A Bibliometric and Visual Analysis of Environmental Behavior Research

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Abstract: Environmental behavior has become one of the most important research areas in the field of sustainable development in recent years. Based on 818 papers on environmental behavior in the Web of Science database from 2002 to 2020, this paper uses CiteSpace software to analyze the trends in publication, subject categories, influential authors and journals, countries, and institutional collaborations. The results show that environmental behavior research has steadily increased over the past 19 years and has gradually achieved diversity and intersection in research subjects. The research on environmental behavior is mainly distributed in the United States, China, and European countries, with the United States being the largest contributor in the field and at the center of the institutional collaboration network. The present research hotspots are as follows: the concept of environmental behavior, factors affecting environmental behavior, the dimension division of environmental behavior, and the construction of a sustainable environmental behavior model. The sustainable development, predictive environmental behavior indicators, factors that affect environmental behavior, and the construction of theoretical models of environmental behavior will become future research trend.

Keywords: environmental behavior; CiteSpace; research trend; bibliometric analysis

1. Introduction

The world has been facing serious environmental problems, such as ecological environment deterioration, air pollution, and scarcity of potable water, since the twentieth century [1]. According to the third assessment report of the United Nations Environment Assembly, 80% of the world’s wastewater is discharged into the natural environment without treatment, and 4.8–12.7 million tons of plastic waste are discharged into the ocean every year. Environmental behavior, one of the behavioral management aspects, is an important aspect of solving environmental issues because of its close connection to the citizens’ behaviors and intentions. Zelezny viewed environmental behavior as the extent to which citizens are aware of the problems regarding the environment and make efforts to solve the problems or indicate a willingness to contribute to the solutions [2]. Stern et al. put forward the value–belief–norm theory model to explain the pattern of environmental behavior, which has become an important theoretical achievement in the field of environmental behavior research [3]. Cleveland argued that environmental behavior is the sustainable development and use of natural resources to prevent the deterioration of the ecological environment [4]. Ertz et al. found that even the environmental behavior, for the purpose of environmental protection, may affect environment quality in a negative way [5]. Although there are many topics on environmental behavior research, it is broadly accepted that exploring changes in environmental behavior is one of the most pressing issues facing scholars and policymakers.

Against this background, research has made profound progress in identifying the determinants of environmental behavior [6–9]. For instance, several studies have revealed that fundamental factors (e.g., sex, age, social class, residence, and politics), internal factors (e.g., knowledge, attitudes, values, and responsibility), external factors (e.g., situation,
interpersonal influence, and law), and structural factors (e.g., cultural differences, policy, norm, stratum differentiation, and information segmentation) have an impact on environmental behavior. Based on these factors, some scholars have put forward the relevant theoretical models of environmental behavior, such as the theory of planned behavior, the value–belief–standard model, the multi-factor integrated model, the environmental behavior model, and the environmental methods and strategies to promote sustainable development. Bibliometrics is a quantitative method for the evaluation and description of published papers that helps researchers to evaluate academic research in key areas. It has been applied in many fields, such as medicine \[10\], mathematics \[11\], energy \[12\], information science \[13\], geophysics \[14\], engineering \[15\], mathematics \[16\], and public administration \[17\]. Although environmental behavior has been well studied and has become a mature branch of environment science, little is known about the visualization and graphical bibliometric analysis of exploring the internal relationship to environmental behavior among articles, authors, references, etc. Hence, visualized bibliometrics is critical for comprehensively understanding the evolution and development of environmental behavior. Furthermore, environmental behavior has reached a certain level of maturity and is now treated as an exclusive field of study; thus, identifying new potential future trends is a necessity. This paper makes two contributions. First, this paper describes the current status of environmental behavior research; objectively reveals the highly cited journals, countries, and authors; and deepens the understanding of highly cited literature and hot issues in this field. Second, the relevant literature is analyzed to trace the transfer of research hotspots and research directions, look for future research opportunities, broaden the horizon of environmental behavior literature, and provide references for relevant research in the field.

CiteSpace, citation visualization software developed by means of scientific metrology and data visualization, makes it easy to locate the original theoretical roots and history \[18\]. CiteSpace is free software founded by Chaomei Chen that can be used for analysis in both natural and social sciences. At present, CiteSpace is mainly used in computer science, information and library science, engineering, and commercial economy in international research is mainly applied to library and archives management and info-science and engineering management, especially on specific technology patents \[18\]. However, there is a lack of comprehensive research on using CiteSpace to analyze the rapidly expanding environmental behaviors literature. To provide a systemic and objective overview of research on environmental behavior, this paper makes a bibliometric analysis of the articles from 2002 to 2020 using CiteSpace and objectively reveals the current research situation and hot topics in this field.

