycle of innovation, and increasing the efficiency of factor utilization, enhanced R&D efficiency lowers both the financial and time costs associated with production, innovation, and business operations, thereby substantially reducing the overall cost of entrepreneurship from the supply side.

Lower entrepreneurial costs provide a solid foundation and powerful incentive for expanding regional entrepreneurial activity. On the one hand, reduced entry barriers and operating costs alleviate the financial, resource, and technological constraints typically faced by start-up firms, significantly reducing entrepreneurial risks and survival pressures while encouraging more potential entrepreneurs to enter the market and expanding the scale of entrepreneurial activity. On the other hand, the cost advantages and technological spillovers generated by an efficient R&D system attract essential entrepreneurial resources—including talent, capital, and technology—to the pilot zones, thereby improving the entrepreneurial ecosystem and increasing the growth potential and success rate of start-up firms. Furthermore, a low-cost and highly efficient innovation environment facilitates the continuous emergence of new technologies, business models, and industrial formats, creating broader entrepreneurial opportunities and more diversified development pathways. Through this virtuous cycle of supply-side optimization, cost reduction, and entrepreneurial expansion, the AI pilot-zone policy ultimately contributes to a significant improvement in regional entrepreneurial vitality.

Hypothesis 4: The establishment of National New Generation Artificial Intelligence Innovation and Development Pilot Zones enhances regional entrepreneurial vitality by improving regional R&D efficiency, reducing entrepreneurial costs, and thereby stimulating entrepreneurial activity.

Transportation infrastructure constitutes the physical foundation for factor mobility and market integration. As discussed in the preceding mechanism analysis, AI pilot zones promote entrepreneurship primarily by stimulating the derived demand generated by the digital economy and the offline experience economy. The realization of this demand-driven effect, however, depends critically on the quality of regional transportation networks. In regions with well-developed transportation infrastructure—such as cities with dense high-speed rail networks and extensive highway connectivity—lower logistics and commuting costs effectively expand market boundaries. This facilitates the rapid commercialization of AI products while enabling innovative resources, including talent and capital from surrounding areas, to flow efficiently into the pilot zones. Consequently, in regions with superior transportation accessibility, the establishment of AI pilot zones can more effectively translate policy support into actual market demand, thereby significantly enhancing local entrepreneurial vitality [30]. By contrast, inadequate transportation infrastructure substantially constrains the free movement of production factors due to geographic isolation. Under such conditions, even generous investment promotion policies introduced by local governments may fail to attract AI enterprises, as high logistics costs and difficulties in acquiring skilled labor reduce firms' incentives to locate in these areas. Without the entry of leading AI enterprises, pilot zones lack the industrial foundation necessary to foster a vibrant entrepreneurial ecosystem and are unable to stimulate entrepreneurship through industrial chain expansion. Therefore, the quality of transportation infrastructure represents a critical threshold determining whether the pilot-zone policy can achieve its intended effects.

Hypothesis 5: The positive effect of National New Generation Artificial Intelligence Innovation and Development Pilot Zones on regional entrepreneurial vitality is stronger in regions with higher levels of transportation infrastructure.

The degree of marketization reflects the relationship between government and the market, as well as the extent to which resource allocation is governed by market mechanisms. The establishment of AI pilot zones is fundamentally a government-led process aimed at improving the business environment, attracting emerging technology firms, and generating spillover benefits for entrepreneurs across industries. However, the marginal effectiveness of such government-led policies is likely to vary substantially across regions with different levels of marketization. In regions with highly developed market economies—such as many of China's eastern coastal cities—the business environment is already well established, market mechanisms play a dominant role in resource allocation, and entrepreneurial ecosystems are relatively mature. Under these circumstances, the additional improvements brought about by pilot-zone policies are likely to be limited, implying diminishing marginal returns to policy intervention. Consequently, the establishment of AI pilot zones may not produce substantial increases in entrepreneurial vitality in highly marketized regions [31]. In contrast, regions with relatively low levels of marketization—particularly some cities in central and western China—typically possess weaker business environments, where entrepreneurial activities remain constrained by institutional and regulatory barriers. In these regions, the establishment of an AI pilot zone can serve as a powerful catalyst for institutional reform. To fulfill the objectives associated with pilot-zone designation, local governments have strong incentives to remove institutional barriers and improve the business environment. Meanwhile, the entry of AI enterprises introduces not only advanced technologies but also modern business practices, market-oriented thinking, and contractual norms. These external influences help revitalize local entrepreneurial ecosystems and substantially amplify the effectiveness of the policy. Therefore, AI pilot-zone policies are expected to exert stronger entrepreneurial effects in regions with lower levels of marketization.

Hypothesis 6: As the degree of marketization increases, the positive effect of National New Generation Artificial Intelligence Innovation and Development Pilot Zones on regional entrepreneurial vitality exhibits diminishing marginal returns.

In summary, the indirect effects of National New Generation Artificial Intelligence Innovation and Development Pilot Zones on regional entrepreneurial vitality can be conceptualized as operating through two complementary channels: a demand-side induced demand effect and a supply-side productivity enhancement effect. On the demand side (corresponding to Hypotheses 2 and 3), the establishment of pilot zones stimulates the digital economy through policy demonstration effects and facilitates the commercialization and launch of new AI products. These developments encourage both government investment and the expansion of offline experiential consumption, thereby generating substantial market demand and creating abundant entrepreneurial opportunities. On the supply side (corresponding to Hypothesis 4), pilot zones improve regional R&D efficiency through investments in new digital infrastructure and the agglomeration of innovation resources. Enhanced R&D efficiency reduces the costs associated with technology acquisition and the commercialization of research outcomes, alleviates resource constraints faced by start-up firms, and fundamentally improves the supply conditions for entrepreneurship. The interaction between expanding market demand and declining entrepreneurial costs constitutes the complete indirect mechanism through which AI pilot zones promote regional entrepreneurial vitality. As a national industrial policy, the entrepreneurial effects of National New Generation Artificial Intelligence Innovation and Development Pilot Zones are expected to exhibit significant heterogeneity across regions. Specifically, the effectiveness of the policy varies according to both the level of transportation infrastructure and the degree of market development, as reflected in Hypotheses 5 and 6.

