



Research article

Research on factors influencing the academic entrepreneurial ability of teachers in the digital age: Evidence from China

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ABSTRACT

In the contemporary digital economy, economic development increasingly relies on the innovation and dissemination of knowledge. Academic entrepreneurship, as a direct channel for knowledge dissemination into the marketplace, is significantly influenced by digital technology. Consequently, how to improve academic entrepreneurial ability has become a hot research topic. This study is grounded in the theory of reciprocal determinism within the context of the digital economy. We use the “2019 China Digital Economy Development Index White Paper” and collect data from 1843 survey questionnaires in China to conduct empirical research with a ridge regression model. It primarily focuses on the following individual factors and social environmental factors on academic entrepreneurial ability of teachers (AEAT): digital economy (DE), organizational support (OS), policy environment (PE), and personal learning growth (PLG). First, the findings show that the DE, OS, PE, and PLG have a significant positive impact on improving AEAT. Second, the results also indicate that social environmental factors relative to personal factors will have a greater impact. Finally, this study not only presents the first attempt to establish a connection between DE and AEAT but also holds significant managerial implications for enhancing AEAT within the context of the DE. Despite the increasing body of literature on academic entrepreneurship, the research domain pertaining specifically to AEAT remains fragmented and lacks comprehensive theoretical development. There is a pressing need for more systematic and thorough investigations to unveil the black box of factors influencing AEAT in the context of the DE.

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1. Introduction

Currently, the world is undergoing a new round of technological revolution and industrial transformation [1]. Digital technologies represented by the Internet, big data, and artificial intelligence have permeated all economic and social fields [2,3]. The widespread proliferation and rapid advancement of digital technology have redefined the fundamental nature of the economy and the foundational principles of entrepreneurship [4]. Simultaneously, it is fundamentally altering the business environment. The characteristics of the digital economy environment, which is based on knowledge and centered around mobility, will have a transformative impact on the entrepreneurial landscape [5,6]. In driving entrepreneurial activities, it offers diverse channels. Including digital platforms [7], digital services [8,9], and digital infrastructure [10,11], among others. Overall, digital technology liberates entrepreneurship from constraints [12], enabling digital entrepreneurship to enhance competitiveness, improve efficiency, and foster innovation within businesses [2].

Academic entrepreneurship has attracted major attention both within the academic literature, policy community as well as business community [13]. It is considered as being an important element in the evolution toward a knowledge society [14,15]. With the cross-integration of scientific and economic fields, the scientific research of universities has increasingly shown a trend toward commercialization and entrepreneurship [16]. University researchers have also increasingly begun accessing the market and engaging in academic entrepreneurial activities [17]. They play a crucial role in creating a sustainable future by becoming innovators through researching activities [18]. So-called academic entrepreneurship refers to the behavior of academic derivative enterprises created by teachers to commercialize the development of knowledge, technology, or other research results created within the university, so as to transfer the academic research results to the market [19]. Currently, teachers generally categorize the forms of academic entrepreneurship into two types [20]. The first type is commercial academic entrepreneurial activity, which includes (1) company establishment, (2) patent licensing, (3) technology transfer, (4) contract (agreement) research (including independent research and development and cooperative research and development), and (5) paid consulting and training. The second type is non-commercial academic entrepreneurship activity (social entrepreneurship), which includes (1) providing suggestions and public speeches, (2) organizing exhibitions, and (3) the publishing works (i.e., the ability to effectively transfer the knowledge of academic institutions to the external social environment and bring economic or social value) [21].

Digital transformation has changed the ways and mechanisms of acquiring knowledge, with academic entrepreneurship serving as a direct channel for knowledge to enter the market [22]. Digital technology and academic entrepreneurship are closely intertwined, exerting a disruptive impact on academic entrepreneurship [2]. The recent advancements in digital transformation demand that the concept of academic entrepreneurship evolves towards a digital direction, giving rise to the notion of digital academic entrepreneurship [23]. This emerging wave of digital academic entrepreneurship will present significant challenges in navigating aspects such as technological considerations, effective management strategies, government policies, and the engagement of stakeholders in the academic entrepreneurship process [2]. Digital technology, as an effective tool, helps stimulate active engagement of stakeholders in entrepreneurial activities. For instance, in specific contexts, academic entrepreneurs may find themselves compelled to develop products and services that cater to digital demands, thus creating opportunities and fostering innovation [24]. Given the context of the DE, the objective of higher education is to develop academic entrepreneurship in its business and social ecosystem [25]. Teachers, as the key individuals in promoting academic commercialization, are the more entrepreneurial and aware of the digital potential [11]. Through teachers' academic entrepreneurship, academic achievements are applied to practice, thus solving social and environmental problems and making important contributions to sustainable development. Therefore, investigating how to improve the academic entrepreneurial ability of teachers (AEAT) and exploring the influential factors of academic entrepreneurship can play an important role in generating huge economic and social value [26].

Studies have pointed that characteristics at both the national level (e.g., intellectual property legislation) and the university level (organizational environment, technology transfer platforms) may impede the emergence of academic entrepreneurial behavior [27–29]. Meanwhile, some researchers believe that examining academic entrepreneurship at the individual level contributes to a deeper understanding of academic entrepreneurship [30,31]. To our knowledge, existing research has largely ignored the current context of digital transformation, with limited reference to digital technologies and their prominent role in AEAT. Consequently, academic research on this subject remains largely fragmented. In light of the development of digital transformation, a turning point has been reached where it is necessary to reconsider academic entrepreneurship for teachers. In contrast to previous studies, this paper is grounded in the theory of reciprocal determinism within the context of the digital economy. The research framework encompasses both personal and social environmental factors, collectively influencing AEAT. The underlying assumption behind our study is that digital technologies can be leveraged in academia to pursue the fundamentals of the pervasive entrepreneurial process influencing the process and form of academic entrepreneurship as well as the achievement of entrepreneurial goals involving crowds at universities.

