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The Impact of Digital Economy on Entrepreneurial Activity: A Perspective on Human Capital

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Abstract. The digital economy fosters the expansion and upgrading of human capital, thereby enhancing entrepreneurial success rates and stimulating innovation potential, which together generate a virtuous cycle. Drawing on provincial panel data from China spanning 2013–2022, this study employs fixed-effects and mediation models to empirically test the interplay among the digital economy, human capital, and entrepreneurial dynamism. The findings reveal that, digitalization significantly can boost entrepreneurial activity, but in the long run its effect may follow an inverted U-shaped trajectory. Moreover, the growth of the digital economy can strengthen regional entrepreneurial vitality through human capital accumulation. Further heterogeneity analysis indicates that this positive influence brought by digital economy is more pronounced in western provinces, where the digital economy exerts a stronger stimulative effect on entrepreneurial activities compared with other regions due to national support and the relatively late start of the region itself. Based on these insights, enhancing entrepreneurial momentum requires intensified investment in human capital, deeper advancement of digital transformation, and greater attention to interregional coordination and complementarity.

Keywords: Digital Economy, Entrepreneurial Activity, Human Capital, Mediation Effect Model

1. Introduction

Driven by the global wave of digitalization, the digital economy has become a pivotal force reshaping industrial structures and modes of growth. Leveraging vast data resources and diverse application scenarios, China has accelerated the digital upgrading of traditional industries, while simultaneously giving rise to new sectors, business forms, and models. The 14th Five-Year Plan explicitly highlights the need to promote comprehensive transformation in production, lifestyles, and governance through digitalization, thereby cultivating new competitive advantages in the digital sphere. Furthermore, the report of the 20th National Congress underscores the urgency of accelerating digital economic development and fostering globally competitive industrial clusters [1]. These policy orientations confirm the central role of the digital economy as a key engine of China's high-quality development. Meanwhile, amid unprecedented global changes and a new wave of technological and industrial revolutions, structural shifts in the world economy are accelerating. In 2024, China's graduating college cohort is projected to reach a record 11.79 million, intensifying

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employment pressures. Ensuring stable employment is thus both a safeguard for sustained economic performance and a strategic imperative for social stability. This requires improving institutional mechanisms that link entrepreneurship with job creation, supporting the regulated growth of new employment forms, and reinforcing the livelihood foundation for high-quality development.

In recent years, rapid expansion of the digital economy and deeper integration with the real economy have nurtured new industries and business models, broadening opportunities for entrepreneurial ventures. According to the China Digital Economy Development Research Report (2024), China's digital economy reached 53.9 trillion yuan in 2023, accounting for 42.8% of GDP [2]. Against this backdrop, this paper adopts a human-capital perspective to examine how the digital economy enhances entrepreneurial vitality in cities through improvements in workforce quality. The study seeks to provide empirical evidence and policy implications for optimizing entrepreneurial ecosystems, unlocking the dividends of digitalization, and alleviating employment pressures.

2. Literature review

In recent years, advanced technologies such as the Internet of Things and cloud computing have increasingly converged and penetrated various sectors, giving rise to a new form of digital economy that centers on data resources and relies primarily on platform-based models. As a product of the latest technological revolution, the digital economy—with its networked, intelligent, and personalized characteristics—substantially expands entrepreneurial resources, generates additional opportunities, and provides a solid material foundation and favorable conditions for enhancing entrepreneurial vitality.

2.1. Research on digital economy and entrepreneurial activity

Currently, the role of the digital economy in driving entrepreneurial activity has become a key topic in research on economic structural optimization and high-quality development. Theoretical studies indicate that its influence on entrepreneurial vitality is multidimensional and complex. At the micro level, the application of digital technologies not only alleviates information asymmetry for entrepreneurs, improving access to knowledge, but also partially compensates for limitations in traditional financing channels and optimizes product supply-demand matching, thereby offering strong technical support and operational assurance for entrepreneurial endeavors [3]. Zhang et al., from a household entrepreneurship perspective, find that in contexts with low financial coverage, weak social security systems, and limited social capital, the digital economy's stimulative effect on entrepreneurial behavior is particularly pronounced [4]. At the macro level, the development of the digital economy helps establish an entrepreneurial ecosystem characterized by cost reduction, financial support, and resource integration [5]. Studies show that the "dual pilot" digital economy policy, by strengthening infrastructure and improving the institutional environment, significantly enhances entrepreneurial activity [6]. Moreover, from the perspective of effective market-government collaboration, when market maturity and government efficiency surpass a certain threshold, the positive impact of the digital economy on entrepreneurial vitality is further amplified, fostering entrepreneurship in surrounding regions through demonstration and diffusion effects [7].

