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Research Advances in Energy Investment Risk Management—A Bibliometric Perspective

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Abstract

To clarify the evolution of energy investment risk management research, we used the Web of Science database, bibliometric, knowledge mapping, and inductive methods to comb through a total of 2150 relevant literature from 2010 to 2021. Firstly, we analyze the time series distribution, core author groups, important journals and source distribution of relevant papers in the field of energy investment risk, and describe the current research status and hot spots of energy investment risk. Secondly, CiteSpace and VOSviewer software are used to cluster the keywords in the field of energy investment risk. The study found four shortcomings in energy investment risk research: firstly, the construction of indicators lacks basis; secondly, the evaluation results lack persuasive power; thirdly, the indicator system lacks pertinence, and fourthly, the evaluation methods and models are not perfect. The directions for future in-depth research include the construction of multivariate evaluation index systems, evaluation methods and models for different industries in a targeted manner.

Keywords

Energy Investment Risk, Knowledge Graph, Citespace, VOSviewer

1. Introduction

Energy is already the material basis for the survival and development of human societies and is strategically important to national economies. Global energy investment is in a state of fluctuating growth from 2017 to 2019, declining significantly in 2020, and exceeding $1.9 trillion in 2021, a rebound of nearly 10% from 2020. However, the composition of investment has shifted to the power and end-use sectors rather than traditional fuel production (International Energy Agency, 2021). In terms of the energy sector, oil and gas are part of fuel supply, while renewable energy transportation, nuclear energy, power networks and battery storage are part of electricity.

Governments and investors are accelerating the clean energy transition as net-zero emissions and dual carbon targets are proposed. global energy demand will increase by 4.6% in 2021, surpassing the 4% contraction in 2020. Clean energy investments are rising moderately, but are far from the levels needed to avoid the severe impacts of climate change. Clean energy investments can deliver greater returns due to improved technology and lower costs (BP Statistical Review of World Energy, 2022). Overall, it is estimated that more than $50 billion in public funds could be available for large-scale low-carbon energy demonstration projects by 2030 (Pringles et al., 2020). While many energy companies are in a fragile financial position, there are signs that developers are taking advantage of the window provided by accommodative monetary policies to plan infrastructure development and new project investments (Zhang et al., 2022). Traditional energy companies are under increasing pressure to adjust their investment strategies to accommodate the clean energy transition.

The gap in energy investment in emerging markets and developing countries is still wide. Emerging markets and developing economies outside of China account for nearly two-thirds of the global population, but only one-third of energy investment and one-fifth of clean energy investment (International Energy Agency, 2021). Analyzing the reasons behind this, the small fiscal space for governments and the restricted access to finance are the main reasons. Energy policy remains an important driver of many energy investments. In 2020, most energy investments are concentrated in a few markets, most notably China, the United States and Europe.

Globally, however, the rapid growth of energy investment is accompanied by increased risks. Most energy investments are established between countries, and companies face many potential risks for energy investments in other countries, such as political unrest and government changes in host countries, unstable social security and economic environment, and changes in bilateral relations between countries with the international situation, which will determine the success or failure of energy investments (Zeng et al., 2014). China is the largest country in terms of clean energy investment worldwide and the largest energy investment market. However, between 2005 and 2014, China had the largest amount of failed OFDI projects in the energy and power sectors, amounting to $89.3 billion, accounting for 36.3% of all failed projects in the same period (https://www.in-en.com/article/html/energy-2240597.shtml). This shows that energy investment risks should receive extensive attention from companies and researchers to avoid unnecessary investment failures.

The main contribution of this paper is an in-depth introduction to the risks faced by energy investments, including their evolution, current status of investments, key themes and basic directions. It shows the changes facing energy investment risk in the world today and the additional challenges ahead.

The following section reviews the knowledge mapping and conclusions regarding energy investment risks. Section 2 composes the key literature on the identification, evaluation and forecasting of energy investment risks. Section 3 presents the research methodology and data sources, and Section 4 presents the main findings, detailing each topic area, core authors, organizations and major countries, a timeline analysis, and burst detection of important keywords. Section 5 presents the discussion and outlook.

2. Literature Review

There is a large body of literature on energy investment risk that has been analyzed, including the identification, evaluation, and prediction of investment risk.

2.1. Risk Identification

On the identification of investment risks, most scholars consider political risk (Jiang & Martek 2021; Shimbar & Ebrahimi, 2019), economic risk (Chang, 2012; Arnold & Yildiz, 2015) and social risk (Li et al., 2010; Schinko et al., 2019) as prevalent risks in energy investments. Chang et al. (2018) consider socio-political stability, institutional quality, economic policies and performance, interactions, and industry conditions as the main factors affecting political risk. Bhattacharya and Kojima (2012) consider financial risk in the power sector as the most important for investors. Some scholars also consider that the risks facing renewable energy investments are also regulatory and policy risks, energy price risks, resource scarcity risks and inflation risks (Gatzert & Vogl, 2016). Sunila et al. (2019) argue that there is a lack of cooperation and coordination between law and regulation in the development of offshore wind power, which becomes the main risk for offshore network investments.

