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A Bibliometric Analysis of Research on the Innovation in Universities on WoS Database

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Abstract

In contemporary times, higher education has emerged as a crucial catalyst for innovative education. Therefore, the categorization of research in relevant disciplines holds paramount significance for future innovative education. After conducting a quantitative analysis of 1732 documents sourced from the WoS database, it was observed that, the correlation between academic engagement, higher education system, and academic performance are most important topic in this research field. It is imperative to delve deeper into the depth of pertinent research, particularly by amalgamating sophisticated theories and technologies from other domains, such as psychology and information technology, to augment research in this sphere.

Keywords

Higher education; innovations in universities; Bibliometric Analysis; WoS database

Introduction

Higher education denotes the delivery of pertinent educational circumstances by universities and colleges as the culminating phase of formal long-term learning subsequent to the attainment of secondary education. Studies have substantiated that higher education holds a crucial position in social benefits and knowledge innovation. Nonetheless, the impact of higher education on innovation and entrepreneurship, specifically the economic impact and the mechanism that underlies it, remains indistinct (Audretsch, 2014; Konget.al., 2022). In the present era, the role of technological innovation in the growth of the economy cannot be overstated. In this regard, innovation and entrepreneurship education in higher education institutions serves as a pivotal force in driving technological progress.

Additionally, as time has progressed, the roles and duties of universities in society have undergone substantial changes, transitioning from an emphasis on the exploration of knowledge and learning to an acknowledgement of the knowledge sources that fuel economic advancement. In accordance with Solow's model, labor has become a paramount factor in economic growth, alongside material capital (Solow, 1956). Given the prevailing innovation and entrepreneurship culture, it is crucial to contemplate the creation of new knowledge while advancing technology transfer, knowledge spillover, and entrepreneurial pursuits, while at the same time cultivating students' innovation acumen. This presents a pressing concern that necessitates thoughtful reflection, particularly in light of the pivotal role that universities play in this arena. Consequently, it is essential to re-examine pertinent research to furnish a point of reference for subsequent research and practical application.

Research design and data collection

Research design

Employing the bibliometric methodology, this inquiry examines the significant research on university innovation and entrepreneurship education. By employing mathematical and statistical methods, as well as computer visualization technology, the bibliometric approach enables a comprehensive analysis of numerous documents, allowing for a more in-depth comprehension of the research hotspots and their evolution within the relevant research fields(Demiret.al, 2020; Rodríguez-Lópezet.al, 2020). Co-citation, co-word, and co-authorship analysis are among the commonly utilized methods of analysis(Utkarsh & Sigala, 2021). Citespace is an example of a computer tool that has been developed using relevant research methods(Chen, 2006).

Drawing from typical database options(Koseogluet.al, 2016), The literature data for this study is sourced from the Web of Science (WoS) database, which boasts a vast collection of over 171 million records from more than 34,000 journals. Additionally, the database includes 1.89 billion citated references and is considered a reliable source for neutralization research(Web of Science Group,2023).

Drawing upon the established metrology techniques, this research employs a keyword-based search strategy to extract data from WoS, manually scrutinizes the retrieved literature to identify relevant sources, and subsequently employs Citespace to conduct a thorough metrology analysis of the chosen literature.

Data collection

The WoS core collection was deemed appropriate for the analysis of Citespace software, given that it comprises a range of databases. The search was conducted on March 3, 2023, using the keywords "TI=innovation OR entrepreneur *" AND "TI=higher education OR university * OR college *", with a preference for literature papers. Only English-language papers were included, resulting in a total of 2512 papers. After a detailed examination of their titles and abstracts, a total of 1732 papers were found to meet the criteria.