4. Research design

4.1. Data sources and descriptive statistics

This study uses a balanced panel of 285 prefecture-level and above cities in China covering the period 2009–2023. The sample includes all four municipalities directly under the central government as well as prefecture-level cities nationwide. Based on the official list of the National New Generation Artificial Intelligence Innovation and Development Pilot Zones, city-year observations after a city's designation as a pilot zone are classified as the treatment group, while all remaining observations constitute the control group. This classification provides the basis for identifying the policy effect using a Difference-in-Differences (DID) framework. Data on provinces, cities, and industries are primarily obtained from the China City Statistical Yearbook (city-level statistical data) and the CSMAR Database. To minimize the influence of extensive missing values on both the treatment and control groups, cities with more than three years of missing city-level observations during the sample period were excluded. After data cleaning, the final sample consists of 285 cities observed from 2009 to 2023, yielding a total of 4,275 city-year observations.

Regarding the dependent variable, entrepreneurial vitality, substantial variation exists across cities, indicating pronounced regional heterogeneity in entrepreneurial development. The core explanatory variable, the AI pilot-zone policy, has a relatively low mean value, reflecting the staggered implementation and gradual expansion of the pilot program. Accordingly, only a limited number of city-year observations are exposed to the policy during the sample period. As for the control variables, all variables fall within reasonable ranges, while their standard deviations suggest considerable heterogeneity across sample cities in terms of economic development, industrial structure, digital infrastructure, financial development, and fiscal resource allocation. Table 1 reports the descriptive statistics for all variables.

Table 1. Descriptive statistics of variables

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
ENT	4,215	120.8345	67.0311	17.5559	399.9465
AI	4,215	0.0176	0.1313	0	1
lnpGDP	4,215	10.7244	0.6170	8.4098	12.4863
Ins	4,215	45.2646	11.1066	10.6800	82.2400
Net	4,215	0.2529	0.2019	0.0035	3.6635
Fin	4,215	2.5587	1.2467	0.5879	21.3015
Fis	4,215	19.7100	10.0814	4.3881	102.6784
Edu	4,215	3.3689	1.7231	0.2135	15.8477
Sci	4,215	0.2791	0.2779	0.0128	6.3100
Retail	4,208	15.58926	1.075476	12.22837	19.0367
ECommerce	4,215	0.1312851	0.2004761	0.00297	4.253579
Effi	4,215	0.3373581	0.2389385	0.001625	1

4.2. Variable definitions

(1) Dependent variable

This study uses urban Entrepreneurial Vitality (ENT) as the dependent variable. Drawing on the existing literature, data availability, and the objectives of this study, entrepreneurial vitality is defined as the intensity and overall dynamism of entrepreneurial activities in a city, with the number of newly established firms during a given period serving as the core indicator. Following established practice, entrepreneurial vitality is measured using multiple indicators to ensure the robustness of the empirical results.

1) Baseline measure: Urban entrepreneurial vitality is measured by the number of newly registered enterprises per 10,000 permanent residents.

2) Robustness measure: Urban entrepreneurial vitality is measured by the number of newly registered enterprises divided by the product of the permanent resident population and the proportion of the working-age population. This measure controls for differences in population age structure across cities and provides a more accurate assessment of entrepreneurial vitality among the working-age population.

(2) Core explanatory variable

The core explanatory variable is the National New Generation Artificial Intelligence (AI) Innovation and Development Pilot Zone policy. This study treats the establishment of AI pilot zones as a quasi-natural experiment and constructs the key explanatory variable within a Difference-in-Differences (DID) framework. Specifically, if city c is designated as a National New Generation Artificial Intelligence Innovation and Development Pilot Zone in year t, the variable AI takes the value of 1 from year t onward and 0 otherwise. The assignment is defined as follows: $AI_{ct} = \begin{cases} 1 c \in experimental\ group\ ,\ and\ t \in experimental\ period \\ 0, others \end{cases}$

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1) First batch (effective from 2019 onward): Beijing, Shanghai, Tianjin, Shenzhen, Hangzhou, Hefei, and Huzhou. For these treatment cities, AI = 1 in 2019 and all subsequent years.

2) Second batch (effective from 2020 onward): Chengdu, Xi'an, Jinan, Guangzhou, Chongqing, and Wuhan. For these treatment cities, AI = 1 in 2020 and all subsequent years.

3) Third batch (effective from 2021 onward): Suzhou, Changsha, Zhengzhou, Shenyang, and Harbin. For these treatment cities, AI = 1 in 2021 and all subsequent years.

4) All other cases: For non-pilot cities and for years prior to policy implementation in pilot cities, AI = 0.

(3) Control variables

Following the existing literature, this study includes a set of control variables that may influence regional entrepreneurial vitality. Specifically, the control variables comprise the level of economic development (measured by GDP per capita), industrial structure, Internet penetration, financial development, population size, the level of fiscal support, educational investment, and investment in science and technology.

(4) Mediating variables

Three mediating variables are incorporated into the analysis: total retail sales of consumer goods, e-commerce transaction volume, and R&D efficiency.

Following Tone Kaoru [32], this study measures urban R&D efficiency using the non-radial, non-oriented Slack-Based Measure Data Envelopment Analysis (SBM-DEA) model. The number of employees in scientific research and technical service industries and the number of higher education institutions are used as input variables, while the number of invention patent applications serves as the output variable. Using this approach, urban R&D efficiency is calculated for all sample cities from 2009 to 2023. The annual mean, median, and the cities with the highest and lowest efficiency scores are summarized in Table 2.