With the turbulent international situation, the impact of country relations on energy investments has gradually increased. Energy investment is seen as relying on the support of state power to be carried out, and thus has received attention from many energy-scarce countries, and related studies have gradually increased. In addition to political, economic, environmental and resource aspects, Duan et al. (2018) argue that energy investment risks also include the China factor, i.e. the closeness of bilateral relations and trade exchanges between China and other countries, and argue that good bilateral relations will reduce investment risks. Wu et al. (2020) assessed the investment risk of implementing renewable energy projects along the Belt and Road in terms of political, economic, resource, social or environmental, and Chinese factors. In addition, Lilliestam et al. (2015) suggested that in the short term, the Gulf Cooperation Council (GCC) countries, investment deterrents are: inefficient bureaucracy, and a combination of fossil fuel/electricity subsidies and lack of renewable energy support. The transparency and efficiency of bureaucracies can affect energy investments.

The Paris Agreement and the internationally proposed dual carbon targets have put many countries under great pressure, especially developing countries, where countries rely on energy for development, but energy use brings a certain degree of environmental pollution, which in turn affects energy investments, and the two interact with each other. As a result, the impact of environmental risk on energy investment has been widely studied. Huang (2019) environmental quality, climate change and ecological vulnerability factors are important factors affecting environmental risk. Pearce (2021) explores energy companies and investors facing climate change litigation risk from a policy and governance perspective, arguing that investment and net zero emissions or emissions reduction targets are aligned to make informed climate risk decisions.

2.2. Risk Evaluation

For the evaluation of energy investment risks, the evaluation methods have evolved from the initial qualitative methods such as expert interviews (Komendantova et al., 2012) and scale methods (Malhotra et al., 2017) to the present combined qualitative-quantitative methods (Gaudard et al., 2016), which are gradually improved and more comprehensive factors are considered. Liu and Zeng (2017) evaluated renewable energy investment risk based on system dynamics, arguing that the risk factors are technology, policy and market risks, and establishing causal loop diagrams and risk assessment models. Komendantova et al. (2012) took solar energy investment as an example, and through expert interview method, argued that regulatory risk is the most important among renewable energy investment risks in North African countries. Solangi et al. (2021) used AHP-Fuzzy TOPSIS to assess the barriers to renewable energy technology development in Pakistan and concluded that socio-cultural barriers were given the most weight and institutional regulation the least. Yuan et al. (2019) used entropy-ANP to assess the risk of Chinese investment in thermal power programs in countries along the beltway, and the results showed that most countries were at high risk. Zhang et al. (2017) evaluated the economic, environmental and social risks of overseas investments under the China-Pakistan Economic Corridor using the fuzzy integrated evaluation method.

2.3. Risk Forecasting

In terms of the prediction of energy investment risks, Costantini et al. (2007) analyzed energy supply security under different energy scenarios from the Perspective of Europe, including energy dependence and vulnerability, and believed that unbalanced energy supply and demand and lack of national infrastructure were possible long-term risks. Therefore, cooperation with energy exporting countries should be strengthened to increase energy investment. Zhang et al. (2021) used scenario analysis to evaluate and compare the impact of three nuclear energy policies, namely, improving technological level, implementing price subsidies and levying taxes, on nuclear power development. Xu et al. (2021) established a non-linear multi-agent intertemporal optimization model and predicted China's CO_2 emission and energy consumption structure under different scenarios from 2018 to 2035 by using scenario analysis method. Browne et al.

(2010) adopted the multi-criteria decision-making method to evaluate 6 policy measures or scenarios related to residential electricity consumption in Ireland and analyze the applicability of different policies or scenarios to different demands. Onar and Kilavuz (2015) used Monte Carlo method to predict the pricing of wind energy investment options and believed that the options had high value. Limited use of renewable energy and investment risk are mutually reinforcing, and governments support and compensate for this. Relevant literature on energy investment risk management is listed in **Table 1**.

3. Research Methods and Data Sources

3.1. Research Methodology

This paper uses bibliometric and scientific knowledge mapping methods to analyze the progress of energy investment risk research. The bibliometric method takes the characteristics of energy investment risk-related literature as the research object and evaluates the research status and development history of different authors, institutions, regions and countries in this field objectively based on mathematical statistics. Scientific knowledge mapping forms a visual mapping by summarizing core vocabulary and key words, revealing the development trend of relevant research in the field, predicting the frontier of discipline development, and giving scholars a clear grasp of the discipline under study.

Table 1. Literature related to energy investment risk management.

Category	Content	Author
Risk Identification	Political Risk	Conrad and Kostka (2017), Yuan et al. (2018), Zhou and Yang (2019), Hashemizadeh (2021), Pearce (2021)
	Economic Risk	Wu et al. (2020), Khan et al. (2022), Alekseev et al. (2021)
	Social Risk	Mrówczyńska et al. (2018), Sheikh et al. (2015), de Groot et al. (2020), Lu et al. (2019)
	Environmental Risk	Huang (2019), Wu et al. (2020), Aquila et al. (2016), Shen et al. (2013), Min and Wu (2008)
	Resource Risk	Liu (2019), Onar and Kilavuz (2015), Brzeszczynski et al. (2019)
	Diplomatic Risk	Duan et al. (2018), Li et al. (2017), Gippner and Torney (2017)
Risk Evaluation	System Dynamics	Liu and Zeng (2017), Calvo et al. (2020), Wang and Zai (2018)
	Fuzzy Integrated Evaluation	Ziemba (2021), Hui et al. (2017)
	TOPSIS	Tang and Diner (2019), Zhong et al. (2020)
	Monte Carlo	Togashi (2019), Nezhnikova and Sébastien (2019)
	Hierarchical analysis method	Zhou and Yang (2019), Ilbahar et al. (2022)
	Interview method	Nehler and Rasmussen (2016), Malhotra et al. (2017)
	Entropy-ANP method	Wu et al. (2019), Bhowmik et al. (2018)
Risk Forecasting	Scenario Analysis	Martinez et al. (2011), Boeck and Sperandio (2019)
	Sensitivity Analysis	Lee (2011), Niu et al. (2021)