While most research emphasizes the positive effects of the digital economy on entrepreneurial vitality, some scholars offer nuanced views. Wang et al. argue that while the digital economy increases overall economic activity, it may disrupt existing traditional sectors. Their study further suggests a potential nonlinear, inverted U-shaped relationship between the digital economy and urban entrepreneurial activity: in the short term, digital economy development stimulates

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entrepreneurship significantly, but beyond a certain threshold, it may inhibit sustained growth in entrepreneurial vitality. Current studies generally conclude that the digital economy continues to significantly promote urban entrepreneurship, largely because the development level in China has not yet exceeded this critical point [8].

2.2. Research on human capital and entrepreneurial activity

As a core driver of modern economic growth, human capital plays a pivotal role in entrepreneurial activity under the influence of the digital economy. Existing studies have confirmed the positive effect of human capital on entrepreneurial vitality from various perspectives. For instance, Zhang et al., using smart cities as the research context, found that the digital economy effectively stimulates entrepreneurial activity in central and western regions and within the information services sector by optimizing the business environment and enhancing social credit [9]. Conversely, Zhao et al. observed that higher education levels may exert a negative moderating effect on entrepreneurship during digital economy empowerment [10]. While prior literature has examined how the digital economy influences entrepreneurial activity through international trade [11], higher education, and entrepreneurial environment moderation [12], in-depth analyses from the human capital perspective remain limited. In practice, human capital not only directly facilitates the absorption and transformation of digital technologies, improving entrepreneurs' cognitive and resource-integration capabilities, but also amplifies the enabling effects of digital platforms through knowledge spillovers and network effects, thereby fostering the dynamic evolution of the entrepreneurial ecosystem.

In summary, existing research has explored the relationships among the digital economy, human capital, and entrepreneurial vitality individually or in pairs. However, the specific mechanisms through which the digital economy affects entrepreneurship are not yet fully understood, and the intrinsic linkages among the three elements remain underexplored. Building on prior studies, this paper integrates all three into a unified analytical framework, examining from a human capital perspective how it mediates and moderates the digital economy's impact on entrepreneurship, offering both theoretical insights and practical policy implications.

3. Theoretical model and research hypotheses

Innovation diffusion theory posits that the adoption of new technologies typically follows an S-shaped curve, starting with limited trials and gradually expanding to widespread use, with economic and social effects varying across stages. In the early phase of digitalization, the development of digital infrastructure, platforms, and information resources significantly reduces information search, transaction coordination, and market entry costs [13], thereby improving entrepreneurial efficiency and triggering a new wave of entrepreneurial activity. As technology becomes more widespread and digital literacy rises, network and scale effects emerge, fostering the growth of platform economies, sharing economies, and digital services, leading to a rapid increase in entrepreneurial vitality. However, according to the law of diminishing marginal returns, the stimulative effect of digitalization on entrepreneurship diminishes once it reaches maturity. Technological and channel convergence leads to product homogeneity and intensified competition, which compresses the survival space for new ventures, while platform centralization may even limit market access for small and medium enterprises. Based on this, Hypothesis 1 is proposed.

H1: The digital economy positively promotes entrepreneurial vitality, but as digitalization advances, its effect initially increases and then declines.

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Human capital theory emphasizes that knowledge and skills acquired through education and training are crucial drivers of economic innovation. Within a digital economy context, online learning platforms and intelligent matching systems enhance both the efficiency and quality of human capital accumulation. Digital learning tools overcome temporal and spatial constraints, enabling entrepreneurs to acquire cutting-edge knowledge at low cost, while algorithm-driven matching optimizes labor allocation and resource utilization. High-level human capital improves opportunity recognition, resource integration, and risk mitigation, thereby increasing entrepreneurial success rates [14-15]. Furthermore, digitalization accelerates knowledge spillovers, creating a positive feedback loop; highly skilled entrepreneurs can absorb and transform external knowledge more quickly, enhancing regional innovation capabilities. In technology-intensive sectors such as AI and biomedicine, knowledge diffusion shortens R&D cycles, significantly boosting entrepreneurial activity. This motivates Hypothesis 2.

H2: Digital economy development enhances human capital, which in turn increases regional entrepreneurial vitality.