Data analysis

Major publication of innovation in universities

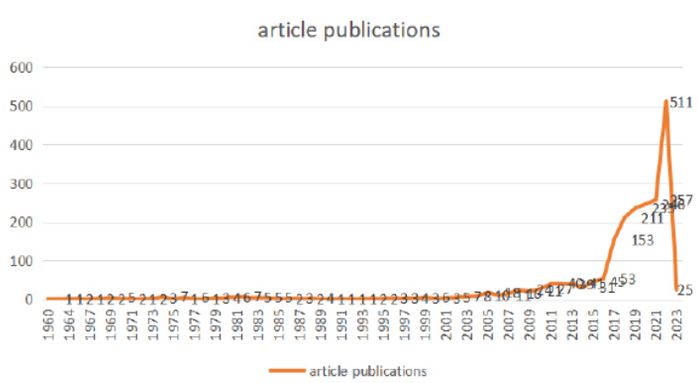

Fig. 1 article publications

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The statistical results concerning the year of publication reveal that the number of research papers published in relevant fields was relatively low before 2010, with an average number of publications. However, between 2011 and 2016, there was a marked increase in the number of publications, indicating a phase of rapid exploration, with an average number of publications. From 2017 to 2022, the field entered a period of rapid development, with an average number of publications reaching a considerable level. The data for the entire year of 2023 is not yet displayed due to the deadline being three months away.

Based on this characteristic, the timeline can be categorized into three phases: the initial phase spanning from 1960 to 2010, the intermediate phase from 2011 to 2016, and the final phase from 2017 to 2022. By analyzing the frequency of highly cited articles during each phase, a more comprehensive comprehension of the development of pertinent research domains can be attained.

During the initial phase, the article delved into the potential correlation between innovation, entrepreneurship, and university education, particularly the cyclical relationship among the university, industry, and government. Institutions are deemed as the safeguarding mechanism for system growth, and universities can assume a crucial function in the knowledge-intensive network innovation process(Etzkowitz & Leydesdorff, 2000).

Table1 Top 10 cited articles between 1960-2010

Rank	Title	Author	Source	Publication Year	Total Citation	Average per Year
1	The dynamics of innovation: from National Systems and Mode 2 to a Triple Helix of university-industry-government relations	Etzkowitz, H; Leydesdorff, L	RESEARCH POLICY	2000	3578	149.08
2	The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm	Etzkowitz, H; Webster, A; Gebhardt, C; Terra, BRC	RESEARCH POLICY	2000	1298	54.08
3	Local geographic spillovers between university research and high technology innovations	Anselin, L; Varga, A; Acs, Z	JOURNAL OF URBAN ECONOMICS	1997	913	33.81
4	University entrepreneurship: a taxonomy of the literature	Rothaermel, Frank T.; Agung, Shanti D.; Jiang, Lin	INDUSTRIAL AND CORPORATE CHANGE	2007	851	50.06
5	Research groups as 'quasi-firms': the invention of the entrepreneurial university	Etzkowitz, H	RESEARCH POLICY	2003	826	39.33
6	Innovation in innovation: the Triple Helix of university-industry-government relations	Etzkowitz, H	SOCIAL SCIENCE INFORMATION SUR LES SCIENCES SOCIALES	2003	812	38.67
7	The norms of entrepreneurial science: cognitive effects of the new university-industry linkages	Etzkowitz, H	RESEARCH POLICY	1998	689	26.5
8	Searching high and low: what types of firms use universities as a source of innovation?	Laursen, K; Salter, A	RESEARCH POLICY	2004	637	31.85

9	Entrepreneurial orientation, technology transfer and spinoff performance of US universities	O'Shea, RP; Allen, TJ; Chevalier, A; Roche, F	RESEARCH POLICY	2005	570	30
10	University start-up formation and technology licensing with firms that go public: a resource-based view of academic entrepreneurship	Powers, JB; McDougall, PP	JOURNAL OF BUSINESS VENTURING	2005	375	19.74