CiteSpace and VOSviewer software have the advantages of easy to read information, and can perform network analysis, network visualization, and timeline analysis to sort out the research trajectory of relevant literature (Jiang & Ashworth, 2021; Yi et al., 2020). Therefore, we used CiteSpace version 5.8R2 and VOSviewer software for quantitative analysis, using "topic + abstract + keywords" as the content of the software analysis. As the content of the software analysis, we analyzed the core authors, institutions and keywords, and sorted out the trends and frontiers of energy investment risk research.

3.2. Data Sources

The research data for this paper were obtained from the Web of Science (WoS), a database that covers a wide and large number of disciplines and journals. In this paper, data will be obtained by searching the following databases included in WoS: Science Citation Index Expanded (SCI-E), Social Science Citation Index (SSCI), and Conference Proceedings Citation Index (CPCI).

To systematically examine the literature in the field of energy investment risk (EIR) management, the search terms included "energy investment risk", "energy cooperation risk" (Energy investment risk, Energy The search terms include "energy investment risk" and "energy cooperation risk" (Energy investment risk, Energy cooperation risk). The time frame was defined as "2010-2021", ending on December 31, 2021. A total of 2150 documents were obtained according to the screening criteria, language (English), document type (article & review).

After excluding duplicates (2), a total of 2150 documents were obtained, including 1942 articles and 208 reviews (Figure 1).

4. Current Status of Research on Energy Investment Risk

4.1. Quantitative Analysis of Literature

A comparative graph of the number of literature was drawn based on the 2150 searched papers (Figure 2). Overall, the number of publications in the field of energy investment risk shows an increasing trend, which indicates that research

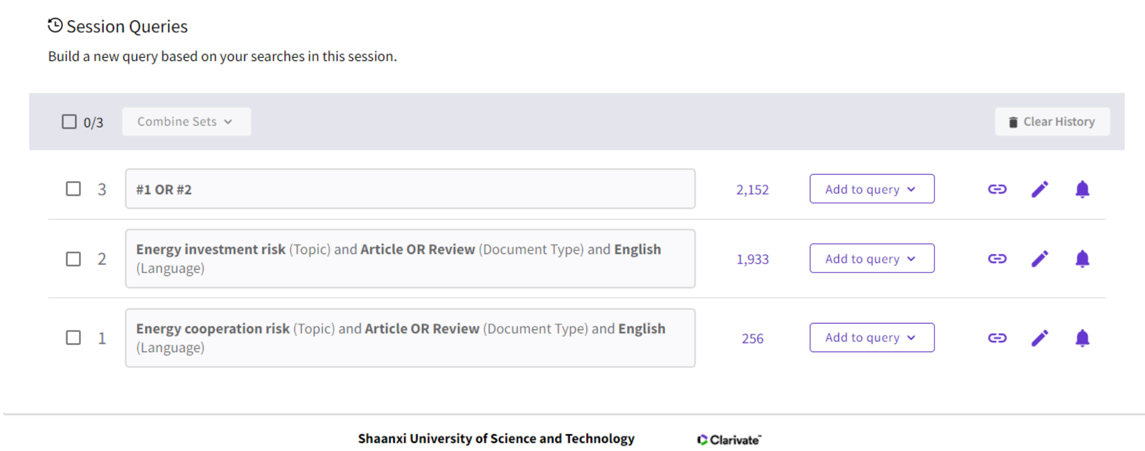

Figure 1. Literature retrieval results. Source: Statistics published by WOS platform.

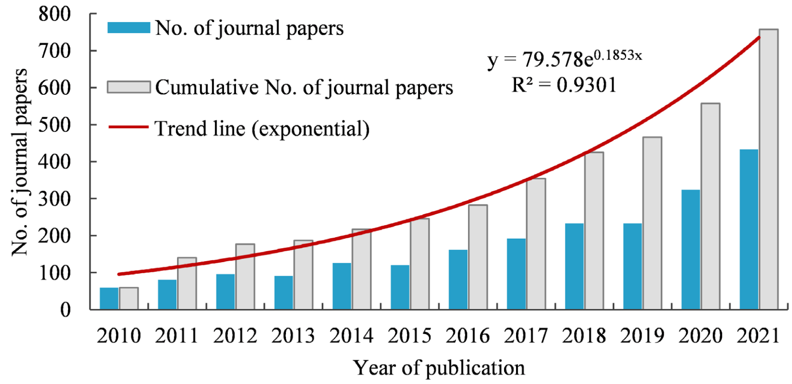

Figure 2. Energy investment risk management research publication volume statistics. Source: Statistics published by WOS platform.

on energy investment has received wide attention from scholars and continues to rise in fervor. Based on the trend in the number of journal articles over the years (Jiang & Ashworth, 2021), we divided the study into the following three phases:

1) Budding period (2010-2014). The research on energy investment risks started to take off and belonged to the slow development stage. The number of publications increased about 17% annually in 2011 and 2014.