Therefore, our research investigates (1) the factors that affect the AEAT against the background of the digital economy (DE) and (2) how to improve the AEAT in the context of the DE. The primary objective of this article is to integrate the DE and academic entrepreneurship of teachers into the same research framework, in order to identify the factors influencing AEAT and propose strategies for enhancing AEAT in the context of the DE. The possible contributions of this article are as follows. First, this paper not only expands the theoretical understanding of AEAT but also establishes a connection between the digital economy and academic entrepreneurship among teachers. Second, this paper employs empirical data to unveil the black box of factors influencing teachers' academic entrepreneurship capability in the context of the digital economy, studying the mechanisms for enhancing teachers' academic entrepreneurship ability. Third, teachers possess unique characteristics and advantages compared to other individuals. Integrating the DE from the perspective of academic entrepreneurship among teachers enriches the literature in the field of academic entrepreneurship. Finally, with the assistance of this study, favorable support can be provided to enhance digital entrepreneurial ability of teachers and

inspire the spirit of digital entrepreneurship among teachers. In the contemporary digital age, this is particularly crucial. In a word, this research hopes to provide a reference for improving the entrepreneurial ability of academic entrepreneurs, stimulating the vitality of digital entrepreneurship, and building a digital entrepreneurial ecosystem in the context of the DE.

The remaining sections of this article are organized as follows. The next section discusses the theoretical basis, literature review and research hypothesis. Section three explains the research methodology of this study, including the research instrument and the reliability and validity test of the scale. Section four describes the empirical process and presents the analysis results. The fifth section is the discussion. The sixth section is the conclusion. Sections seven and eight respectively cover theoretical contributions and practical implications, while the ninth section addresses research limitations and future research direction.

2. Theoretical basis, literature review and research hypothesis

2.1. Theoretical basis

The theory of Reciprocal Determinism was proposed by the psychologist Albert Bandura (1978), exploring the complex relationships between individual factors, behavior, and the environment [32,33]. The theory emphasizes the reciprocal interactions among these three elements, suggesting that behavior, individual factors, and the environment mutually influence each other. Within this theoretical framework, individual factors influence the individual's behavior. Additionally, the formation of individual characteristics, including personality traits and cognitive factors, is influenced by the surrounding environment, but this influence is not absolute and depends on the individual's grasp of these factors. Furthermore, under the influence of the environment, the outcomes of behavior can change, and human behavior has the ability to alter and shape the environment. This indicates that the relationship between individuals and the environment is one of mutual influence and mutual shaping. Reciprocal Determinism posits that, under the influence of both the environment and individual factors, human behavior undergoes changes. The occurrence and success of academic entrepreneurship depend not only on institutional and environmental factors but also on the individual background and attributes of prospective entrepreneurs, such as entrepreneurial motivation, intention, and existing knowledge and experience [34]. According to a recent Finnish study, entrepreneurial teachers are a major component of the institutional environment and will be influenced by personal growth and development within the institution [35]. Overall, the entrepreneurial ability of university entrepreneurship teachers is affected by government policies at the macro level, by the school system and incentive measures at the meso-level and by the individual factors of the teachers at the micro level.

These viewpoints contribute to explaining why entrepreneurs exhibit different behaviors within specific domains. Bandura's Reciprocal Determinism provides the fundamental theoretical foundation for this article, offering a systematic perspective for understanding the relationships among individual factors, behavior, and the environment.

2.2. Literature review and research hypothesis

In the field of entrepreneurship research, Chandler and Hanks proposed the concept of entrepreneurial ability in 1993, defining it as "the ability to identify, foresee and take advantage of opportunities." This is considered the core ability of entrepreneurship and will continue to be strengthened as entrepreneurs become more familiar with the market [36]. Bird proposed the concept of entrepreneurial ability earlier, defining it from a trait perspective as the inherent capacity of entrepreneurs, encompassing factors such as motivation, personality, and risk-taking propensity [37]. Therefore, entrepreneurial ability is a very complex and multi-dimensional concept [38,39]. It comprises the key skills and tacit knowledge possessed by entrepreneurs [40]. It is a kind of intellectual and technological capital owned by individuals. As a high-level feature, it encompasses personality, skills, and knowledge and is considered the overall ability of entrepreneurs to perform their duties successfully.

A qualified academic entrepreneurial teacher must have an entrepreneurial spirit, entrepreneurial knowledge, professional ability, teaching ability, and research ability [41]. An analysis of the literature on entrepreneurial ability reveals that entrepreneurial ability of entrepreneurial teachers in universities is the ability of individual teachers to transform their ideas into action. Teachers and entrepreneurs have the same perspective on entrepreneurial capabilities. However, as individuals or groups with unique academic attributes, university entrepreneurial teachers possess varying entrepreneurial capabilities. Effectively balancing the relationship between academia and entrepreneurship is crucial for teachers [31], primarily achieved by transforming their academic prowess into entrepreneurial skills, essentially constituting academic entrepreneurial ability.

In the era of the DE, the tremendous waves of globalization and technological advancements are creating new market forces [12, 42]. Teachers have been increasingly placing academic entrepreneurship research against the background of the DE. Based on reciprocal determinism theory and existing research, our research design framework involves individual factors and social environment factors, we conclude that the AEAT is affected by four factors: digital economy (DE), organizational support (OS), policy environment (PE) and personal learning growth (PLG).

2.2.1. Impact of the DE on the AEAT

The current DE is rapidly becoming an important driving force for global economic and social development [43]. Estimating the growth level of economic globalization should not only reflect the current economic development scale but also pay attention to its future development potential [44]. Some teachers believe that digital technology has the potential to profoundly influence the basic principles, processes, and forms of academic entrepreneurship, as well as the stakeholders involved in achieving university entrepreneurial goals [45]. An increasing number of universities are incorporating digital technologies into their academic activities, which

is expected to accelerate the competitiveness of academic startups in comparison to the traditional academic startup market [46]. Digital technology has the potential to support the transformation of the traditional motivation behind academic entrepreneurship [47]. This transformation extends beyond the pure economic value generated by the commercialization of university research to encompass broader social and democratic values generated through the active participation of various university stakeholders [23]. Nowadays, the motives of academic entrepreneurship include not only personal material or non-material benefits but also encompass multiple stakeholders such as employers, governments, or companies [48]. The increasing popularity of technology has expedited the democratization process. Technologies such as social media, Massive Open Online Courses (MOOCs), and virtual platforms have democratized opportunities for acquiring high-quality entrepreneurial experience and cultivated broader potential for stakeholders in academic entrepreneurship [49]. Within academia, researchers and students can now connect with a broader network of individuals, enabling them to discover new opportunities and enrich their entrepreneurial ideas [10].