2. Literature Review on Environmental Behavior

Environmental behavior was defined by Kollmuss and Agyeman as behavior that consciously seeks to minimize the negative impact of one’s actions on the world \[19\]. However, environmental behavior can have positive connotations, such as recycling, and negative ones, such as wasting resources \[20\]. Positive environmental behaviors can be adopted in the workplace to effectively achieve workplace sustainability. Kaiser et al. argued that environmental behavior is a conscious behavior based on responsibility and values \[21\]. The existing literature regards environmental behavior as positive environmental behavior, emphasizing the active participation of individuals in solving or preventing ecological problems.

In view of the key role of environmental behavior in regulating the environment, there is now growing interest in the research of environmental behavior in academia and government. Stern argued that four types of environmental behavior should be considered: radical environmental behavior, such as participation in demonstrations; non-radical behavior in the public domain, such as supporting or accepting public policy; environmental behavior in the private domain, including paying attention to the usage and maintenance of articles that affect green consumption; and other meaningful environmental behavior, such as reducing gas emissions in the production process \[3\]. Such types of environmental
behaviors are typically accompanied by individual and group reflection about the environment and iterative attempts to apply the skills garnered to make incremental changes to the eco-environment system. Although the classification of behaviors has certain limitations in the research, it covers almost all research fields, among which environmental behavior in the private field is easy for individuals to realize. Since environmental behavior in the public domain requires citizens to integrate environmental and legal knowledge and a sense of civic engagement skills, it is difficult to conduct non-radical or radical environmental behaviors in the public domain, such as taking political or legal actions. Furthermore, the general individual usually starts from the lower level of environmental behavior and moves to the higher level in a democratic society.

Prior researchers have made a big contribution to the theatrical and empirical study of environmental behavior related to various aspects. Some scholars use the theory of planned behavior to conduct research on environmental behavior. Kaiser et al. illustrated that perceived behavioral control has a significant impact on environmental behavior [21]. Starik and Rands argued that the anticipation of environmental behavior could be based on the environmental literacy model [22]. The cognitive variables include the knowledge of environmental problems, environmental concepts, and environmental behavioral strategy, and the attitude variables include values, belief, and sensitivity. Hsu and Roth used the MLR method to discuss the impact of the corresponding variables in the environmental literacy model and found that the factors that affect environmental behavior are environmental sensitivity and behavioral strategies [23]. Based on relevant research, McCarty and Shrum changed the original environmental behavioral strategy to the citizen action strategy in order to modify the environmental literacy model [24]. Bamberg and Möser used meta-analysis based on 128 environmental behavior essays to model responsible environmental behavior [25]. Based on this and other related research, Chawla and Cushing believed that three main types of variables that affect environmental behavior show a linear relationship: the threshold variable (the cultivation of sensibility), the autonomous variable (profound understanding of environmental problems), and permission variables (including the knowledge and skills to adopt environmental action strategies and the willingness to enhance the expectation and action) [26].

In recent years, many studies have tended to focus on the factors influencing environmental behavior. Cottrell argued that environmental behavior is affected by general or special individual attitudes and external conditions (such as social structure and economic or political incentives) [27]. Cottrell suggested that environmental behavior is also influenced by perceptions, values, beliefs, views, and other psychosocial variables. Xiao and McCright found that gender is a key factor influencing environmental behavior based on the Chinese General Social Survey (CGSS) in 2015 [28]. Women expressed stronger pro-environmental attitudes and a higher tendency to engage in protecting the environment than men. Batel et al. argued that environmental behavior also corresponds to the social structure and the cultural background, influencing the life of the actor and the way of experiencing social life [29].

Previous literature, including concept and framework, is comprehensive enough to study and includes creative theoretical contributions of researchers who combine two or more dimensions of environmental behavior. On the basis of this literature, this paper presents a visual analysis that provides a more useful and valuable study for future studies on environmental behavior.

3. Methodology and Data

Mayr and Scharnhorst defined bibliometrics analysis as the statistical analysis of literature applied to the quantitative analysis of publications in a given field [30]. A comprehensive statistical review of a specific topic can help researchers to better understand the basic knowledge and the knowledge structure within a subject field. Bibliometrics mainly analyzes the information on the authors, keywords, references, journals, countries, institutions, and even directions or its trends in a special field [30]. Indeed, many scholars
have adopted a longitudinal social network analysis to study a field in terms of its past, its current situation, and the possible future development trend [31]. For instance, Small analyzed the co-citation analysis on the basis of graphical visualization research, which can provide more information, and studied the correlation of articles [32]. A co-citation relationship exists when two articles are cited by one or more articles at the same time. Furthermore, the higher the citation frequency, the higher the co-citation degree, and the higher the correlation between these articles. Damschroder et al. posited that co-citation analysis helps researchers to consider any new theory that arises from an existing one and can be used to reflect the scientific communicational structure between researchers and the evolution of knowledge, providing a historical perspective of the knowledge structure [33].