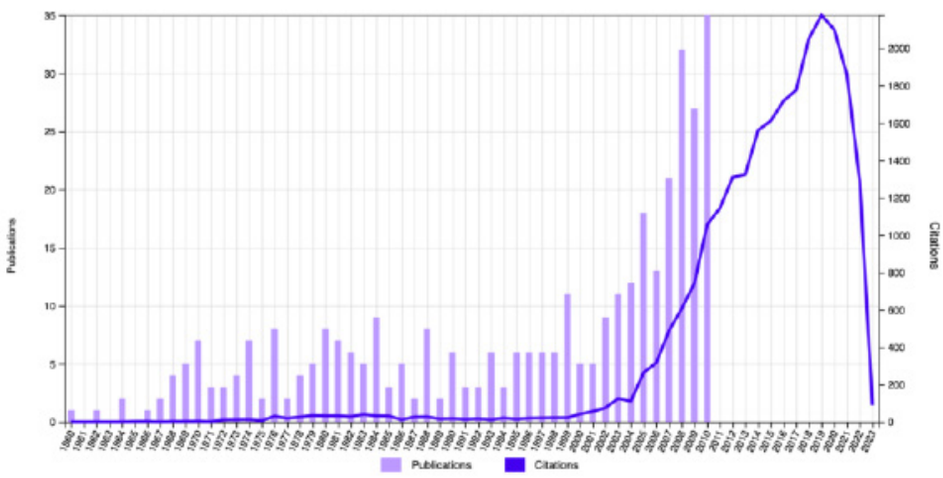

Fig2 Publications and Citations of articles pulicated between 1960-2010

During the second stage of development from 2011 to 2016, there was considerable discussion and debate surrounding the concept of entrepreneurial universities. Research indicated that while many scholars, university institutions, and industries collaborated on further research, the primary motivation for establishing patents and spin-off companies was purely for commercial gain. Consequently, when it comes to joint research, contract research, and consultation between universities and industry, it is important to consider broader incentives in addition to monetary rewards for industry participation(D'Este & Perkmann, 2011; Rideout & Gray, 2013).

Table2 Top 10 cited articles between 2011-2016

Rank	Title	Author	Source	Publication Year	Total Citation	Average per Year
1	Why do academics engage with industry? The entrepreneurial university and individual motivations	D'Este, Pablo; Perkmann, Markus	JOURNAL OF TECHNOLOGY TRANSFER	2011	540	41.54
2	Regional variations in entrepreneurial cognitions: Start-up intentions of university students in Spain	Linan, Francisco; Urbano, David; Guerrero, Maribel	ENTREPRENEURSHIP AND REGIONAL DEVELOPMENT	2011	372	28.62

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3	From the entrepreneurial university to the university for the entrepreneurial society	Audretsch, David B.	JOURNAL OF TECHNOLOGY TRANSFER	2014	368	36.8
4	The development of an entrepreneurial university	Guerrero, Maribel; Urbano, David	JOURNAL OF TECHNOLOGY TRANSFER	2012	328	27.33
5	Research collaboration in universities and academic entrepreneurship: the-state-of-the-art	Bozeman, Barry; Fay, Daniel; Slade, Catherine P.	JOURNAL OF TECHNOLOGY TRANSFER	2013	300	27.27
6	Innovation, spillovers and university-industry collaboration: an extended knowledge production function approach	Ponds, Roderik; van Oort, Frank; Frenken, Koen	JOURNAL OF ECONOMIC GEOGRAPHY	2010	290	20.71
7	The entrepreneurial university: Examining the underlying academic tensions	Philpott, Kevin; Dooley, Lawrence; O'Reilly, Caroline; Lupton, Gary	TECHNOVATION	2011	286	22
8	The Evolution of Entrepreneurial Competencies: A Longitudinal Study of University Spin-Off Venture Emergence	Rasmussen, Einar; Mosey, Simon; Wright, Mike	JOURNAL OF MANAGEMENT STUDIES	2011	263	20.23
9	Does Entrepreneurship Education Really Work? A Review and Methodological Critique of the Empirical Literature on the Effects of University-Based Entrepreneurship Education	Rideout, Elaine C.; Gray, Denis O.	JOURNAL OF SMALL BUSINESS MANAGEMENT	2013	259	23.55
10	The role of entrepreneurship education as a predictor of university students' entrepreneurial intention	Zhang, Ying; Duysters, Geert; Cloodt, Myriam	INTERNATIONAL ENTREPRENEURSHIP AND MANAGEMENT JOURNAL	2014	256	25.6