The first hypothesis in this study seeks to confirm the relationship between the DE and the AEAT.

Hypothesis 1. The DE has a significant positive impact on the AEAT.

2.2.2. Impact of OS on the AEAT

Alessandrini (2013) asserts that the key success factors for academic entrepreneurship include clear policies, top management commitments, and a supportive working environment [50]. Specifically, the organizational characteristics of universities will affect the entrepreneurial participation of teachers. It is important to acknowledge that the level of OS provided by different universities may vary [27]. Senior managers of universities need to develop and support “interactions between institutions and other stakeholders to generate entrepreneurial ability and enhance the socio-economic impact of the university” [51]. The OS factors have yielded both expected and unexpected results. Organizational management support can influence the entrepreneurial atmosphere within the institution, consequently affecting the academic entrepreneurial behavior of teachers [35]. Time allocation, as an OS factor in university entrepreneurial activities, positively influences academic entrepreneurial output. In addition, research institutions, industry and government can collaborate to establish a conducive academic entrepreneurship ecosystem, which plays a vital role in fostering innovation within the academic environment [52]. Nelles and Vorley also contend that all components of an organization must work together in a mutually supportive way to promote the success of academic entrepreneurship [53]. Perceived support within an organization is characterized by individuals feeling valued, secure, and essential, with their opinions holding significance; this significantly contributes to individual creativity [54].

The second hypothesis in this study seeks to confirm the relationship between OS and the AEAT.

Hypothesis 2. The OS has a significant positive impact on the AEAT.

2.2.3. Impact of PE on the AEAT

The entrepreneurial abilities of university teachers are affected by government policies at a macro level. Effective entrepreneurial policies and actions should operate at multiple levels [55]. Furthermore, these policies need to be integrated within and outside organizations and individuals [56]. The effectiveness of a university in academic entrepreneurship is a policy issue related to the operation and objectives of the university organization [28]. The Chinese government has introduced numerous policies that have significantly promoted entrepreneurship education [41]. The research discovered that after the introduction of the *Bayh-Dole Act* in the United States (that is, the ownership of government-funded university research results is with universities) [57], developers actively pursued patents and showed a strong interest in commercialization [15,58]. Conversely, other studies have shown that government-sponsored invention patent rights belong to the inventor. It may inhibit the creation of spin-offs [59]. Goldfarb and Henrekson argue that the introduction of national policies influences the academic entrepreneurship of teachers [60]. Government funding schemes help to reduce the institutional problems of adverse selection and moral hazard in the relationship between the government and actors involved in research commercialization. Additionally, these initiatives promote the emergence of academic entrepreneurial activities within universities [61].

The third hypothesis in this study seeks to confirm the relationship between PE and the AEAT.

Hypothesis 3. The PE has a significant positive impact on the AEAT.

2.2.4. Impact of PLG on the AEAT

The personal knowledge, skills, and experience acquired by individuals through education, on-the-job training, and other experiences that enhance work efficiency can equip academic staff with higher cognitive abilities, enabling them to undertake demanding tasks [62]. The success of academic entrepreneurship depends not only on institutional and environmental factors but also other personal attributes of teachers [34,63]. Teachers' awareness of lifelong learning will influence their level of academic entrepreneurship, with a moderate increase observed as their inclination toward lifelong learning grows [64]. Many research-oriented teachers mentioned that engaging in teaching-related entrepreneurial activities allows them to gain a deeper understanding of industry trends and expand their professional networks [65,66]. In this study, we posit that this synergy arises from the combination of knowledge, skills, and networks, which can further enhance the entrepreneurial capabilities of educators. When teachers actively participate in relevant training and seminars, they engage in informal interactions with their peers. These informal discussions facilitate their comprehension of emerging industry trends, thereby enhancing their entrepreneurial abilities [67]. Teachers with a high degree of entrepreneurial ability and that grow through personal learning will be more likely to participate in entrepreneurial initiatives initiated by others or start their own enterprises [68]. The experiences of individuals who have indirectly participated in

entrepreneurial activities through their students or colleagues can influence their inclination toward entrepreneurship [69].

The fourth hypothesis in this study seeks to confirm the relationship between PLG and the AEAT.

Hypothesis 4. The PLG has a significant positive impact on the AEAT.

Based on the above four hypotheses, a mechanism model for improving AEAT against the background of the DE is established, as shown in Fig. 1.

3. Research method

3.1. Research instrument

In this study, we collected data from two primary sources: questionnaire survey data and data extracted from the “2019 China Digital Economy Development Index White Paper” (full version, hereinafter referred to as *the white paper*). We matched survey data with DE data, both covering 30 provinces (autonomous regions and municipalities directly under the Central Government) in China and maintaining consistency over time.

First, the questionnaire of this research mainly included the basic information of the interviewed entrepreneurial teachers, OS, PE, PLG, and the evaluation of the AEAT (refer to Table 1). We conducted the survey from September 15, 2018, to January 18, 2019. On the basis of random sampling, the questionnaire surveyed 30 provinces in China, with a doctorate degree (post-doctoral degree) required for respondents. A total of 2000 questionnaires were distributed in China, and 1843 valid questionnaires were collected (response rate of 92.15%). The questionnaire employed a five-point Likert scale, where 5 represents “Strongly Agree” and 1 represents “Strongly Disagree.” The survey was anonymous, and all data were used for academic research only. Consent from all research participants was obtained by virtue of survey completion.