The network view, the cluster view, and the time zone view can all be used for analyzing different information types in terms of knowledge structure, time span, and the evolution trend of keywords, respectively. These types of visualization graphs reflect the internal links in scientific literature. They provide various functions to help users specify the time period, select the nodes, and set thresholds on the same screen. Visualization knowledge maps consist of nodes and links, and the color of nodes and lines represents different years. Different nodes in a knowledge network map represent elements such as cited reference, institution, author, and country. The links between nodes represent relationships of collaboration or co-citations. Various relationships among the underlying network can also be represented by the links. For instance, the size of a node demonstrates the aggregate co-occurrence frequency of an item, and the thickness of a link shows the strength of the connection between two nodes. Another important index of a node is the betweenness centrality, which measures the ability of a node to connect with other nodes. The node with a high centrality acts as a key point linking two or more groups, showing a transition pattern and further indicating the primary topics in a network. It is argued that an algorithm can monitor a burst and identify terminology concepts for frontier research [34].

This study used CiteSpace V and VOSviewer as visual and analytic research tools. The literature was downloaded in July 2021 from Web of Science, which is one of the best academic databases [35]. Web of Science is recommended as the preferred database website for CiteSpace analysis and contains citation information sources crucial for this study. To retrieve accurate target articles, titles are set as "environment* behavio*", "environment* engagement", "pro* environment* behavio*", "environment* friendly behavio*", "green behavio*", "ecological behavio*", "environment* responsible behavio*", "environment* significant behavio*", and "environment* sustainable behavio*". Several restrictions were set before the search. First, we selected the Science Citation Index Expanded (SCI) and the Social Sciences Citation Index (SSCI) rather than all databases for the purpose that articles would be of high quality and influential in the field. Second, only academic journals were selected for scientometric analysis in view of their impact on environmental behavior studies. Finally, the time span was set from 2002 to 2020 because the first journal paper related to environmental behavior was published in 2002 [36]. We selected 818 articles, covering almost every important article in the field of research. Therefore, key points can be highlighted on the knowledge map of cited references, authors, or institutions.

4. Results and Analysis
4.1. Analysis of Publications and Subject Categories

The progression of papers published related to environmental behavior from 2002 to 2020 is shown in Figure 1. A clear upward trend over time can be observed, indicating the increased role of scientific research in environmental behavior. The studied period can be divided into the following three stages: the first stage, from 2002 to 2005; the second stage, from 2006 to 2013; and the third stage, from 2014 to 2020. The number of publications fluctuated from 2002 to 2005, with 7 papers in 2002, which decreased to 4 papers in 2005. The publication output increased from 2006 to 2013, during which some scholars proposed many basics theories and empirical research on environmental behavior [37,38].
The number of articles increased rapidly, and more than 100 articles were published during this period. However, the total number of publications was higher in the third stage (629) compared with the other stages (33 and 156 in the first and second stages, respectively). These results show that pro-environmental behavior as a complementary concept of environmental behavior is receiving increasing attention, and more environmental behavior research is being performed.

Figure 1. The number of publications on environmental behavior (2002–2020).

The top 10 subject categories in terms of frequency are shown in Table 1, which include environmental sciences and ecology (the highest frequency, 701), environmental sciences (the second-highest frequency, 382), and applied and preventive psychology (the third-highest frequency, 341). In addition, there are other subjects, such as environmental studies, engineering, science and technology, psychology, business and economics, behavioral sciences, and material sciences. Environmental behavior research involves not only social science and psychology but also ecology science. The distribution of subject categories shows the high priority of environmental, psychological, and behavioral issues in the field. Moreover, environmental behavior has become more interdisciplinary over time. In the late 2000s, environmental behavior research was mostly concerned with ecology, geography, and energy science. By the end of the 2010s, environmental behavior research had evolved into a research topic ranging from science and engineering (e.g., environmental science and material sciences) to social science (e.g., business and economics, public administration, behavioral sciences, and psychology). It is noticeable that interdisciplinary research has made a big contribution to this field [39]. Internal factors often change, especially in
the process of psychological science. Social science reflects the institutional defect in the development of environment constructions. Thus, environmental behavior involving multidisciplinary research will be one of the most applicable behavioral patterns in future research. Notably, betweenness centrality (BC) refers to the metric of a node and measures the likelihood of an arbitrary shortest path in a network to go through the node, which shows the ability of the node to make connections with other nodes in a network. For example, environmental sciences take the lead in environmental behavior research, which plays a crucial role in making connections with other subjects according to its high BC (0.29). Science and technology also play a crucial role in making connections with other subjects according to their high BC (0.20). Even though environmental studies are a dominant contributor to environmental behavior research, there is a trend for psychology, business and economics, behavioral sciences, and engineering to share leadership in the near future.