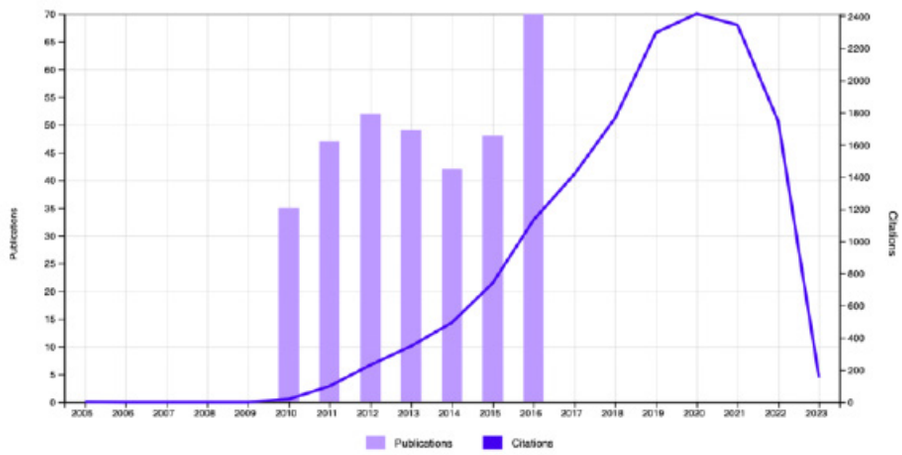

Fig3 Publications and Citations of articles published between 2011-2016

The third phase, spanning from 2017 to the present, is characterized by a greater quantity of research, wider-ranging and more diverse research fields and methodologies. Furthermore, countries have conducted research tailored to their own national contexts, providing a wealth of nuanced case studies and experiences. Despite the increased volume of research, citation rates have been relatively low in this phase. Notably, research has increasingly focused on subtopics such as self-efficacy and gender differences, academic capital, knowledge sharing and leadership, and innovation and entrepreneurship systems(Elrehailet.al, 2018; Jessop, 2017; Miller & Acs, 2017; Nowińskiet.al, 2017).

Table3 Top 10 cited articles between 2017-2023

Rank	Title	Author	Source	Publication Year	Total Citation	Average per Year
1	The impact of entrepreneurship education, entrepreneurial self-efficacy and gender on entrepreneurial intentions of university students in the Visegrad countries	Nowinski, Witold; Haddoud, Mohamed Yacine; Lancaric, Drahoslav; Egerova, Dana; Czegledi, Csilla	STUDIES IN HIGHER EDUCATION	2019	161	32.2
2	The entrepreneurial university as driver for economic growth and social change - Key strategic challenges	Klofsten, Magnus; Fayolle, Main; Guerrero, Maribel; Mian, Sarfraz; Urbano, David; Wright, Mike	TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE	2019	128	25.6
3	Academic entrepreneurship in Spanish universities: An analysis of the determinants of entrepreneurial intention	Javier Miranda, Francisco; Chamorro-Mera, Antonio; Rubio, Sergio	EUROPEAN RESEARCH ON MANAGEMENT AND BUSINESS ECONOMICS	2017	117	16.71
4	University-industry innovation collaboration: Reconceptualization	Rajalo, Sigrid; Vadi, Maaja	TECHNOVATION	2017	115	16.43

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5	The impact of Transformational and Authentic leadership on innovation in higher education: The contingent role of knowledge sharing	Elrehail, Hamzah; Emeagwali, Okechukwu Lawrence; Alsaad, Abdallah; Alzghoul, Amro	TELEMATICS AND INFORMATICS	2018	108	18
6	Barriers to innovation and sustainability at universities around the world	Avila, Lucas Veiga; Leal Filho, Walter; Brandli, Luciana; Macgregor, Colin J.; Molthan-Hill, Petra; Ozuyar, Pinar Gokcin; Moreira, Rodrigo Martins	JOURNAL OF CLEANER PRODUCTION	2017	101	14.43
7	From knowledge management to organizational performance Modelling the mediating role of innovation and intellectual capital in higher education	Iqbal, Amjad; Latif, Fawad; Marimon, Frederic; Sahibzada, Umar Farooq; Hussain, Saddam	JOURNAL OF ENTERPRISE INFORMATION MANAGEMENT	2019	98	19.6
8	The campus as entrepreneurial ecosystem: the University of Chicago	Miller, David J.; Acs, Zoltan J.	SMALL BUSINESS ECONOMICS	2017	94	13.43
9	Varieties of academic capitalism and entrepreneurial universities	Jessop, Bob	HIGHER EDUCATION	2017	85	12.14
10	Entrepreneurial intention among University students in Malaysia: integrating self-determination theory and the theory of planned behavior	Al-Jubari, Ibrahim; Hassan, Arif; Linan, Francisco	INTERNATIONAL ENTREPRENEURSHIP AND MANAGEMENT JOURNAL	2019	84	16.8