Second, the DE data used in this study came from *the white paper* issued by the China Electronics Information Industry Development Research Institute (CCID Research Institute, The China Electronic Information Industry Development Research Institute, 2019) (refer to Table 2). The *white paper* employed an index-based approach to assess four key domains of regional digital economy: infrastructure, digital industry, industrial integration, and government environment. The assessment framework comprised 4 primary indicators, 10 secondary indicators, and 38 tertiary indicators, utilized for analyzing the developmental level, potential, and characteristics of the digital economy across various provinces and cities in China. Therefore, the adoption of the Digital Economy Development Index from *the white paper* for the DE data in this study demonstrated a certain level of scientific validity.

3.2. Reliability and validity test of the scale

Cronbach’s alpha, determined using SPSS 25.0 software, was used to assess the reliability of the scale. Cronbach’s alpha of the OS scale, PE scale, PLG scale and AEAT scale were all greater than 0.8. Exploratory factor analysis, using SPSS 25.0 software, was employed to test validity. The KMO values of the OS scale, PE scale, PLG scale, and AEAT scale were higher than 0.7, indicating that the variables had a strong partial correlation. Simultaneously, the approximate chi-square values of Bartlett statistics were all significant, indicating that the correlation coefficient matrix between variables was unlikely to be an identity matrix and that they were correlated. The factor loading value of each scale was above 0.5, and there was no cross-factor phenomenon.

AMOS 24.0 software was used to further explore the reliability and validity through confirmatory factor analysis. Here, we tested the overall model fit index, divided into the absolute fit index, value-added fit index, and simplified fit index. The values for the absolute fit index were as follows: RMR = 0.018 (<0.05), RMSEA = 0.049 (<0.08), GFI = 0.977 (>0.9), and AGFI = 0.962 (>0.9). The values for the value-added fit index were as follows: CFI = 0.987 (>0.9), NFI = 0.984 (>0.9), TLI (NNFI) = 0.982 (>0.9), and IFI =

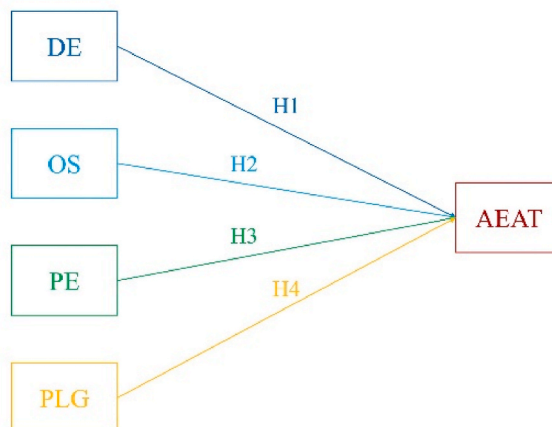


Fig. 1. Theoretical model of the study.

Table 1
Confirmatory factor analysis.

Factor (latent variable)	Measurement item (observable variables)	Std. Estimate	Reliability coefficient	Measurement error	CR	AVE
OS	X11: a systematic special planning for entrepreneurial development	0.849***	0.721	0.279	0.885	0.720
	X12: set up a special business management department	0.810 ***	0.656	0.344		
	X13: equipped with full-time management personnel	0.888 ***	0.789	0.211		
PE	X21: emphasizes inter-academic or inter-disciplinary entrepreneurship education cooperation mechanism	0.841 ***	0.707	0.293	0.890	0.730
	X22: encourage entrepreneurship based on innovation or high-end technology	0.863***	0.745	0.255		
	X23: the school actively implements the entrepreneurial support policies issued by governments at all levels	0.861***	0.741	0.259		
PLG	X31: relevant teachers go to the company for temporary training	0.793***	0.629	0.371	0.863	0.678
	X32: incorporate teachers' personal entrepreneurial performance into teacher performance evaluation standards	0.834***	0.696	0.304		
	X33: set up entrepreneurship teaching and research projects for teachers	0.842***	0.709	0.291		
AEAT	Y1: possess strong identifying entrepreneurial opportunities skills	0.879***	0.773	0.227	0.889	0.727
	Y2: possess strong entrepreneurial opportunity development skills	0.843***	0.711	0.289		
	Y3: possess strong management, operation and coordination of entrepreneurial project skills	0.836***	0.699	0.301		

Note: N = 1843. *p < 0.1, **p < 0.05, ***p < 0.01.

Table 2
The DE date of the research.

Number	Province	DE
1	Guangdong	69.3
2	Beijing	56.5
3	Jiangsu	56.1
4	Shanghai	52.7
5	Zhejiang	50.8
6	Shandong	48.1
7	Fujian	42.6
8	Sichuan	40.6
9	Henan	35.3
10	Hubei	34.8
11	Anhui	33.1
12	Hunan	31.8
13	Liaoning	31.4
14	Chongqing	29.4
15	Jiangxi	28.6
16	Hebei	27.7
17	Guizhou	27.4
18	Guangxi	27.1
19	Shaanxi	26.5
20	Tianjin	24.9
21	Shanxi	24.4
22	Heilongjiang	23.9
23	Jilin	23.3
24	Yunnan	22.0
25	Hainan	19.5
26	Inner Mongolia	19.5
27	Gansu	19.2
28	Xinjiang	18.2
29	Qinghai	16.1
30	Tibet	12.7

Note: Province (autonomous regions and municipalities directly under the Central Government).

0.987 (>0.9). The values for the simplified fit index were as follows: PGFI = 0.601 (>0.5) and PNFI = 0.716 (>0.5). The fit index of the confirmatory factor analysis model met the standard. Table 1 shows the results of the confirmatory factor analysis. The CR was 0.885 for OS, 0.890 for PE, and 0.863 for PLG. The CR was 0.889 for the AEAT. All values were greater than the standard of 0.7, indicating good reliability. AVE is an indicator of convergence validity calculated using a standardized factor loading value and measurement

errors. The AVEs for OS, PE, PLG, and the AEAT were 0.720, 0.730, 0.678, and 0.727, respectively. All values were greater than 0.5, indicating good convergence validity.