Table 2. Annual statistics of urban R&D efficiency

Year	Mean R&D Efficiency	Median Efficiency	City with Highest Efficiency	Lowest Efficiency	City with Lowest Efficiency
2009	0.3686444	0.5017	Nantong	0.0018333	Daqing
2010	0.3575598	0.5017	Nantong	0.001625	Daqing
2011	0.3608564	0.5017	Nantong	0.0025378	Daqing
2012	0.3481905	0.5017	Suzhou	0.0021122	Daqing
2013	0.3070013	0.5017	Suzhou	0.002414	Daqing
2014	0.2994005	0.5013	Suzhou	0.0040912	Hohhot
2015	0.3085551	0.5017	Suzhou	0.0044291	Hohhot
2016	0.3158666	0.5017	Suzhou	0.0052094	Hohhot
2017	0.3359537	0.5025	Suzhou	0.0056096	Hohhot

Table 2. Continued

2018	0.3646345	0.5050	Suzhou	0.00625	Hulunbuir
2019	0.3319947	0.5025	Shenzhen	0.00625	Hulunbuir
2020	0.3414208	0.5025	Shenzhen	0.00625	Hulunbuir
2021	0.3389955	0.5025	Shenzhen	0.00625	Tianshui
2022	0.3412728	0.5025	Beijing	0.00625	Tianshui
2023	0.340025	0.5025	Beijing	0.00625	Tianshui

Note: Source: Calculated by the authors. Under the Data Envelopment Analysis (DEA) framework, the maximum efficiency score is always equal to 1; therefore, it is not reported separately in the table.

The estimation results indicate that the average level of urban R&D efficiency remained relatively low throughout the sample period, ranging from 0.299 to 0.369. The maximum efficiency score consistently reached 1 in each year, while the temporal trend exhibits an initial decline followed by a gradual recovery. This pattern suggests that, although R&D efficiency varies substantially across cities, the overall innovation efficiency of Chinese cities improved moderately in the latter part of the sample period.

4.3. Model specification

To identify the net effect of the National New Generation Artificial Intelligence Innovation and Development Pilot Zone policy on regional entrepreneurial vitality, this study first estimates a multi-period Difference-in-Differences (DID) baseline model, as specified in Equation (1).

$$ENT_{ct} = a_0 + a_1 AI_{ct} + \sum a_k X_{kct} + \mu_c + \lambda_t + \varepsilon_{ct} \tag{1}$$

In Equation (1), the dependent variable, ENT_{ct}, denotes the entrepreneurial vitality of city c in year t. The key explanatory variable, AI_{ct}, is a policy dummy that equals 1 if city c has been designated as a National New Generation Artificial Intelligence Innovation and Development Pilot Zone in year t or any subsequent year, and 0 otherwise.

The parameter α_0 represents the intercept term, while α_1 is the coefficient of the AI pilot-zone policy and captures the average treatment effect of the policy on entrepreneurial vitality. The vector α_k denotes the coefficients of the control variables, and X_{kct} represents the set of control variables, including GDP per capita, industrial structure, Internet development, financial development, population size, fiscal support, educational investment, and investment in science and technology. In addition, μ_c and λ_t denote city fixed effects and year fixed effects, respectively, while ε_{ct} is the random error term.

To further investigate the mechanisms through which the AI pilot-zone policy influences entrepreneurial vitality, this study introduces the mediating variable M_{ct} and adopts the conventional two-step mediation analysis framework, as specified in Equations (2), (3), and (4).

$$ENT_{ct} = a_0 + a_1 AI_{ct} + \sum a_k X_{kct} + \mu_c + \lambda_t + \varepsilon_{ct} \tag{2}$$

$$M_{ct} = \beta_0 + \beta_1 AI_{ct} + \sum \beta_k X_{kct} + \mu_c + \lambda_t + \varepsilon_{ct} \tag{3}$$

$$ENT_{ct} = \gamma_0 + \gamma_1 AI_{ct} + \gamma_2 M_{ct} + \sum \gamma_k X_{kct} + \mu_c + \lambda_t + \varepsilon_{ct} \tag{4}$$

In Equation (2), all variables are defined identically to those in Equation (1). This equation estimates the total effect of the AI pilot-zone policy on entrepreneurial vitality. For the total effect to be established, the coefficient α_1 should be statistically significant. In Equation (3), M_{ct} represents the mediating variable, which is alternatively measured by e-commerce development, consumer market size, and R&D efficiency. The parameter β_0 denotes the intercept, β_1 is the coefficient of the AI pilot-zone policy, and β_k represents the coefficients of the control variables. All other variables are defined in the same manner as in Equation (1). This step examines whether the AI pilot-zone policy has a statistically significant effect on the proposed mediator M_{ct}. A significant β_1 indicates that the policy affects the mediating variable. In Equation (4), γ_0 denotes the intercept term, γ_1 is the coefficient of the AI pilot-zone policy, γ_2 is the coefficient of the mediating variable, and γ_k represents the coefficients of the control variables. The definitions of the remaining variables are identical to those in Equation (1). The mediation effect is considered to exist if both β_1 and γ_2 are statistically significant. If γ_1 remains statistically significant after the inclusion of the mediator but its absolute value is smaller than that of α_1, the mediation effect is partial, indicating that the AI pilot-zone policy affects entrepreneurial vitality through both direct and indirect channels. If γ_1 becomes statistically insignificant after the mediator is introduced, the mediation effect is complete, suggesting that the policy influences entrepreneurial vitality entirely through the mediating variable.

5. Empirical results

5.1. Baseline regression analysis

To examine the impact of the National New Generation Artificial Intelligence Innovation and Development Pilot Zone policy on regional entrepreneurial vitality, this study estimates the baseline model using a multi-period Difference-in-Differences (DID) approach. The regression results are reported in Table 3. Column (1) presents the benchmark regression without control variables or two-way fixed effects. The coefficient of the core explanatory variable, AI, is 119.1019, which is positive and statistically significant at the 1% level, providing preliminary evidence that the establishment of AI pilot zones enhances regional entrepreneurial vitality. In Column (2), after controlling only for city and year fixed effects, the estimated coefficient of AI declines to 25.7345, yet remains significant at the 1% level. This finding suggests that city-specific characteristics and nationwide time shocks partially attenuate the estimated policy effect, while the positive impact of the pilot-zone policy remains robust. Column (3) further introduces the full set of economic control variables while controlling only for city fixed effects. The estimated coefficient of the policy variable is 21.1763, which remains statistically significant at the 5% level. Finally, Column (4) incorporates all control variables together with both city and year fixed effects. Under this preferred specification, the coefficient of AI is 22.3223, remaining positive and statistically significant at the 1% level. As additional controls are introduced progressively, neither the sign nor the statistical significance of the core explanatory variable changes. This consistency indicates that, after accounting for differences in economic development, industrial structure, Internet penetration, and other sources of city-level heterogeneity, the establishment of AI pilot zones continues to exert a stable and significant positive effect on entrepreneurial vitality. These findings provide preliminary empirical support for the study's central hypothesis. Furthermore, the estimated coefficients of the control variables are generally consistent with theoretical expectations, and most are statistically significant, indicating that the model specification is well founded.