According to resource-based theory, regional entrepreneurial advantages depend on access to heterogeneous resources. In the digital economy, digital infrastructure, data assets, and platform ecosystems are key strategic resources, yet their effectiveness depends on initial regional conditions and scarcity. In underdeveloped regions, digital resources can overcome constraints such as inadequate infrastructure and market fragmentation, strongly stimulating entrepreneurship. In contrast, in more developed regions where digitalization is mature, competitive homogenization and diminishing traffic dividends weaken its entrepreneurial impact. Therefore, Hypothesis 3 is proposed:

H3: The effect of the digital economy on entrepreneurial vitality exhibits regional heterogeneity.

4. Model setting and description of variables

4.1. Research design

To examine the relationships among the digital economy, human capital, and entrepreneurial vitality, this study constructs the following regression model.

$$Enp_{it} = \beta_0 + \beta_1 Dige_{it} + \theta X_{it} + \mu_i + \varepsilon_{it} \tag{1}$$

In Model (1), Enp_{it} denotes entrepreneurial vitality, $Dige_{it}$ represents the digital economy, X_{it} is a vector of control variables, i denotes provinces and t denotes years, μ_i captures province fixed effects, and ε_{it} is the error term.

Considering the potential nonlinear relationship between the digital economy and entrepreneurial activity, Model (2) introduces a squared term of the digital economy. $Digesq_{it}$ is the squared term of the digital economy, and other variables are defined as in the baseline model.

$$Enp_{it} = \beta_0 + \beta_1 Dige_{it} + \beta_2 Digesq_{it} + \theta X_{it} + \mu_i + \varepsilon_{it} \tag{2}$$

To investigate the mediating role of human capital in promoting entrepreneurial vitality, the following models are further specified. $Hcap_{it}$ represents human capital, while the remaining variables have the same meanings as in Model (1).

$$Hcap_{it} = \beta_0 + \beta_1 Dige_{it} + \theta X_{it} + \mu_i + \varepsilon_{it} \tag{3}$$

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$$Enp_{it} = \beta_0 + \beta_1 Hcap_{it} + \theta X_{it} + \mu_i + \varepsilon_{it} \quad (4)$$

4.2. Variable selection

This study uses entrepreneurial vitality (Enp) as the dependent variable. Following the approach of Bai et al. [16], the number of newly established enterprises in each province is standardized using the population method, resulting in entrepreneurial vitality measured as the number of new enterprises per one million people. The core explanatory variable is the digital economy (Dige). Drawing on Wang et al. [17], the digital economy index is constructed from four dimensions: digital industrialization, industrial digitalization, digital infrastructure, and digital innovation factors. A hierarchical entropy weighting method is applied to generate a comprehensive digital economy development index. Human capital (Hcap) is measured by the proportion of the regional population with higher education, defined as the share of individuals with a college degree or above among the population aged six and older.

To comprehensively assess the potential spillover effects of the digital economy on regional entrepreneurial vitality, several control variables are included based on prior research: the share of employment in the tertiary sector (lnter, the logarithm of the proportion of tertiary employment), infrastructure (road, measured by total road mileage), and credit scale (lnloan, the logarithm of the year-end outstanding RMB loans of financial institutions). These variables capture additional factors that may influence changes in entrepreneurial activity.

4.3. Data source and descriptive statistics

This study utilizes panel data from 30 Chinese provinces (excluding Tibet, Hong Kong, Macao, and Taiwan) covering the period 2013–2022. The data are primarily drawn from the China Statistical Yearbook of various years, the National Bureau of Statistics database, and the China Socioeconomic Big Data Research Platform. Descriptive statistics of all variables are presented in Table 1. As shown, although the spatial and temporal variation in the digital economy across China is not pronounced, the overall national level of digital economic development remains relatively low. In contrast, substantial disparities exist in human capital and infrastructure across provinces and over time, reflecting the uneven distribution of resource endowments and economic development. In particular, the western region faces constrained entrepreneurial conditions due to geographical limitations and lower levels of economic development.