The Pearson’s correlation coefficient and the square root of AVE can be used to analyze discriminant validity. If the square root of AVE for a factor is greater than the absolute value of the correlation coefficient between the factor and other factors, and all other factors present such a conclusion, it means that they have good discriminant validity. Table 3 shows the results. This indicated that the discriminant validity was better.

In summary, the scale had good reliability and validity.

4. Result

4.1. Descriptive statistics

The 1843 teachers surveyed in this article were all doctors (post-doctoral): 837 (45.4%) female teachers and 1006 (54.6%) male teachers. There were 333 teachers aged 30 and below, accounting for 18.1%, 451 teachers aged 31–35, accounting for 24.5%, 556 teachers aged 36–40, accounting for 30.2%, and 503 teachers aged 41–above, accounting for 27.3%. Among the disciplines covered by teachers, engineering had the highest proportion of 507 (27.5%), followed by management (14.6%) and science (13.0%) and economics (10.7%). In terms of academic titles, senior titles accounted for the majority (24.6%). Deputy senior titles accounted for 40.2%, intermediates accounted for 30.0%, juniors accounted for 3.1%, and the unrated accounted for 2.1%. The surveyed teachers come from different types of schools, including “double first-class” universities, ordinary colleges, independent colleges, vocational colleges, and others. There were 373 teachers from “double first-class” colleges (20.2%), 1167 teachers from ordinary colleges (63.3%), 50 teachers from independent colleges (2.7%), 184 teachers from vocational colleges (10.0%), 63 teachers from private colleges (3.4%), and 6 teachers from other (no choice made) (0.3%). Table 4 shows the background of the research teachers.

According to the white paper, the average value of China’s DE development index is 32.0, of which 11 provinces and cities are above the average, the maximum value is 69.3, and the minimum value is 12.7. The development of the DE is uneven and shows a gradual decline from the eastern coast of China to the western inland.

The survey questionnaire has four scales: OS, PE, PLG and AEAT; the descriptive statistical analysis is conducted on relevant items. Table 5 shows the results.

4.2. Ridge regression

Ridge regression is a commonly used parameter estimation method. It is used to solve the research algorithm of independent variable collinearity in linear regression analysis [70]. Ridge regression provides analysts with a systematic way to scan many bias estimators. It often leads them to make meaningful estimates of regression coefficients, which can be used to evaluate changes in dependent variables to independent variables and predict the response value at a specified point in the design space [71]. Before applying the ridge regression analysis, it is necessary to confirm the K value with the ridge trace diagram, which is the minimum value of K when the standardized regression coefficient of each independent variable becomes stable. Taking the DE development index, OS, PE, and PLG as independent variables, the AEAT as dependent variables, using software to perform ridge regression analysis, concluded that ridge trace figure (Fig. 2). When the K value is 0.99, the standardized regression coefficient of the independent variable tends to be stable. Therefore, the optimal K value is set to 0.99.

After the K value is determined, it can be actively input, and the ridge regression model estimation can be obtained through the software. Table 6 shows the results.

The ridge regression ANOVA test (also called the F test) is used to determine whether the model is meaningful. DE, OS, PE, and PLG are used as independent variables; AEAT is used as the dependent variable, then conducting ridge regression analysis.

The regression coefficient value of the DE development index was 0.019 ($t = 1.840, p = 0.066 < 0.1$), indicating a statistically significant positive impact of DE on AEAT. The rapid development of DE has always been concerned by the academic community [2]. The process of academic entrepreneurship is intrinsically linked to the influence of digital technology, which can enhance the entrepreneurial orientation of organizational members [72,73]. Digital technologies are widely integrated into university entrepreneurship systems, and an increasing number of universities are embracing these technologies to streamline academic activities. This adoption of digital tools and practices is rapidly enhancing the competitive edge of academic entrepreneurship when compared to traditional approaches. The digital economy presents a wealth of resources and opportunities for academic entrepreneurship among educators, but it also comes with heightened expectations and demands.

Table 3

Discriminant validity: Pearson’s correlation coefficient and AVE square-root value.

	OS	PE	PLG	AEAT
OS	0.849	0.789***	0.685***	0.447***
PE	0.789***	0.854	0.748***	0.445***
PLG	0.685***	0.748***	0.823	0.393***
AEAT	0.447***	0.445***	0.393***	0.853

Note: N = 1843. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The diagonal is the square-root value of the average variance extracted (AVE).

Table 4
Descriptive statistics of the background of the research teachers.

	Variable	Frequency	Percentage (%)
Gender	Man	1006	54.6%
	Women	837	45.4%
Age	≤30	333	18.1%
	31~35	451	24.5%
	36~40	556	30.2%
	≥41	503	27.3%
Discipline fields	Philosophy	63	3.4%
	Economics	198	10.7%
	Law	98	5.3%
	Pedagogy	88	4.8%
	Literature	65	3.5%
	History	37	2.0%
	Neo-Confucianism	240	13.0%
	Engineering	507	27.5%
	Agronomy	74	4.0%
	Medicine	129	7.0%
	Military science	17	0.9%
	Management	269	14.6%
	Art	58	3.1%
Professional title	Senior	454	24.6%
	Deputy senior	740	40.2%
	Intermediate	553	30.0%
	Junior	58	3.1%
	Unrated	38	2.1%
The type of school	"Double first-class" universities	373	20.2%
	Ordinary colleges	1167	63.3%
	Independent colleges	50	2.7%
	Vocational college	184	10.0%
	Private colleges	63	3.4%
	Other (no choice made)	6	0.3%

Note : N = 1843.

Table 5
Descriptive statistical analysis of items in the survey scale.