Table 3. Baseline regression results

	(1)	(2)	(3)	(4)
	Entrepreneurial Vitality	Entrepreneurial Vitality	Entrepreneurial Vitality	Entrepreneurial Vitality
AI	119.1019***	25.7345***	21.1763**	22.3223***
	(7.2687)	(6.1854)	(8.6256)	(6.0670)

Table 3. Continued

lnpGDP			60.3887***	9.4070*
			(3.2027)	(4.8473)
Ins			-1.4263***	0.3186*
			(0.0898)	(0.1751)
Net			60.0574***	17.6330**
			(13.7860)	(8.3420)
Fin			-0.0297	-4.1729***
			(0.9109)	(1.4466)
Fis			0.1904	-1.2807***
			(0.1487)	(0.2445)
Edu			2.1377***	4.2937***
			(0.8275)	(1.4232)
Sci			2.7106	23.4213***
			(3.6389)	(6.5853)
N	4215	4215	4215	4215
City FE	NO	YES	NO	YES
Year FE	NO	YES	NO	YES
Adj. R^2	0.0542	0.7190	0.4999	0.7329

Note: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. Robust standard errors are reported in parentheses.

5.2. Multicollinearity test

To ensure that multicollinearity among the explanatory variables does not bias the regression results, this study employs the Variance Inflation Factor (VIF) test. The results are reported in Table 4.

Table 4. Test for multicollinearity

Variable	VIF	1/VIF
Edu	4.60	0.217209
Fis	4.33	0.231152
lnpGDP	2.87	0.348627
Net	2.26	0.442518
Ins	1.71	0.583828
Fin	1.69	0.590704
Sci	1.28	0.778319
AI	1.14	0.876157
Mean	2.49	/

The minimum VIF is 1.14, the maximum is 4.60, and the average VIF is 2.49. Since all VIF values are well below the conventional threshold of 5, the regression model does not suffer from serious multicollinearity, indicating that the explanatory variables are suitable for inclusion in the empirical analysis.

5.3. Robustness tests

To ensure the reliability of the baseline findings and to eliminate potential concerns arising from sample selection, outliers, or omitted policies, this study conducts seven robustness checks. The results are summarized in Table 5.

First, a parallel trends test is conducted using an event-study specification to verify the identifying assumption of the DID model. Taking the establishment of AI pilot zones as the policy shock, the dynamic treatment effects are examined over time. The estimated coefficients for the pre-treatment periods fluctuate only slightly around zero and are statistically insignificant, indicating that entrepreneurial vitality follows parallel trends in the treatment and control groups prior to policy implementation. Following the policy intervention, the estimated coefficients become persistently positive and statistically significant, providing further evidence of the policy's positive impact. The corresponding results are illustrated in Figure 1. Second, a placebo test is implemented by randomly assigning the AI pilot-zone policy across cities and repeating the estimation 500 times. The resulting placebo coefficients are concentrated around zero, with only a very small proportion reaching statistical significance. This finding demonstrates that the positive policy effect identified in the baseline regression is unlikely to be driven by random chance or omitted variables. The placebo distribution shown in Figure 2 further supports this conclusion.

Third, a Propensity Score Matching Difference-in-Differences (PSM-DID) approach is employed. Industrial structure and the share of educational and research expenditure are selected as matching covariates, and 1:4 nearest-neighbor caliper matching is applied to reduce observable differences between the treatment and control groups. After matching, the balance test yields a p-value of 0.13, indicating no statistically significant differences between the matched groups and confirming the common support assumption (see Figure 3). The DID regression based on the matched sample continues to produce a positive and statistically significant coefficient for the policy variable at the 1% level, suggesting that the main findings remain unchanged after addressing potential sample selection bias. The corresponding results are reported in Column (5) of Table 5.