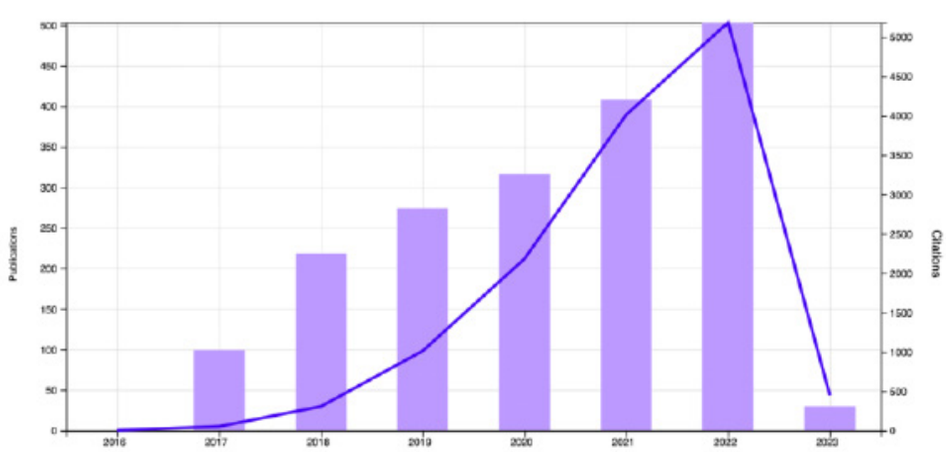

Fig4 Publications and Citations of articles published between 2017-2023

Principal authors of innovation in universities

The research on university innovation and entrepreneurship education involved 751 authors, who collectively produced an average of 2.3 articles. However, the dispersion of research in this field is evident as only 15 authors have published three or more articles. Citespace analysis further confirms the absence of a well-known research team or leading author, as no sudden detection result was found. David Urbano,Maribel Guerrero,Paola Rucker Schaeffer and Einar Rasmussen published 14,13 and 6 articles related in this field separately.

Table4 Top authors whose articles published more than 3

Rank	Freq	Degree	Author	Year
1	14	8	DAVID URBANO	2008
2	13	9	MARIBEL GUERRERO	2011
3	6	4	PAOLA RUCKER SCHAEFFER	2018
4	6	2	EINAR RASMUSSEN	2010
5	5	4	DAVID B AUDRETSCH	2008
6	5	5	H ETZKOWITZ	1983
7	4	3	ALEX MARITZ	2010
8	4	2	LUIS FABRICIO LASCANO PEREZ	2017
9	3	1	ALBERT N LINK	2013
10	3	1	ABEL GARCIAGONZALEZ	2020
11	3	0	AIDIN SALAMZADEH	2019
12	3	0	ANDREAS PANAGOPOULOS	2016
13	3	4	ERIK E LEHMANN	2012
14	3	1	WENJING WANG	2021
15	3	1	MABEL SANCHEZBARRIOLUENGO	2019

Furthermore, in worldwide investigations, the United States, Canada, the Netherlands, Belgium, Sweden, and France emerge as the foremost nations in the area of city entrepreneurship, indicating that experts from these nations display a higher degree of attention in scrutinizing this domain. A more extensive cluster analysis also uncovers that the United States and China are more focused on the association between universities and industries, Australia and the United Kingdom prioritize entrepreneurship education, and Mexico and Spain lay emphasis on social innovation and entrepreneurship education.