Scale	Item	Minimum	Maximum	Mean (M)	Variance
OS	X11: a systematic special planning for entrepreneurial development	1.00	5.00	3.863	0.847
	X12: Set up a special business management department	1.00	5.00	3.889	1.016
	X13: Equipped with full-time management personnel	1.00	5.00	3.841	0.965
PE	X21: Emphasizes inter-academic or inter-disciplinary entrepreneurship education cooperation mechanism	1.00	5.00	3.819	0.919
	X22: Encourage entrepreneurship based on innovation or high-end technology	1.00	5.00	3.865	0.905
	X23: The school actively implements the entrepreneurial support policies issued by governments at all levels	1.00	5.00	3.890	0.837
PLG	X31: Relevant teachers go to the company for temporary training	1.00	5.00	3.763	0.945
	X32: Incorporate teachers' personal entrepreneurial performance into teacher performance evaluation standards	1.00	5.00	3.744	1.034
	X33: Set up entrepreneurship teaching and research projects for teachers	1.00	5.00	3.856	0.911
AEAT	Y1: Possess strong identifying entrepreneurial opportunities skills	1.00	5.00	4.099	0.694
	Y2: Possess strong entrepreneurial opportunity development skills	1.00	5.00	4.051	0.716
	Y3: Possess strong management, operation and coordination of entrepreneurial project skills	1.00	5.00	4.104	0.707

Note : N = 1843.

The regression coefficient value of the OS was 0.137 ($t = 15.592$, $p = 0.000 < 0.01$), which indicates that OS has a significant positive impact on AEAT. Universities, closely linked with teachers, play a pivotal role in providing essential resources and information to academic entrepreneurs for discovering new business opportunities [74]. With the promotion of OS and research commercialization, more and more teachers and scholars actively engage in commercial activities [21,75]. Organizations can provide support in terms of infrastructure (e.g., laboratories, office space), funding and financing channels, legal and intellectual property assistance, helping teachers transform their research outcomes into tangible value, while also bridging the gap between the academic and industrial sectors.

The regression coefficient value of PE was 0.131 ($t = 15.495$, $p = 0.000 < 0.01$), which indicates that PE has a significant positive impact on AEAT. There exists an interaction between PE and teachers' engagement in academic entrepreneurship [45]. The stability and predictability of the policy environment contribute to the establishment of a sustainable innovation ecosystem, instilling

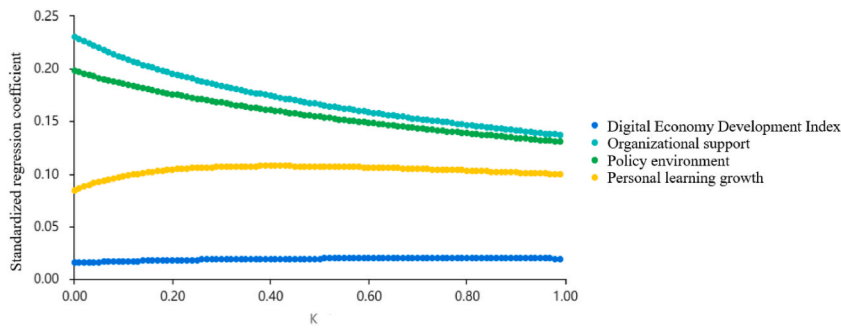


Fig. 2. The ridge trace diagram.

Table 6
Ridge regression analysis results.

Independent variable	Unstandardized Coefficients		Standardized Coefficients	t	p
	B	Std. Error	Beta		
Constant	-0.054	0.036	-	-1.498	0.134
OS	0.137	0.009	0.137	15.592	0.000***
PE	0.131	0.008	0.131	15.495	0.000***
PLG	0.100	0.009	0.100	11.015	0.000***
DE	0.001	0.001	0.019	1.840	0.066*
	Sum of squares	df	Mean square	F	P
Regression	379.443	4	94.861	119.212	0.000
Residual	1462.557	1838	0.796		
Total	1842.000	1842			

Note: N = 1843. *p < 0.1, **p < 0.05, ***p < 0.01. Dependent variable: AEAT.

greater confidence in teachers to smoothly transition between academia and business. Instead of solely focusing on individual factors, institutions should adopt an ecosystem approach and utilize policy decisions to further augment the potential economic impact of academic entrepreneurship [76]. In summary, a favorable entrepreneurial policy environment helps to stimulate teachers' innovative potential, facilitate the integration of knowledge production and practical application, thus driving the development of academic entrepreneurship. It is imperative for government agencies to understand the factors associated with academic entrepreneurship to formulate effective policies.

The regression coefficient value of PLG was 0.100 (t = 11.015, p = 0.000 < 0.01), which indicates that PLG has a significant positive impact on AEAT. It is noteworthy that in studies conducted to date, researchers have paid little attention to the characteristics of individual entrepreneurs, which may play a central role in the commercialization of research results [58]. Therefore, delving into academic entrepreneurship from the individual level can offer a deeper understanding [30]. In the era of the digital economy, teachers should improve their learning ability to produce, use, present and manage information [77,78]. This heightened competence enables them to attain a higher level of innovation and entrepreneurial value, thereby fostering academic entrepreneurship [79].

The summary analysis reveals that the DE, OS, PE, and PLG all exhibit a positive impact on the AEAT. Among them, the coefficient values of OS, PE, and PLG were relatively larger and more significant. However, the coefficient value of the DE was smaller, and the significance was weaker. This discrepancy may be attributed to the current stage of DE development, which is still in its early phases. With the continuous integration of digital technology and academic entrepreneurship, its impact on AEAT will change accordingly. In addition, the effect of PLG on AEAT is smaller than that of OS and PE. This implies that personal factors have a lesser influence on educators' academic entrepreneurship when compared to social environment factors.

5. Discussion

This passage demonstrates the impact of the digital economy on academic entrepreneurial capabilities. This aligns with the research findings of Siegel and Wright, as well as Youssef et al. providing mutual corroboration [45,46]. Additionally, this article further deepens the research. Digital technology is a key driving factor promoting the development of academic entrepreneurship and knowledge-transfer mechanisms. It has the capability to disrupt the traditional rigidity associated with entrepreneurial processes and activities. Through the widespread adoption of innovative digital technologies to bolster emerging forms of academic entrepreneurship and involve a diverse range of stakeholders [80], the field is enriched and elevated to a more academic level. The emergence of digital technology platforms and the development of modern digital infrastructure, which encompass a wide range of technologies including financial technology, data analytic, artificial intelligence, cloud computing, block chain, and more, are collectively fostering the creation of a globally opportunistic ecosystem for academic entrepreneurship. Simultaneously, digital technologies have greatly expanded the set of actors involved in innovation and entrepreneurial processes [4].