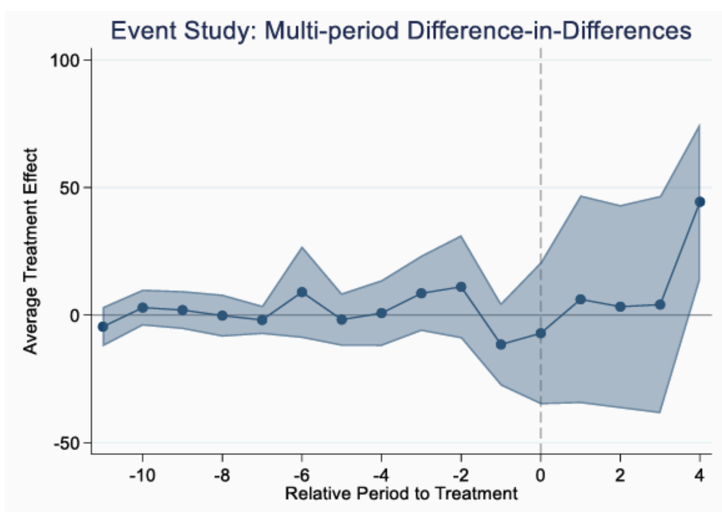

Figure 1. Results of parallel trend test

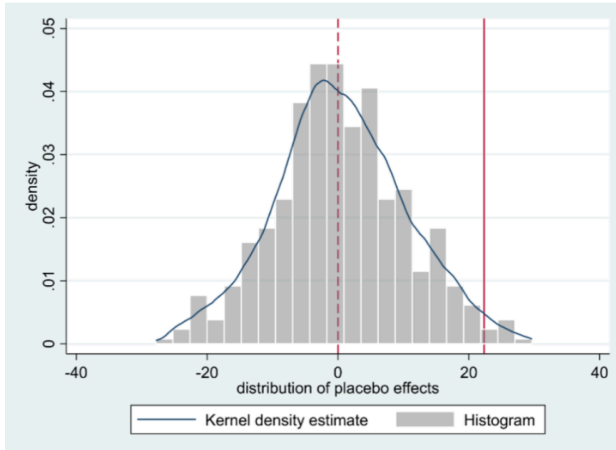

Figure 2. Results of placebo test

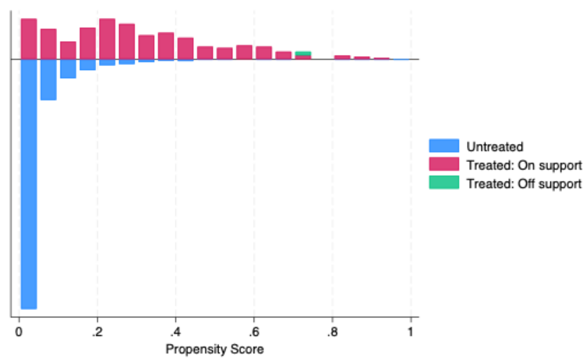

Figure 3. Common support graph

Fourth, four additional robustness checks are conducted: replacing the dependent variable with an alternative measure of entrepreneurial vitality, excluding municipalities directly under the central government, winsorizing the variables to mitigate the influence of outliers, and introducing province-by-year interaction fixed effects. The regression results, presented in Columns (1)–(4) of Table 5, consistently show that the coefficient of the core explanatory variable remains positive and statistically significant at the 1% level under all specifications. These findings further confirm the robustness of the baseline results.

Table 5. Results of robustness test

	(1)	(2)	(3)	(4)	(5)
AI	33.6104***	29.8810***	20.4498***	28.0314***	22.32***
	(8.8275)	(7.3418)	(5.9050)	(6.8968)	(4.987)
lnpGDP	13.3290*	11.5071**	6.9804	-0.5867	9.407**
	(6.9703)	(4.8743)	(4.7384)	(5.5431)	(4.657)
Ins	0.3229	0.3197*	0.2134	-0.2194	0.319**

Table 5. Continued

	(0.2516)	(0.1759)	(0.1657)	(0.1682)	(0.152)
Net	25.4759**	26.5197***	15.4772*	33.7949***	17.63***
	(11.5384)	(9.8399)	(8.0678)	(9.4067)	(5.719)
Fin	-5.6846***	-4.1675***	-5.3233***	0.5725	-4.173***
	(2.0540)	(1.4534)	(1.6156)	(1.1386)	(1.150)
Fis	-1.9184***	-1.2757***	-1.5293***	-0.2904*	-1.281***
	(0.3541)	(0.2461)	(0.2424)	(0.1589)	(0.202)
Edu	6.6656***	4.4736***	4.3043***	1.7788	4.294***
	(2.0461)	(1.4225)	(1.4483)	(1.2759)	(1.433)
Sci	35.1745***	22.1848***	35.6280***	11.3984**	23.42***
	(9.8823)	(6.3319)	(5.3618)	(4.7575)	(3.214)
N	4,215	4,155	4,215	4,125	4,215
ProvinceYearFE	NO	NO	NO	YES	NO
CityFE	YES	YES	YES	YES	YES
YearFE	YES	YES	YES	YES	YES
r2_a	0.7399	0.7339	0.7415	0.8303	0.635

Note: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. Robust standard errors are reported in parentheses.

5.4. Mechanism analysis

The baseline regressions demonstrate that the establishment of National New Generation Artificial Intelligence Innovation and Development Pilot Zones significantly enhances urban entrepreneurial vitality. To further identify the underlying transmission channels, this study employs the two-step mediation approach introduced earlier, sequentially examining the effects of the policy on each mediating variable.

(1) Digital Economy Vitality

The estimation results for the digital economy vitality mechanism are reported in Column (1) of Table 6. The estimated coefficient of the AI pilot-zone policy is 0.1034, which is positive and statistically significant at the 1% level, indicating that the establishment of AI pilot zones significantly promotes the development of urban e-commerce. In addition, the level of e-commerce development exerts a positive effect on entrepreneurial vitality at the 5% significance level. These findings are consistent with the theoretical analysis presented earlier and provide empirical support for Hypothesis 2, namely that AI pilot zones enhance entrepreneurial vitality by stimulating the digital economy.

The widespread adoption of AI technologies promotes the expansion of digital economic activities, including online transactions and platform-based services, thereby enlarging market opportunities and business channels available to entrepreneurs. Meanwhile, the development of the digital economy reduces information asymmetry and lowers barriers to entrepreneurship, enabling broader participation in entrepreneurial activities and strengthening urban entrepreneurial vitality.

(2) Consumer Market Size

The results for the consumer market size mechanism are reported in Column (2) of Table 6. The estimated coefficient of the AI pilot-zone policy is 0.1186, which is positive and statistically significant at the 1% level, indicating that the establishment of AI pilot zones significantly expands the size of the urban consumer market. Moreover, consumer market size exerts a positive effect on entrepreneurial vitality at the 1% significance level, providing empirical support for Hypothesis 3.

The commercialization of AI technologies enriches consumption scenarios and enhances consumer experiences, thereby stimulating consumer demand. The expansion of the consumer market creates additional entrepreneurial opportunities, attracts entrepreneurial resources such as capital and skilled labor, provides a more stable market environment for new ventures, and ultimately contributes to higher levels of urban entrepreneurial vitality.

(3) R&D Efficiency

The estimation results for the R&D efficiency mechanism are presented in Column (3) of Table 6. The coefficient of the AI pilot-zone policy is 0.1076, which is positive and statistically significant at the 1% level, indicating that the establishment of AI pilot zones significantly improves urban R&D efficiency. Furthermore, R&D efficiency has a positive effect on entrepreneurial vitality at the 10% significance level, providing empirical support for Hypothesis 4.