2) Development period (2015-2018). Research on energy investment aspects gradually rose, from 126 articles in 2014 to 233 articles in 2018, with a steady growth in the number of articles published.

3) Boom period (2019-2021). Research on energy investment risk aspects is growing exponentially and belongs to the high growth period. As net-zero emissions and dual-carbon targets receive more attention, energy investment gradually grows, and at the same time, risk uncertainty increases accordingly, scholars pay more attention to energy investment risks, and the number of publications grows rapidly, with an average annual growth rate of more than 17% in 2020, and the number of publications exceeds 400 in 2021.

Using statistical principles, the cumulative number of publications on energy investment risk management research is fitted and the fitted curve (R2 = 0.8612) is obtained, with R2 close to 1, indicating that the fit is good and consistent with the exponential growth law. And in 2021, the actual value of the cumulative number of publications has exceeded the theoretical value, indicating that energy investment risk is precisely a hot area at the moment and will continue to receive extensive attention.

4.2. Principal Authors and Journals

Using Citespace software, authors and institutions with frequencies greater than 3 times were extracted and mapped (**Figure 3**), where the number of author or institution publications reflects the key research themes and the co-occurrence relationship indicates their cooperation. The larger font size of the nodes indicates the more author publications, the cooler color indicates the earlier research

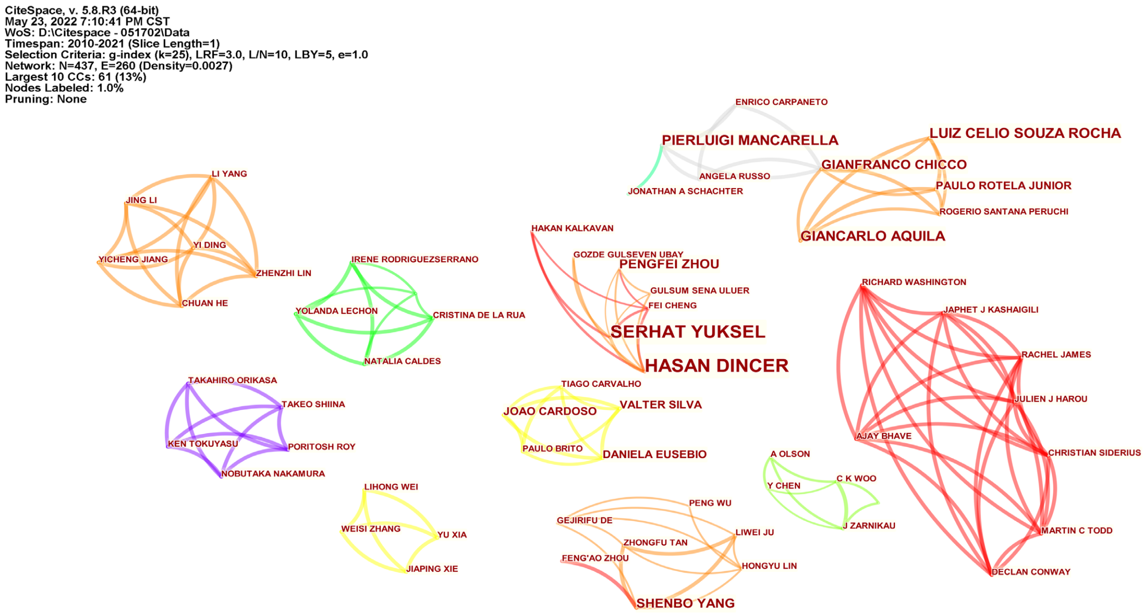

Figure 3. Author co-citation analysis.

time, and the thickness of the connecting line indicates the strength of the connection between authors. From the perspective of author collaboration, the early team of Takeo shina, nobutaka nakamura, NAKAMURA NOBUTAKA, Poritosh Roy and KEN TOKUYASU was formed in 2012, and the recent team of Serhat Yuksel, Hasan Dincer, and Pengfel Zhou is the representative of the authors. The team represented by three authors, Serhat Yuksel, Hasan Dincer, Pengfel Zhou, has published an outstanding number of articles in this field and formed a close collaborative network. On the whole, the team collaboration is "scattered and concentrated", and there is not much inter-team collaboration and the intensity of collaboration is not high.

The statistical mapping of the number of articles published in major journals is shown in Figure 4, with cooler colors indicating earlier research time and warmer colors indicating more recent research time. The specific number of publications is shown in Table 2. The journals with more than 20 publications are: ENERGY POLICY, ENERGY, RENEWABLE SUSTAINABLE ENERGY REVIEWS, JOURNAL OF CLEANER PRODUCTION, etc. with 41.35% of the total number of publications. Among them, ENERGY POLICY, the most published in the field, has 196 articles.