OS has a significant positive impact on AEAT. Teacher academic entrepreneurship thrives within a nurturing institutional environment, comprising elements such as financial investments, access to facilities and equipment, and the promotion of an academic culture [28,31]. This comprehensive support environment cultivates an environment conducive to innovation, further igniting the enthusiasm and motivation of teachers to engage in the commercialization of academic research. Universities should emphasize the establishment of organizational structures that encourage teachers to engage in entrepreneurship through avenues such as patent licensing or the creation of new enterprises [81,82]. It is of paramount importance that universities do not overlook the strategic utilization of OS to enhance the academic entrepreneurship of teachers [69].

PE has a significant positive impact on AEAT. Research indicates that policies play a crucial role in influencing entrepreneurship [83]. Higher education institutions globally have formulated a range of regulations and policies in accordance with their respective national or regional constitutions and legal systems [84]. These policies encompass areas such as technology transfer, intellectual property, and industry-academic collaboration frameworks, among others. A favorable policy environment creates conditions conducive to innovation and entrepreneurship, thereby fostering the enhancement of teachers' academic entrepreneurial capabilities.

A significant and positive impact of PLG on AEAT. The existing research has shown that the personal attributes of academic entrepreneurs, such as their experiences, levels of knowledge, and personality characteristics, may play a much larger role than initially perceived [85–87]. For example, some teachers possess specific prior knowledge that enables them to more effectively identify entrepreneurial opportunities. This prior knowledge extends beyond their disciplinary expertise and encompasses areas related to innovation and entrepreneurship, such as market trends, technological developments, and business models. The existing knowledge contributes to bolstering educators' academic entrepreneurial motivation and intentions [30]. Teachers must commit to continuous learning, accumulate extensive knowledge, and augment their abilities to better confront the challenges and seize the opportunities presented in the context of the digital economy [88].

Furthermore, as per the findings of this study, social environmental factors exert a more significant influence on the academic entrepreneurial ability of teachers (AEAT) than personal factors. In other words, the influence of OS and PE on AEAT is likely to outweigh the impact of PLG. This study posits that social environmental factors can create a conducive external environment for educators, thereby fostering academic entrepreneurship from multiple dimensions. These factors collectively not only encourage the initiation of entrepreneurial endeavors by educators but also play a pivotal role in nurturing and amplifying their scholarly entrepreneurial pursuits. Hence, it is imperative for both government entities and university organizations to prioritize the development of a favorable organizational support system and policy environment to enhance AEAT.

Anyway, a theoretical analysis framework for systematically explaining the enhancement of academic entrepreneurship capabilities has not yet been formed. The research contribution of this article lies in its novel synthesis of DE and AEAT. It takes a global perspective on DE and investigates the constructive roles played by DE, OS, PE, and PLG in shaping AEAT.

6. Conclusions

This article conducts an in-depth investigation into the influencing factors of academic entrepreneurial ability among teachers in the digital age. Propose research hypotheses regarding the impact of AEAT from the perspectives of DE, OS, PE, and PLG. We use the "2019 China Digital Economy Development Index White Paper" and 1843 survey questionnaires in China, empirical research is conducted using a ridge regression model. This study's results support hypotheses 1, 2, 3, and 4. The DE, OS, PE, and PLG all positively influence the AEAT.

Firstly, DE has a significantly positive impact on AEAT. With the rapid advancement of technology, the DE has become a crucial engine driving social progress and innovation. In the digital age, teachers are provided with a vast stage where they are not only disseminators of knowledge but also leaders in innovation. The rapid development of digital technologies has greatly transformed the traditional motivations behind academic entrepreneurship, shifting from the pure economic value generated by commercializing research to generating broad social value through the involvement of more university stakeholders. Moreover, the widespread application of the internet and digital tools enables academic entrepreneurs to overcome geographical and disciplinary limitations, swiftly accessing the latest research findings and innovative ideas globally. This circulation of information promotes academic exchange and collaboration, sparking interdisciplinary research cooperation and providing richer resources for academic entrepreneurship. Simultaneously, the DE offers teachers a platform for entrepreneurship, encouraging them to translate research outcomes into practical applications and driving the deep integration of technological innovation with industrial development.

Secondly, OS significantly enhances AEAT. To achieve this, the establishment of a dedicated entrepreneurship management department, equipped with professional management talents, is a crucial step in enhancing AEAT. The creation of such an institution not only helps regulate entrepreneurial activities but also provides necessary support and guidance to teachers, facilitating their innovation and practice. Simultaneously, the formulation of a systematic entrepreneurial development plan is of paramount importance. Through strategic planning, resources can be better integrated, clear goals can be set, and teachers can be provided with an organized and sustainable academic entrepreneurial platform. This systematic planning ensures that teachers receive comprehensive support throughout the entrepreneurial process, enabling them to better address the challenges and opportunities of academic entrepreneurship. Furthermore, the responsibilities of the entrepreneurship management department also include establishing bridges for collaboration with teachers, fostering a deep integration between academia and industry. Through collaboration with external organizations, teachers can effectively translate their research outcomes into practical entrepreneurial projects, achieving the transformation of academic achievements and further enhancing the success rate and impact of their academic entrepreneurship.

Certainly, PE has a significant positive impact on AEAT. Various universities are actively promoting relevant policies to facilitate academic entrepreneurship, emphasizing inter-academic or inter-disciplinary entrepreneurship education cooperation mechanism.

They encourage entrepreneurship based on innovation or high-end technology and actively implement the entrepreneurial support policies issued by governments at all levels. Encouraging teachers to engage in academic entrepreneurship, continually advancing the development of technological patents during the entrepreneurial process, further obtaining cutting-edge technology patents, and promoting the enhancement of their AEAT through the progression of technology.

Finally, PLG have a significant positive impact on AEAT. Academic entrepreneurship is the gradual commercialization of technological patents developed within the university. This process requires comprehensive expertise and an experienced community of entrepreneurial teachers. Throughout this journey, teachers continuously acquire experience and enhance their knowledge through self-learning and personal growth, thereby further elevating their AEAT.