By optimizing the allocation of innovation resources and improving the regional innovation environment, AI pilot zones enhance the efficiency of research, development, and technology commercialization. Higher R&D efficiency reduces technological costs and innovation risks for start-up firms, strengthens firms' innovation capabilities, and facilitates the emergence of more innovation-driven entrepreneurial activities, thereby providing sustained technological support for improvements in urban entrepreneurial vitality.

Table 6. Results of mechanism analysis test

	(1)		(2)		(3)	
	ECommerce	ENT	Retail	ENT	Effi	ENT
AI	0.1034***	21.27***	0.1186***	18.40***	0.1076***	23.10***
	(0.0237)	(5.005)	(0.0235)	(4.953)	(0.0220)	(5.007)
ECommerce		10.17**				
		(4.419)				
Retail				32.35***		
				(3.416)		
Effi						7.216*
						(4.263)
lnpgdp	-0.0613***	10.03**	0.6030***	-10.37**	-0.0182	9.275**
	(0.0147)	(4.662)	(0.0319)	(5.049)	(0.0186)	(4.656)
ins	-0.0013*	0.332**	-0.0063***	0.521***	-0.0015***	0.308**
	(0.0008)	(0.152)	(0.0008)	(0.152)	(0.0005)	(0.152)

Table 6. Continued

net	-0.0780***	18.43***	0.0905***	14.57**	-0.0343**	17.39***
	(0.0206)	(5.726)	(0.0306)	(5.669)	(0.0171)	(5.719)
fin	-0.0095**	-4.076***	-0.0170	-3.616***	0.0192***	-4.035***
	(0.0045)	(1.150)	(0.0183)	(1.139)	(0.0041)	(1.152)
fis	-0.0012***	-1.268***	-0.0137***	-0.832***	-0.0005	-1.285***
	(0.0004)	(0.202)	(0.0018)	(0.206)	(0.0007)	(0.202)
edu	0.0078*	4.214***	-0.0198**	4.822***	-0.0027	4.274***
	(0.0047)	(1.432)	(0.0078)	(1.421)	(0.0050)	(1.432)
sci	-0.0214**	23.64***	0.1434***	18.73***	0.0341**	23.67***
	(0.0104)	(3.214)	(0.0409)	(3.218)	(0.0135)	(3.217)
N	4,215	4,215	4,208	4,208	4,215	4,215
CityFE	YES	YES	YES	YES	YES	YES
YearFE	YES	YES	YES	YES	YES	YES
r2_a	0.6095	0.635	0.9777	0.643	0.7045	0.635

Note: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. Robust standard errors are reported in parentheses.

5.5. Heterogeneity analysis and further discussion

To explore regional heterogeneity in the effects of the National New Generation Artificial Intelligence Innovation and Development Pilot Zone policy, this study conducts subgroup regressions based on two dimensions: the level of factor market development and the quality of transportation infrastructure. The measurement and grouping procedures are as follows. Provincial marketization indices [31] are merged with the city-level dataset by province and year to proxy the level of factor market development, while transportation infrastructure is measured by urban highway freight volume (10,000 tons). The 2018 cross-sectional values of both indicators are extracted, and missing city-level observations are completed using linear interpolation. Since the first batch of AI pilot zones was approved in 2019, the 2018 indicators are used to avoid policy endogeneity. Cities are divided into high and low groups according to the median value of each indicator, and subgroup regressions are subsequently estimated. The results are reported in Table 7, where Columns (1) and (2) present the regressions by transportation infrastructure, and Columns (3) and (4) report the results by factor market development.

(1) Factor Market Development

The subgroup analysis reveals substantial heterogeneity in the policy effect across cities with different levels of factor market development. For cities with more developed factor markets, the estimated coefficient of AI is 6.2504. Although positive, the coefficient is not statistically significant at conventional levels. In contrast, for cities with less developed factor markets, the coefficient reaches 63.6964 and is statistically significant at the 1% level. Both the magnitude and significance of the policy effect are considerably greater than those observed in the high-marketization group. These findings indicate that the AI pilot-zone policy exerts a stronger promotional effect on entrepreneurial vitality in regions where factor markets remain relatively underdeveloped. A plausible explanation is that cities with mature factor markets already possess favorable market institutions and strong endogenous entrepreneurial dynamics, leaving limited room for additional policy gains. By contrast, cities with less developed factor markets are constrained by imperfect market mechanisms and inefficient resource allocation. In such contexts, the AI pilot-zone policy helps compensate for institutional deficiencies, transforms policy advantages into entrepreneurial momentum, and therefore produces substantially larger effects.

(2) Transportation Infrastructure

The policy effect also varies significantly across cities with different levels of transportation infrastructure. In cities with relatively weak transportation infrastructure, the estimated coefficient of AI is 20.2213, which is positive and statistically significant at the 10% level. For cities with well-developed transportation infrastructure, the coefficient is 14.3729 and remains positive and statistically significant at the 5% level, indicating a more stable and robust policy effect. Overall, the findings suggest that the entrepreneurial benefits of the AI pilot-zone policy are more pronounced in cities with superior transportation conditions. Well-developed transportation networks improve logistics efficiency and facilitate the movement of entrepreneurial resources, thereby providing the physical foundation necessary for the effective implementation of AI pilot-zone policies. Consequently, the channels through which AI policies stimulate entrepreneurship—such as digital economy development and improvements in R&D efficiency—operate more effectively. Conversely, cities with inadequate transportation infrastructure face higher logistics costs and greater constraints on the mobility of talent and capital, weakening the policy's entrepreneurial impact. To verify the statistical significance of these subgroup differences, this study further conducts coefficient equality tests across groups. The results indicate that the *p*-values are significant at the 1% level, confirming that the policy effects differ systematically across cities with different levels of factor market development and transportation infrastructure.

Overall, the positive impact of the AI pilot-zone policy on urban entrepreneurial vitality exhibits clear heterogeneity, with stronger effects observed in cities characterized by less developed factor markets and better transportation infrastructure.