4.3. Research Institutions and Countries

The threshold of institutional presence was set to 4, and 270 of 2589 institutions met the condition. Among them, the institutions with more than 20 institutional publications are shown in Table 3, and the energy investment risk research is formed by North China Elect Power Univ (North China Electric Power University), Delft Univ Technol (Delft University of Technology), univ oxford (Oxford University) and Swiss Fed Inst Technol (Swiss Federal Reserve Bank Institute of

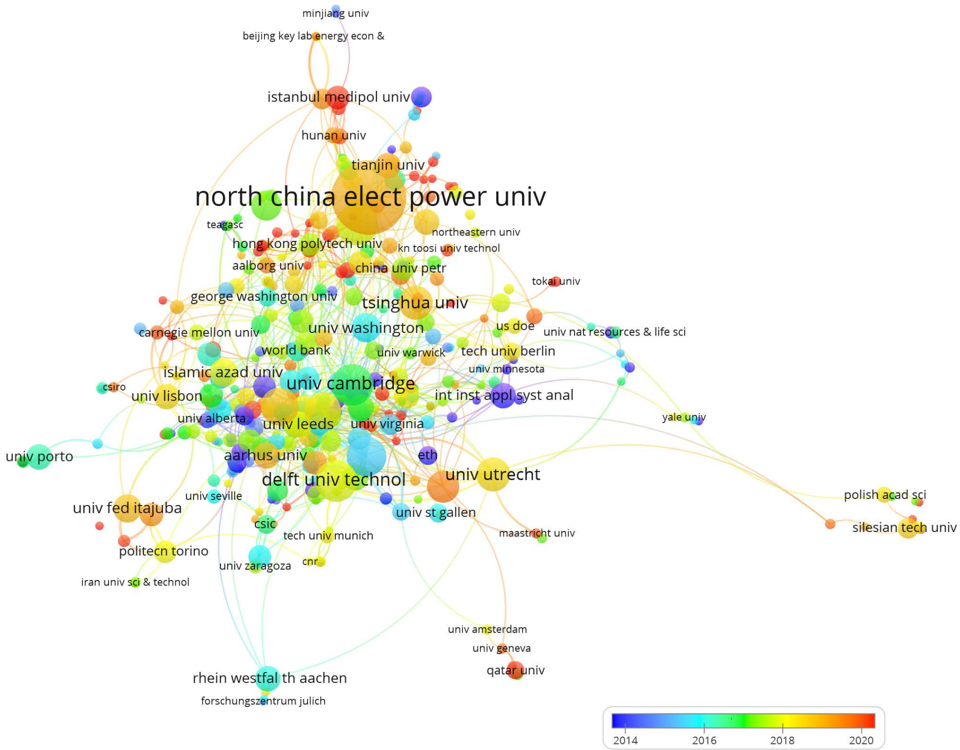

Figure 4. Journal mapping analysis.

Table 2. Journal publication statistics.

Journal	No. publications	Percentage of Total	Cumulative Proportion	Journal Impactor (2020)
ENERGY POLICY	196	9.12%	9.12%	6.142
ENERGY	127	5.91%	15.02%	7.147
RENEWABLE SUSTAINABLE ENERGY REVIEWS	116	5.40%	20.42%	14.982
ENERGIES	113	5.26%	25.67%	3.004
JOURNAL OF CLEANER PRODUCTION	89	4.14%	29.81%	9.297
SUSTAINABILITY	80	3.72%	33.54%	3.251
APPLIED ENERGY	76	3.54%	37.07%	9.746
RENEWABLE ENERGY	71	3.30%	40.37%	8.001
BIOMASS BIOENERGY	21	0.98%	41.35%	5.061
ENERGY AND BUILDINGS	19	0.88%	42.23%	5.879
IEEE TRANSACTIONS ON POWER SYSTEMS	19	0.88%	43.12%	6.663
ENERGY CONVERSION AND MANAGEMENT	16	0.74%	43.95%	9.709
ENERGY JOURNAL	16	0.74%	44.70%	2.414
IEEE ACCESS	16	0.74%	45.44%	3.367
ENVIRONMENTAL RESEARCH LETTERS	15	0.70%	46.19%	6.800
EUROPEAN JOURNAL OF OPERATIONAL RESEARCH	15	0.70%	46.88%	5.334

Source: Statistics published by WOS platform.

Table 3. Distribution of institutions with a frequency of 20 or more occurrences.

Organization	Documents
North China Elect Power Univ	60
Chinese Acad sci	26
Univ cambridge	26
Univ Manchester	25
Univ oxford	23
UCL	22
Univ utrecht	20

Source: Statistics published by WOS platform.

Technology) are represented by highly productive research teams, which shows that universities are the main force of research in this field. As seen in the plot (Figure 5), the darker the color indicates the earlier the research, and the evolution of the main research institutions gradually from Univ Manchester in the past to North China Elect Power Univ in recent years, the research on energy investment risks by Chinese institutions has gradually increased, which is closely related to the continuous foreign energy investments by Chinese companies.

From the country network analysis Figure 6, the size of the nodes in the figure indicates the high frequency of occurrence and the color indicates the chronological order of postings. Energy investment risk studies are mainly concentrated in the United States, China, the United Kingdom, Germany, France, and Brazil. In terms of number, there are 456 articles from the United States, 388 from China, 273 from the United Kingdom, 149 from Germany, and 138 from Italy; in terms of chronology, articles represented by the United States and Canada are concentrated in 2016, articles from China, Poland, and Turkey in this field are concentrated in 2018, and UAE posts are concentrated in the last two years (Table 4). The United States and China occupy an important position in world energy investments, especially in recent years, and China is the world's largest in the fields of primary energy consumption, hydroelectricity, wind power and photovoltaic power capacity installed. Therefore, Chinese scholars also pay more attention to the research in this field.