Major themes of innovation in universities

Keyword statistics is a crucial bibliometric method that enables us to identify the central focus of relevant research. Based on the statistical findings of Citespace, a total of 545 keywords were identified, with an average of 3.96 keywords per article. The top 21 keywords and the top 7 burst detection results are presented in the following table. Burst detection refers to the widespread use of a particular keyword during a specific period, indicating that the research field has garnered significant attention from scholars at that time. This highlights the emergence of an important academic research hotspot and signifies the evolution of the research field. Apart from the research subject itself, performance, impact, knowledge, entrepreneurship education, model, technology transfer, research and development, firm, scale, and entrepreneurship education have emerged as the most significant research areas.

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Table5 Top 21 keywords

Keyword	Rank	Freq	Burst	Keyword
academic entrepreneurship	1	90	7.2	research and development
industry	2	157	7.17	knowledge
triple helix	3	89	6.74	firm
technology	4	22	6.09	academic research
intention	5	13	5.62	biotechnology
self efficacy	6	21	4.96	bayh dole act
management	7	15	4.81	ivory tower

Additionally, interdisciplinary research in biotechnology, the Bayh-Dole Act, industry, social entrepreneurship, and regional innovation systems has gained significant attention as key areas that require legal and social system support for fostering university innovation and entrepreneurship education. The UK has emerged as a prominent case study in this regard in recent years.

After further scrutinizing the timeline and creating a visual representation thereof, it has been ascertained that the most prominent areas of focus include enrollment intention, academic enrollment, university-industry collaboration, higher education, enrollment ecosystem, public policy, student enrollment, higher education system, and special knowledge.

Within the second cluster, the central research topics include technology transfer, entrepreneurial universities, knowledge management, third mission, and structured quality review.

The third cluster focuses on the research question of social entrepreneurship, entrepreneurial education, assessment tools, social entrepreneurship skills, and the perspective of college students.

The fourth cluster comprises essential elements such as entrepreneurship education, 3D virtual worlds, virtual reality, and learning technologies, which play a pivotal role in improving learning efficiency.

The fifth cluster has placed significant emphasis on the subject matter of the entrepreneurial university, institutional theory, regional entrepreneurship, the third mission, and the Triple helix.

The sixth cluster is characterized by a focus on intellectual pursuits and educational endeavors. Academic entrepreneurship; entrepreneurial intention; third mission; entrepreneurial mindset; entrepreneurial university plays an important part.

Of utmost concern in the seventh cluster are underrepresented students, with a particular emphasis on social cognitive care theory, critical entrepreneurship, STEM education, and community college.

Within the last cluster, there has been a significant focus on open innovation, specialist knowledge, collaboration, social capital, and absorptive capacity. It is worth noting that absorptive capacity has garnered the most attention and analysis.

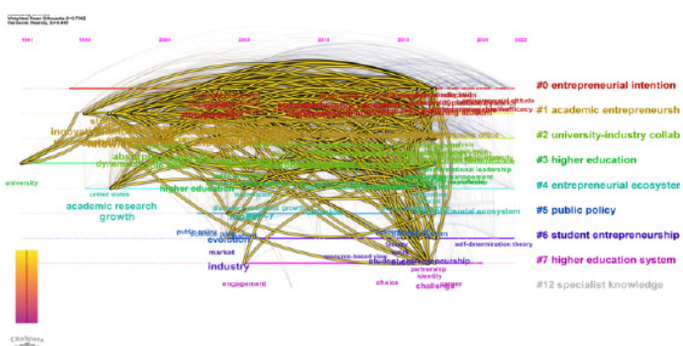

Fig5 Timeline of articles in university innovations

Conclusion

Based on bibliometric analysis conducted by WoS, it is evident that research in this particular field is still burgeoning, signifying the need for more profound and comprehensive research. Presently, the majority of research is concentrated on the correlation between academic engagement, higher education system, and academic performance, which is vital at a logical deductive level. Nevertheless, the research area necessitates further exploration and investigation.

From the standpoint of the author's and research institution's location, Western developed nations such as the United States and the United Kingdom place a higher degree of significance on this subject matter, whereas developing countries, exemplified by China, are presently in an advanced stage of research, evincing sustained interest in this area of study.

It is imperative to delve deeper into the depth of pertinent research, particularly by amalgamating sophisticated theories and technologies from other domains, such as psychology and information technology, to augment research in this sphere.

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[2]Talent quality cultivation and improvement project provided by Northwest Minzu University（No.2022XJJG-19）

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