At the same time, the research results indicate that personal factors have a smaller impact on AEAT compared to social environmental factors.

7. Theoretical contributions

This article has made three theoretical contributions to a deep understanding of the academic entrepreneurial ability improvement mechanism of teachers against the background of the DE.

First, this article discovers the role of the DE in improving the AEAT. Although the topics of digital technology and academic entrepreneurship have been largely enriched and investigated separately [6,89,90]. The research on digital academic entrepreneurship is generally still in its infancy, with few relevant studies and a lack of empirical research on large-sample data [11]. Few studies combine DE with AEAT. The research leading to the academic entrepreneurship of DE is still unclear. Based on the theoretical concept of academic entrepreneurship, this research enriches the theoretical concepts of digital academic entrepreneurship. Using the emerging perspective of economics, this article explores the construction of a theoretical framework for DE factors and the academic entrepreneurship of teachers, combining DE with the academic capabilities of teachers, closely following the background of the times, and further enriching the theoretical understanding of the academic entrepreneurship of teachers against the background of the DE.

Second, it reveals the theoretical mechanism for the improvement of the AEAT through OS, PE, and PLG based on the theory of reciprocal determinism. According to previous literature, the research on the impact of digital academic entrepreneurship ability is still in its infancy [22,23]. It mainly focuses on the theoretical elaboration or the phenomenon description of digital academic entrepreneurship [25]. The impact research focuses on the impact of digital technology on academic entrepreneurship. Consequently, the understanding of the factors influencing the AEAT is still in a state of “black box (a system whose internal structure and mechanism of action are unknown).” This research combines the background of the DE, explores the multiple influencing factors of the AEAT, further improves the theoretical understanding of the AEAT, and provides certain insights and reference for follow-up research and related policies.

Third, this study uses a large sample of data, involving 30 provinces in China. A total of 1843 questionnaires were collected. The ridge regression model was used to conduct an empirical analysis of the academic entrepreneurship of teachers against the background of the DE, aiming to improve a sound and rational understanding of the mechanism of improving academic entrepreneurial ability.

8. Practical implications

With the development of the DE, internet thinking and entrepreneurship have become closely intertwined [91]. Although many countries are advocating teachers to carry out academic entrepreneurship and to be innovative. But there are still many deficiencies in practice. The findings of the study propose three practical suggestions for the academic entrepreneurship improvement mechanism of teachers against the background of the DE.

Firstly, we should focus on the cultivation of digital ability and improve the digital entrepreneurial ability of teachers. Digitization represents a key driving factor that promotes the development of academic entrepreneurship and knowledge-transfer mechanisms [45]. First, they need the ability to use digital technology to set the strategic direction—that is, the necessary technology. Second, there should be a commitment to using the entrepreneurial knowledge developed in universities to develop internal technology-transfer ability and research commercialization and to cooperate with governments, enterprises, and society to implement digital academic entrepreneurship strategies.

Secondly, it is imperative to ensure the effective implementation of academic entrepreneurship policies for teachers and the stimulation of their digital entrepreneurial spirit. Inadequate entrepreneurial policies and a lack of entrepreneurial enthusiasm have been observed as hindrances to the enhancement of teachers' entrepreneurial abilities in universities [41,60]. Efforts to guide local departments to implement relevant policies should be strengthened. This includes supporting researchers to take leave and engage in entrepreneurial activities, take leave and engage in entrepreneurial activities, promoting part-time innovation and entrepreneurship, enabling entrepreneurship while retaining their academic positions, and facilitating assignments to work in enterprises. We should stimulate the vitality of digital entrepreneurship, encourage teachers to pursue academic entrepreneurship, and effectively promote the transformation of science and technology into real productivity.

Thirdly, we should build a digital entrepreneurial ecological community to support teachers in all aspects of digital entrepreneurship. The digitization drive has fostered increasing connections among different industries, regions, and enterprises [92], gradually breaking down the barriers imposed by industry, region, and other factors to create a new ‘digital entrepreneurial ecosystem’. This study believes that we can construct an academic entrepreneurship network with a government-led entrepreneurial environment, enhanced university support systems, effective collaboration between academia and industry, and continuous learning and growth opportunities for teachers. This will enable comprehensive support for teachers' digital entrepreneurship initiatives.

9. Limitations and future research directions

There are some limitations in this study. First, the available literature that can be consulted is very limited. Second, it mainly focuses on the benefits of academic entrepreneurship activities but does not consider the hindrance of academic entrepreneurship activities to traditional academic duties. Third, in the choice of variables, the influence of gender difference on academic entrepreneurial activities of teachers was not considered. In the future, we should broaden our research perspective to investigate the impact of academic entrepreneurship on the execution of traditional academic responsibilities in resource-constrained environments. A particular focus should be placed on examining whether there is synergy or competition between these two activities. The novelty of these phenomena opens up multiple research opportunities, such as case studies and database analysis. Additionally, future research should further expand its focus, paying particular attention to the role of gender in academic entrepreneurship.

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Data availability statement

The datasets used and analyzed during the present study are available from the Corresponding author upon reasonable request.

Ethical statement

Ethics approval for this research was not required as per institutional and national guidelines.

Informed consent

No animal studies are presented in this manuscript.
 No human studies are presented in this manuscript.
 No potentially identifiable human images or data is presented in this study.
 Consent from all research participants was obtained by virtue of survey completion.

CRedit authorship contribution statement

Yangjie Huang: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Ying Xu:** Writing – review & editing, Data curation. **Jiali Zhang:** Data curation. **Zehai Long:** Writing – original draft, Data curation. **Zuoyi Qian:** Writing – original draft, Methodology, Conceptualization. **Wenjie Liu:** Investigation, Data curation. **Lu Chen:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix. Please refer to Tables 1 and 3 for the contents of the questionnaire

Abbreviations

AEAT	academic entrepreneurial ability of teachers
DE	digital economy
OS	organizational support
PE	policy environment
PLG	personal learning growth

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