4.4. Timeline of Keywords

To clearly represent the process of energy investment risk research over time, we drew a timeline graph using high-frequency keywords (Figure 7). A node in the graph represents a keyword, and the size of the node is proportional to the frequency of the keyword, and when the node appears particularly frequently, it forms a circle. The connecting lines of different colors represent keywords of different years, and the position of the node represents the year of the first occurrence. On the right side of the graph are clusters (# characters) generated

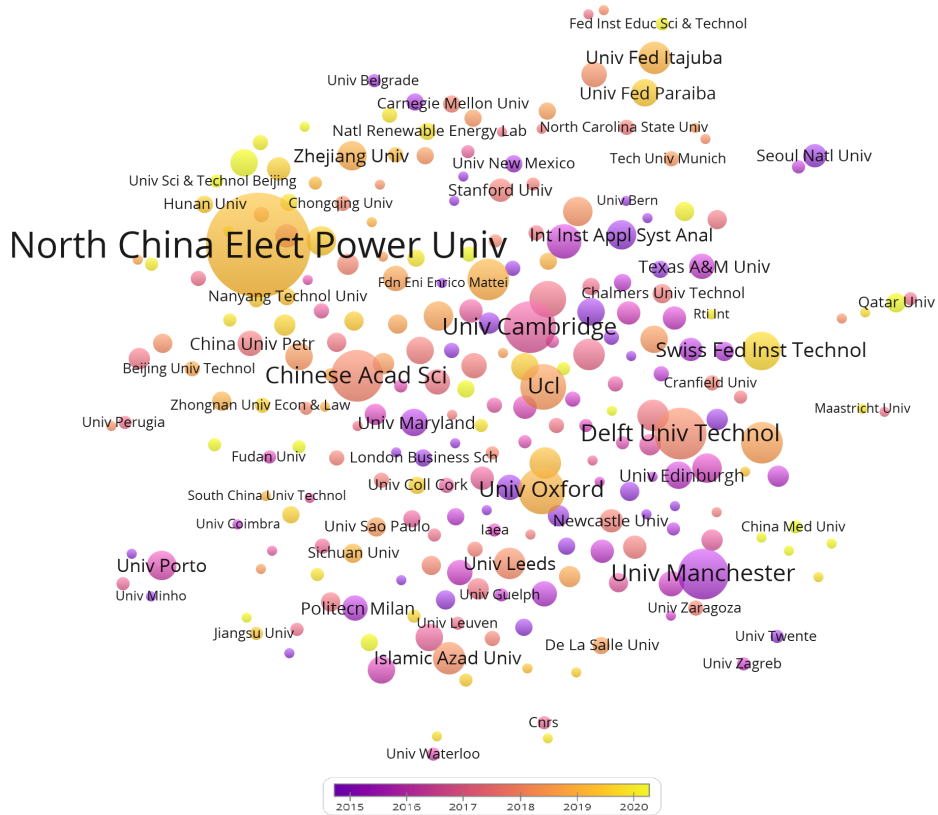

Figure 5. Institutional network analysis.

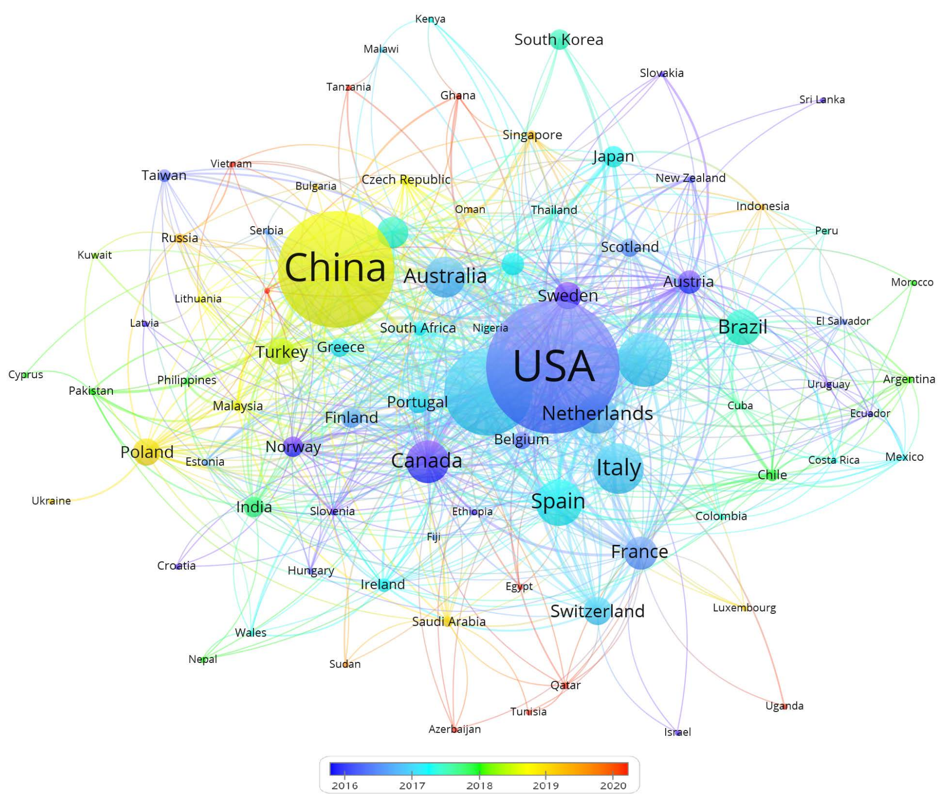

Figure 6. Country network analysis.