Table 1. Descriptive statistics of variables (N=300)

Variable	Mean	Std Dev	Min	Max
Enp	9.281	0.297	8.539	10.431
Dige	0.130	0.122	0.015	0.776
Hcap	16.027	7.805	6.810	50.486
ln ter	-0.822	0.215	-1.399	-0.185
ln loan	10.296	0.907	6.570	12.412
road	15.868	8.444	1.260	40.540

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5. Analysis of empirical results

5.1. Benchmark regression

The baseline regression results on the relationship between the digital economy and entrepreneurial activity are reported in Table 2. Columns (1)-(4) present the outcomes as control variables are added sequentially. Column (1) includes only the core explanatory variable—the digital economy—while Columns (2)-(4) incorporate additional controls step by step. The findings reveal that the estimated coefficient of the digital economy is significantly positive. Although the magnitude of the coefficient declines with the inclusion of more controls, it remains statistically significant at the 10% level. This indicates that digital economy development exerts a positive effect on entrepreneurial dynamism. Specifically, a 1% increase in the level of the digital economy raises regional entrepreneurial activity by 74.7%, thereby validating Hypothesis 1.

Regarding the control variables, the share of employment in the tertiary sector significantly enhances entrepreneurial activity. The coefficient of credit scale is also positive, but its effect weakens once infrastructure is accounted for. As an indicator of economic development, credit scale reflects the intensity of regional economic activity. Its influence on entrepreneurship varies across development stages. At the early stage of urbanization, when infrastructure remains underdeveloped, credit expansion by financial institutions plays a more prominent role in stimulating entrepreneurship.

Considering that the digital economy's contribution to entrepreneurial vitality may differ across stages of development, a nonlinear specification is further tested by including the squared term of the digital economy (Digesq) in model (2). The results, shown in Column (5) of Table 2, indicate that the coefficient of Digesq is negative and statistically significant at the 1% level. This suggests an inverted U-shaped relationship, whereby the digital economy initially strengthens entrepreneurial activity but the effect diminishes once digitalization surpasses a certain threshold. Thus, while the digital economy provides short-term impetus to urban innovation and entrepreneurship, its long-term impact tends to moderate, again supporting Hypothesis 1.

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Table 2. Baseline regression results (N=300)

Variable	Enp				
	(1)	(2)	(3)	(4)	(5)
Dige	2.134*** (0.605)	1.058** (0.521)	0.842* (0.459)	0.747* (0.397)	3.736*** (0.905)
Digesq					-3.755*** (1.110)
ln ter		1.093*** (0.304)	0.918*** (0.317)	0.688** (0.316)	0.418 (0.279)
ln loan			0.086* (0.046)	0.075* (0.040)	0.057* (0.034)
road				0.034** (0.014)	0.014 (0.015)
Industry fixed			Yes		
Constant	8.427*** (0.194)	9.014*** (0.218)	8.103*** (0.578)	8.134*** (0.505)	7.769*** (0.485)
R^2	0.281	0.423	0.443	0.466	0.513

Note: Robust standard errors are in parentheses; ***, **, and * denote significance levels of 1%, 5%, and 10%, respectively, as in the table below.

5.2. Robustness and endogeneity test analysis

This study employs three approaches to verify the robustness of the preceding empirical findings, with the regression outcomes reported in Columns (1)-(3) of Table 3. (1) Excluding the pandemic year: The COVID-19 outbreak, as a global shock, exerted profound impacts on economic, social, and environmental systems. To ensure consistency and comparability, the data for 2020 are excluded, and the corresponding regression results are presented in Column (1). (2) Excluding municipalities: Given that municipalities such as Beijing, Shanghai, Tianjin, and Chongqing possess a distinct advantage in digital economy development, their observations are removed and the analysis is re-estimated with the remaining provinces. (3) Winsorization: To mitigate the influence of potential outliers in the baseline regressions, all relevant variables are winsorized at the 1% and 99% quantiles. This procedure reduces bias caused by extreme values. Across these three specifications, the positive effect of the digital economy on entrepreneurial activity remains stable, indicating that the results are robust.

In addition, possible endogeneity concerns are addressed by employing the one-period lag of the digital economy as an instrumental variable. The first-stage regression, reported in Column (4), shows that the instrument is strongly correlated with the endogenous regressor, with a significantly positive coefficient at the 1% level and a Kleibergen–Paap rk Wald F-statistic of 494.096, ruling out the weak-instrument problem. The second-stage regression, reported in Column (5), further demonstrates that the coefficient of the digital economy variable remains significantly positive. Hence, after addressing endogeneity, the core conclusion still holds—digital economy development continues to exert a significant promoting effect on entrepreneurial vitality.