Having established the positive local effects of the AI pilot-zone policy, this study further investigates its spatial implications. Specifically, it asks whether the policy generates a leading effect that stimulates entrepreneurship throughout the surrounding region, a siphon effect that attracts entrepreneurial resources from neighboring areas, or a spillover effect through which entrepreneurial activities gradually diffuse outward. To address this question, the dependent variable is replaced with the share of a city's entrepreneurial vitality in the provincial total, and the model is re-estimated.

From a theoretical perspective, regional industrial policies may generate three distinct types of spatial effects. The first is the leading effect, whereby the establishment of an AI pilot zone not only stimulates local entrepreneurship but also promotes entrepreneurial activities in other cities within the same province through institutional innovation, technological progress, and demonstration and imitation mechanisms [33]. Under this mechanism, both local entrepreneurial vitality and total provincial entrepreneurial activity increase simultaneously. The second is the siphon effect, which typically emerges during the early stages of policy implementation when preferential policies and concentrated innovation resources attract capital, talent, and entrepreneurial resources away from neighboring regions toward the pilot zone [34]. If the siphon effect dominates, the establishment of the pilot zone would significantly increase the city's share of provincial entrepreneurial activity, implying that local gains are achieved at the expense of surrounding areas. The third is the spillover effect, which generally occurs once the pilot zone reaches a certain stage of development. As local entrepreneurial capacity approaches saturation and factor costs increase, entrepreneurial activities and technological benefits begin to diffuse to other cities within the province [35]. If this mechanism dominates, the city's share of provincial entrepreneurial activity would decline following the establishment of the pilot zone.

The regression results reported in Columns (5) and (6) of Table 7 provide evidence in favor of the leading effect. When city fixed effects are omitted and the dependent variable is defined as the city's share of provincial entrepreneurial vitality, the estimated coefficient of the AI pilot-zone policy is positive and statistically significant at the 1% level (Column 5). However, once city fixed effects are included (Column 6), the policy coefficient becomes statistically insignificant. These findings suggest that the apparent siphon effect observed in the specification without city fixed effects merely reflects the inherent attractiveness of central cities rather than the AI pilot-zone policy itself. After controlling for city-specific characteristics, neither the siphon effect nor the spillover effect appears to dominate. Instead, the evidence supports the existence of a leading effect. The statistically insignificant coefficient in Column (6) indicates that although the pilot-zone policy substantially increases entrepreneurial vitality within the treated city, it does not alter the city's share of total provincial entrepreneurship. In other words, the policy enlarges not only the local "entrepreneurial pie" but also the overall scale of entrepreneurial activity across the province.

This leading effect can be attributed primarily to the General-Purpose Technology (GPT) characteristics of artificial intelligence and the demonstration–imitation mechanism associated with the pilot-zone policy. On the one hand, AI technologies possess strong platform-based and pervasive characteristics. New technologies, algorithms, and business models developed within pilot zones can rapidly transcend geographic boundaries, facilitating industrial upgrading throughout the province and even nationwide while generating abundant entrepreneurial opportunities across a broader spatial scope [36]. On the other hand, the pilot zones' pioneering experiences in institutional innovation, data openness, and adaptive regulatory practices provide replicable policy models for other cities within the province. Through learning and policy imitation, neighboring cities can improve their own business environments and stimulate local entrepreneurial activities [33]. Consequently, AI pilot zones function not as isolated growth poles that drain surrounding regions of entrepreneurial resources, but rather as innovation hubs and engines of regional development that promote coordinated growth in entrepreneurial vitality through technological diffusion and institutional demonstration.

Table 7. Results of heterogeneity test and discuss

	(1)	(2)	(3)	(4)	（5）	（6）
AI	14.3729**	20.2213	6.2504	63.6964***	0.108***	0.00111
	(6.3734)	(15.9379)	(6.5564)	(11.5943)	(0.0159)	(0.00315)
lnpgdp	1.9818	19.3389***	-14.8241**	36.9624***	0.0904***	0.0153***
	(6.6644)	(6.8744)	(7.5566)	(6.7427)	(0.00690)	(0.00294)
ins	0.1143	0.3236	0.8844***	-0.3746	-0.00156***	-0.000133
	(0.2453)	(0.2519)	(0.2484)	(0.2414)	(0.000250)	(0.0000961)
net	18.6994*	17.1228	18.4310*	20.6363*	-0.0127	0.00267
	(10.7618)	(11.4316)	(11.1706)	(10.8308)	(0.0148)	(0.00361)
fin	-5.4547***	-3.6178**	-6.3751**	-3.6613	0.0382***	0.000163
	(1.8723)	(1.7258)	(2.7732)	(2.3250)	(0.00204)	(0.000726)
fis	-1.5903***	-0.9853***	-0.9577**	-1.2320***	0.00117***	0.000278**
	(0.4210)	(0.2587)	(0.4027)	(0.2818)	(0.000405)	(0.000128)
edu	3.9036	4.1055**	0.6429	6.3072***	0.00745***	0.00144
	(2.4222)	(1.6742)	(2.4944)	(1.6548)	(0.00255)	(0.000905)

Table 7. Continued

sci	31.1755***	18.3468***	30.0125***	16.2504**	0.0110	-0.00586***
	(7.2070)	(6.8227)	(10.8656)	(6.4413)	(0.00802)	(0.00203)
N	2,100	2,115	2,040	2,175	4,215	4,215
CityFE	YES	YES	YES	YES	NO	YES
YearFE	YES	YES	YES	YES	YES	YES
r2_a	0.7756	0.6887	0.7368	0.7388	0.237	0.237

Note: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. Robust standard errors are reported in parentheses.

6. Conclusion and policy implication

Against the backdrop of China's transition toward high-quality economic development and the continuous upgrading of its industrial structure, stimulating regional entrepreneurial vitality has become an important means of fostering new drivers of economic growth and alleviating structural employment pressures. As a major national policy initiative designed to accelerate the application of artificial intelligence technologies and promote innovation-driven entrepreneurship, the National New Generation Artificial Intelligence Innovation and Development Pilot Zones warrant careful evaluation with respect to their impact on regional entrepreneurial vitality. Using panel data for 285 prefecture-level and above cities in China over the period 2009–2023, this study treats the establishment of AI pilot zones as a quasi-natural experiment and employs a multi-period Difference-in-Differences (DID) model to examine the policy's impact on regional entrepreneurial vitality. The analysis further explores the underlying transmission mechanisms and regional heterogeneity, while a series of robustness tests—including parallel trends and placebo tests—are conducted to validate the empirical findings. The main conclusions are summarized as follows.