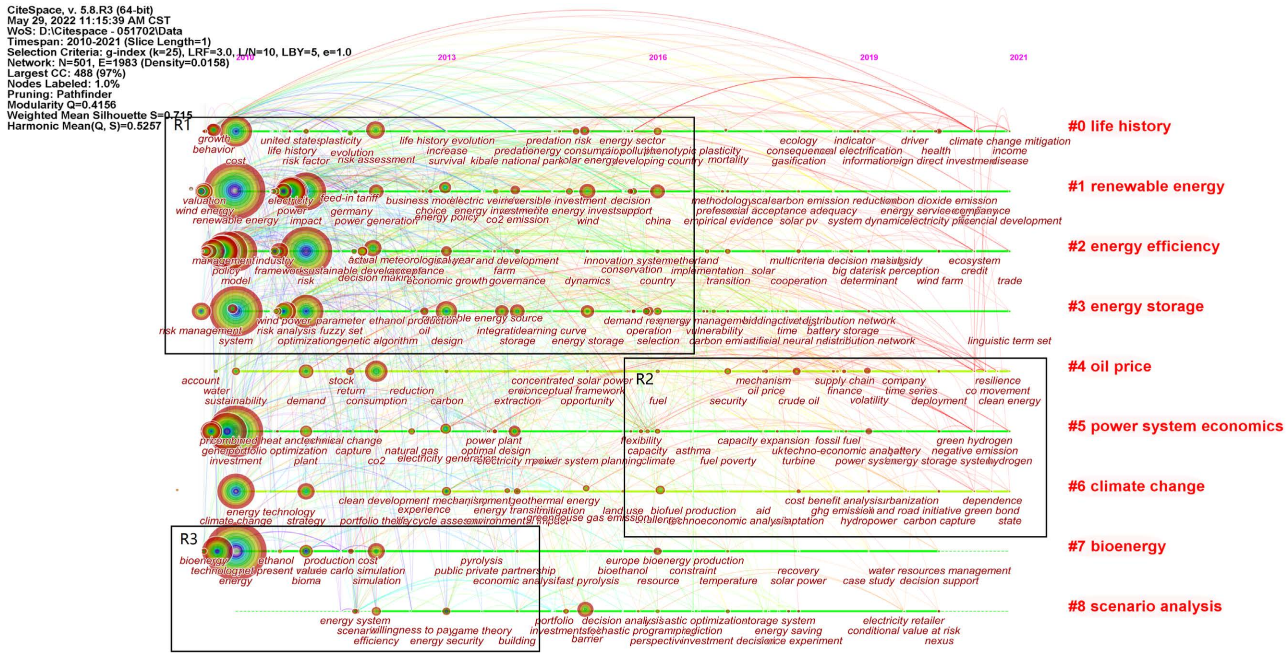

Figure 7. Timeline mapping of energy investment risk literature.

Table 4. Distribution of countries with 50 or more published articles.

Organization	Documents
USA	456
China	388
England	273
Germany	149
Italy	138
Spain	124
Canada	112
Australia	105
Netherlands	98
Brazil	91
France	81
Iran	76
Switzerland	66
Poland	63
Sweden	63
Turkey	61
Austria	53
Denmark	50

Source: Statistics published by WOS platform.

based on the frequency of the keywords, representing different research areas, where keywords on the same timeline share the same research topic. Smaller cluster IDs indicate the inclusion of more keywords. A Q value of 0.4156, which is greater than 0.3, indicates a significant cluster structure; an S value of 0.715, which is greater than 0.7, indicates that the clusters are convincing. In this paper, 10 clusters of clusters were formed, and the figure shows the first 9 clusters.

Most of the major crossovers occurred in 2010, with the largest one, "renewable energy", appearing 281 times. This is followed by "energy" (262), "risk" (230), "system" (216), "model" (193), and "investment" (182). "Investment" (182), and the density of connecting lines around these keywords is high, and the density reflects the centrality of the keyword, which suggests that it is the starting point for energy investment risk research.

We have marked the densely connected lines with black boxes (**Figure 7**, for "R1", "R2", and "R3") to some extent reflecting the evolution of energy investment risk research.

"R1" appears from 2013 to 2016 with keywords such as "wind energy", "system", "investment", "renewable energy", "renewable energy policy" and other keywords, with highly dense lines answering the energy The clusters covered are #0 life history, #1 renewable energy, #2 energy efficiency, #3 energy storage. it is worth noting that the nodes CO_2 emmission, solar energy, wind, china, and other nodes have purple outer circles, indicating the high importance of wind and solar energy related renewable energy studies in energy investment risk studies as a bridge to subsequent research progress.

"R2" is the closest group, containing "consumption", "oil price", "crued oil", "electricity market", "combined heat and power", "economic growth", "climate change" and other keywords, this cluster is focused on oil price, energy system economics and climate change, covering the clusters #4 oil price, #5 power system economics, #6 climate change. With the acceleration of global climate change, the economic situation is very closely linked to energy, and the economic fluctuations and environmental impacts of traditional energy sources are spread across all sectors, with the electricity market and other industries gradually shifting their demand for energy to clean and green, green energy and clean energy, such as green hydrogen and hydropower. It is worth noting that the nodes crude oil, CO_2, security, volitality, power system, power plant have purple outer circles, indicating that these nodes have a high intermediary centrality and have a significant influence on the research direction.