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Table 3. Robustness and endogeneity test results

Variable	(1)	(2)	(3)	(4)	(5)
	Excluding year2020 samples	Excluding municipalities	Winsorizing	Instrumental variable method	
Dige	0.673*	0.618*	0.880**		0.682***
	(0.387)	(0.375)	(0.391)		(0.200)
Ldig				1.031***	
				(0.046)	
Controls			Yes		
Industry fixed					
Constant	8.232***	7.026***	7.979***	-0.003	8.252***
	(0.493)	(0.852)	(0.526)	(0.019)	(0.302)
N	270	260	300	270	270
R^2	0.496	0.476	0.480	0.994	0.687

5.3. Mechanism analysis

As shown in Column (1) of Table 5, when the dependent variable is human capital, the coefficient of digital economy development is 18.910 and significant at the 1% level, indicating that digitalization plays a facilitating role in enhancing human capital. Column (2) reports that the coefficient of human capital on entrepreneurial vitality is 0.022, significant at the 5% level, suggesting that improvements in human capital contribute to the growth of regional entrepreneurial activity. Taken together, these results demonstrate that the development of the digital economy helps to elevate human capital, which in turn fosters higher levels of entrepreneurial vitality, thereby confirming Hypothesis 2.

Table 4. Mechanism test results (N=300)

Variable	(1)	(2)
	Hcap	Enp
Digeco	18.910***(4.732)	
Hcap		0.022**(0.009)
ln ter	11.160***(2.354)	0.517*(0.310)
ln loan	-0.245(0.317)	0.091**(0.041)
road	0.344***(0.119)	0.029**(0.015)
Industry fixed	Yes	
Constant	44.100***(3.590)	7.185***(0.642)
R^2	0.634	0.475

5.4. Heterogeneity analysis

Due to variations in resource endowments and stages of development, the digital economy exhibits significant regional heterogeneity, which implies that its impact on entrepreneurial vitality may also differ across areas. Following the common classification in related studies, this paper divides the

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sample into eastern, central, western, and northeastern cities for grouped regressions, with the results presented in Table 5. The findings indicate that the digital economy exerts a statistically significant influence on entrepreneurial vitality in the western region at the 1% level, whereas its effect is not significant in the other three regions. This suggests that the capacity of the digital economy to stimulate entrepreneurship is shaped by underlying local foundations, resource conditions, and geographical contexts.

A possible explanation is that the eastern, central, and northeastern regions face higher market saturation and more intense competition, which weakens the marginal stimulus of the digital economy on entrepreneurship. By contrast, the western region, benefiting in recent years from preferential policies and improved resource allocation, has lowered barriers to entry and leveraged its latecomer advantage to overcome traditional entrepreneurial constraints. Consequently, entrepreneurial vitality has been markedly enhanced in the west, providing empirical support for Hypothesis 3.

Table 5. Heterogeneity analysis

Variable	Enp			
	Eastern	Central	Western	Northeastern
Digeco	-0.178	-0.969	2.943***	-0.260
	(0.386)	(1.468)	(0.736)	(3.904)
Constant	9.808***	-4.084	6.849***	4.557
	(1.363)	(3.976)	(1.045)	(1.562)
Controls	Yes			
Province fixed				
N	100	60	110	30
R^2	0.554	0.700	0.570	0.538

6. Conclusion and recommendation

6.1. Conclusion

Based on panel data from 30 Chinese provinces between 2013 and 2022, this study systematically explores the interconnections among the digital economy, human capital, and entrepreneurial vitality. The results show three key findings: (1) the effect of the digital economy on entrepreneurship follows an inverted U-shaped trajectory, where it significantly stimulates entrepreneurial activity at the early stage but shows diminishing marginal returns once reaching a certain level; (2) digital development contributes to the improvement of human capital, which in turn strengthens regional entrepreneurial dynamism; and (3) the western region, benefiting from combined policy support and a relatively weak initial foundation, experiences stronger entrepreneurial stimulation from the digital economy compared with the central, eastern, and northeastern regions.

6.2. Recommendation

Building on these findings, several policy recommendations are proposed. First, strengthening digital infrastructure and institutional frameworks is essential to enhance the entrepreneurial driving

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force of the digital economy, including expanding 5G networks, data centers, and industrial internet, while also advancing digital finance to ease financing constraints. Second, reinforcing human capital development should be prioritized through education reform, digital skills training, industry–education integration, and policies that attract both high-end digital professionals and returning youth entrepreneurs. Third, differentiated regional strategies are needed: the eastern region should serve as a leader and disseminator of advanced practices, the western region should leverage policy advantages and resource endowments to foster digital industries and green energy applications, while the central and northeastern regions should accelerate digital infrastructure construction and promote cross-regional flows of computing power and data to narrow disparities and enhance overall entrepreneurial vitality.

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