First, the establishment of AI pilot zones significantly enhances regional entrepreneurial vitality. The baseline regression results indicate that, after controlling for city and year fixed effects together with a comprehensive set of control variables, the coefficient of the policy variable remains positive and statistically significant. This finding confirms that the AI pilot-zone policy provides effective incentives for entrepreneurship and supports Hypothesis 1.

Second, the AI pilot-zone policy promotes entrepreneurial vitality through three complementary channels operating on both the demand and supply sides. The mechanism analysis demonstrates that the policy stimulates the development of e-commerce and broadens entrepreneurial opportunities by strengthening the digital economy (Hypothesis 2). It also promotes the commercialization of AI products and expands the offline consumer market, thereby creating demand-driven entrepreneurial opportunities (Hypothesis 3). In addition, by improving innovation infrastructure, attracting scientific and technological resources, and enhancing regional R&D efficiency, the policy alleviates supply-side constraints on entrepreneurship (Hypothesis 4). Together, these three mechanisms constitute a comprehensive transmission framework through which the policy enhances entrepreneurial vitality.

Third, the entrepreneurial effects of the AI pilot-zone policy exhibit significant regional heterogeneity. The policy generates stronger effects in cities with less developed factor markets and better transportation infrastructure, whereas its effectiveness is weaker in cities constrained by underdeveloped market institutions or inadequate transportation networks. Formal tests of coefficient differences across groups confirm that these regional disparities are statistically significant.

Fourth, urban development conditions exert heterogeneous influences on entrepreneurial vitality. Higher levels of GDP per capita, Internet penetration, and investment in education and scientific innovation significantly promote entrepreneurial activity. In contrast, excessive expansion of financial and fiscal support may inhibit entrepreneurship, providing empirical evidence for the design of more targeted and differentiated entrepreneurial support policies.

Drawing upon the empirical findings and the practical experience of AI pilot-zone development across different regions, several policy recommendations are proposed to maximize the effectiveness of the pilot-zone policy, further stimulate regional entrepreneurial vitality, deepen the integration of artificial intelligence with entrepreneurial activities, and promote high-quality regional economic development.

First, the development of National New Generation Artificial Intelligence Innovation and Development Pilot Zones should be further strengthened to fully leverage their demonstration effects. Building upon differences in educational resources, industrial foundations, and comparative advantages across eastern, central, and western China, the pilot program should be expanded in a phased and orderly manner. Non-pilot cities should be encouraged to adapt successful experiences from pilot zones to local conditions, thereby facilitating the deep integration of AI technologies with regional industries. At the same time, governments should capitalize on the institutional advantages of policy experimentation by streamlining administrative approval procedures for AI-related entrepreneurial activities, reducing institutional transaction costs, and introducing targeted support measures—including computing power subsidies, entrepreneurship incubation funds, and tax incentives—to provide comprehensive policy and resource support for entrepreneurs while amplifying the demonstration and spillover effects of the pilot zones.

Second, policy efforts should focus on the three core transmission mechanisms identified in this study, promoting coordination between demand-side and supply-side drivers of entrepreneurship. To strengthen the digital economy, governments should accelerate the development of digital infrastructure, including 5G networks and computing centers, while advancing market-oriented reforms of data resources. The continued development of e-commerce and platform-based industries will provide entrepreneurs with low-cost and highly efficient digital business platforms. To promote the offline experience economy, local governments should expand AI application scenarios—including smart commercial districts, intelligent cultural tourism, and smart healthcare—based on regional industrial characteristics, thereby stimulating experiential consumption and creating entrepreneurial opportunities in areas such as intelligent scenario development and AI-related services. To improve R&D efficiency, governments should integrate the innovation resources of universities, research institutes, and enterprises by establishing collaborative innovation platforms linking government, industry, academia, research institutions, and end users. Greater access to public computing resources, shared research facilities, and technology transfer services will enhance the commercialization of innovation, reduce R&D costs, and lower overall entrepreneurial costs.

Third, governments should improve the fundamental conditions supporting entrepreneurship in order to strengthen the enabling role of AI technologies. Greater investment should be directed toward education and scientific innovation, while targeted talent recruitment policies should be implemented to attract AI professionals. Universities and vocational institutions should expand AI-related education and training programs to strengthen human capital accumulation and provide a sustainable talent pool for entrepreneurial development. In parallel, Internet penetration should continue to improve through coordinated investments in industrial Internet platforms, big data centers, and other forms of new digital infrastructure, thereby providing a solid technological foundation for AI applications and entrepreneurial activities. Financial and fiscal resources should also be allocated more efficiently. Financial institutions should expand credit support for AI start-ups while introducing diversified financing instruments such as entrepreneurship-guaranteed loans and government-guided venture capital funds to alleviate financing constraints. Fiscal expenditure should increasingly prioritize entrepreneurship incubation platforms and public service provision while reducing excessive administrative intervention in markets, thereby fostering an efficient, fair, and market-oriented business environment.

Fourth, governments should promote the deep integration of artificial intelligence with the real economy to cultivate more diversified entrepreneurial opportunities through industrial convergence. Pilot-zone cities should leverage their local industrial strengths by integrating AI technologies into manufacturing, agriculture, and service industries, with particular emphasis on areas such as intelligent manufacturing, smart agriculture, and intelligent logistics. The digital transformation of traditional industries will generate new entrepreneurial opportunities across a wide range of specialized sectors. At the same time, platforms facilitating the exchange of technology, talent, and capital within pilot zones should be established to strengthen collaboration between small and medium-sized enterprises, start-ups, and innovation-oriented organizations. Such collaboration will enable entrepreneurs to better understand technological trends, identify market opportunities, and align entrepreneurial activities more closely with the development of the real economy. Through this process, enhanced entrepreneurial vitality and industrial upgrading can reinforce one another, ultimately contributing to high-quality economic development.

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