"R3" contains clusters #7 Bioenergy, #8 Scenario analysis, and keywords including but not limited to: investment risk, energy security, barrier, climate change, The main themes of the study are energy growth, energy emissions and climate change, and the focus of this part is on the impact of energy investments due to climate change and emissions growth. However, the nodes with high intermediation centrality in this group are Bioenergy, barrier, energy system, monte carlo simulation which have a very high importance in the research field.

Above, we analyzed the evolution of energy investment risk studies and the distribution of important nodes, while some of them have a tendency to cool down. For example, Bioenergy started in 2010 and was extensively studied until 2016.

There are nine categories of keyword clustering, and the clustering coefficient of each category indicates the good or bad clustering effect, and the specific information is shown in Table 5, and overall, the clustering effect is good.

4.5. Research Hotspots

To further analyze the relationship between the research hotspots, the LLR algorithm was used to detect the keywords' highlighted words, and the γ value was set to 0.5, and a total of 45 highlighted words were obtained. The top 25 keywords have a relatively high "intensity" (Table 6). The higher the intensity, the more focused the keywords are, and the more representative of the fast-growing topics and hotspots in energy investment risk research. The year in the table is when the keyword first appeared, and the red bar in the last column refers to the time when the keyword had a high intensity, was closely watched and got explosive growth.

"valuation" has been closely followed by scholars from 2010 to 2013, with an outbreak intensity of 5.24. Other popular research topics include "industry", "life history", "bioma" and "education". "life history", "bioma", "industry" which exploded in 2011; "feed-in tariff", "Germany", "support scheme" and "portfolio theory" exploded in 2012; in 2015, the sudden attention was paid to "dynamics" and "scenario"; while "information", "framework", "power system", "supply chain", and "techno-economic analysis" have exploded so far in 2019, indicating that these topics are the forefront of energy investment risk research.

Table 5. Summary of the 9 clusters.

Cluster-ID	Cluster	Size	Silhouette	Mean (year)
0	Life history	81	0.759	2015
1	Renewable energy	66	0.619	2014
2	Energy efficiency	58	0.766	2014
3	Energy storage	53	0.653	2015
4	Oil price	47	0.676	2017
5	Power system economics	46	0.752	2015
6	Climate change	39	0.71	2016
7	Bioenergy	35	0.75	2013
8	Scenario analysis	34	0.754	2015
9	sensitivity analysis	29	0.743	2016

Source: Statistics published by WOS platform.

Table 6. Top 25 keywords with the strongest citation bursts.

Keywords	Year	Strength	Begin	End	2010-2021
valuation	2010	5.24	2010	2013	
wind energy	2010	3.97	2010	2014	
food	2010	3.97	2010	2014	
option	2010	3.71	2010	2018	
industry	2010	4.09	2011	2016	
life history	2010	4.09	2011	2017	
bioma	2010	3.4	2011	2016	
feed-in tariff	2010	5.18	2012	2017	
germany	2010	4.1	2012	2018	
support scheme	2010	3.61	2012	2013	
portfolio theory	2010	3.24	2012	2016	
energy security	2010	4.51	2013	2015	
farm	2010	3.34	2014	2015	
dynamics	2010	4.29	2015	2017	
scenario	2010	3.94	2015	2017	
bioenergy	2010	3.23	2016	2018	
energy management	2010	3.3	2017	2018	
risk factor	2010	3.29	2017	2019	
feasibility	2010	3.24	2017	2019	
investment decision	2010	3.2	2017	2019	
information	2010	4.83	2019	2021	
framework	2010	3.94	2019	2021	
power system	2010	3.65	2019	2021	
supply chain	2010	3.62	2019	2021	
techno-economic analysis	2010	3.22	2019	2021	

Source: Statistics published by WOS platform.

5. Discussion and Outlook

In this paper, we systematically review the research literature on energy investment risk. CiteSpace and VOSviewer software were used to analyze and visualize the number of journal papers, major authors and journals, research institutions and countries, timeline of keywords, and research hotspots for energy investment risk. The main findings are as follows: 1) The research on energy investment risk has grown exponentially in terms of the number of journal papers. The core research in this field started in 2010 and has gone through three development stages: the nascent period, the development period, and the boom period. 2) At present, energy investment risk research has not yet formed a stable core group of authors, but core research institutions and core research journals have been formed. 3) Power systems have become a key topic in this field. Research hotspots include information, frameworks, power systems, supply chains, and techno-economic analysis.

Energy investment risk research has several drawbacks. For example, most scholars study a single risk factor, and although the impact of that aspect of risk can be analyzed in detail, the investment for companies needs to measure all aspects of risk factors, thus lacking comprehensive and integrated analysis and systematic evaluation. In addition, the lack of innovation in the content of some authors' studies has slowed down the progress of innovative ideas in energy investment risk. Therefore, future research should consider the following aspects: 1) The energy system structure should be considered. Future research on energy investment risk should consider the combined impact of all risk factors in investment; 2) Research on energy investment risk should combine quantitative and qualitative analysis to make the assessment results more objective and fair; 3) Researchers should conduct more case studies, which will help energy companies cope with the changing environment and develop risk-averse countermeasures and strategies.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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