Table 1. Top 10 subject categories based on frequency.

| Subject                          | Frequency | BC  |
|----------------------------------|-----------|-----|
| Environmental Sciences and Ecology| 701       | 0.06|
| Environmental Sciences           | 382       | 0.29|
| Applied and Preventive Psychology| 341       | 0.07|
| Environmental Studies            | 323       | 0.19|
| Engineering                      | 225       | 0.12|
| Science and Technology           | 183       | 0.2 |
| Psychology                       | 181       | 0.12|
| Business and Economics           | 162       | 0.04|
| Behavioral Sciences              | 132       | 0.1 |
| Material Sciences                | 124       | 0.11|

4.2. Analysis of Countries and Institutions

CiteSpace analyzed collaborative patterns; each node represents a country, and nodes with the same color are grouped as a cluster, implying a specific and major research focus. The relatively low maturity of the research community is indicated by the relatively loose structure and fewer close relationships. Figure 2 shows that almost all countries had a cooperative relationship with the United States from 2002 to 2020. Moreover, China, England, Canada, Germany, Australia, Spain, France, and Italy played a key role in contact with other countries according to their high betweenness centrality. China was the largest contributor, publishing 208 papers, followed by the United States (186), and the other prominent Asian node was Japan (24), ranking eleventh in terms of publication counts. The number of publications from England was 70, and the country ranked third. Australia and Germany ranked fourth and fifth, respectively. Generally, the number of outputs is associated with the number of research institutions, the availability of research funding, and the proportion of people who have an environmental focus. Another possibility for high output is that some countries are considered at environmental risk; for example, Australia and the Netherlands are faced with various environmental deterioration [40].

The year in Table 2 represents when the agency first published papers on environmental behavior research. As shown, Chinese Academic Science (2003) was the first institution to participate in the study on environmental behavior research. As for the frequency, Chinese Academic Science was ranked first, with 41 publications; followed by the University of Minnesota and Vrije University Amsterdam, with 18 publications; the University of Groningen with 16 publications; and the University of Florida, with 15 publications. The top five institutions that dominated are from the United States and Europe, and it should be noted that half the institutions were from the United States, one from China, one from Australia, one from Canada, and two from Europe. It can also be observed that American institutions were more important and were widely linked through the network. Furthermore, Chinese Academic Science was a high-frequency institution in the network, and three central institutions were linked to it. We can also observe that institutions from the United States were the relative focus, connecting with the most institutions.
Table 2. Top 20 institutions based on frequency.

| Year   | Institution                          | Frequency | Year   | Institution                        | Frequency |
|--------|--------------------------------------|-----------|--------|-------------------------------------|-----------|
| 2002   | Chinese Academy of Sciences          | 41        | 2003   | University of Michigan              | 11        |
| 2005   | University of Minnesota              | 18        | 2004   | Virginia Commonwealth University    | 11        |
| 2004   | Vrije Universiteit Amsterdam         | 18        | 2005   | University of Minnesota             | 18        |
| 2007   | University of Groningen              | 16        | 2008   | University of Washington            | 10        |
| 2004   | Vrije Universiteit Amsterdam         | 18        | 2015   | University of Porto                 | 10        |
| 2007   | University of Florida                | 16        | 2015   | University of Porto                 | 15        |
| 2010   | The University of Queensland         | 13        | 2016   | Ghent University                    | 13        |
| 2011   | Michigan State University            | 13        | 2013   | Monash University                   | 13        |
| 2013   | Stanford University                  | 13        | 2007   | University of Exeter                | 12        |
| 2009   | Laval University                     | 12        | 2007   | China University of Mining and Technology | 12    |
| 2010   | Penn State University                | 12        | 2015   | University of Sao Paulo             | 13        |

4.3. Analysis of Authors

Table 3 shows the frequent author co-citation network. The emergence, formation, and development of a field cannot be separated from the experts and scholars in the field. Moreover, the knowledge map can be used to find the authors who have published a great number of articles. The number of articles published by one author is an indicator of the author’s ability to produce knowledge, and the citations made by the author can indicate the author’s academic level and influence. For example, the largest node author at the center of the map is Stern, who was quoted 317 times, and the number of quotes shows an increasing trend. At the same time, the centrality is 0.15, which indicates a broad co-citation relationship with others. As an accomplished expert in the field of environmental behavior research, Stern believed that psychology is one of the most effective ways to understand how people interpret information about the environment and how to respond on the basis of this understanding.

Table 3. Top 10 most frequently cited authors.

| Author     | Frequency | BC  | Author     | Frequency | BC  |
|------------|-----------|-----|------------|-----------|-----|
| P.C. Stern | 317       | 0.15| L. Steg    | 188       | 0.01|
| I. Ajzen   | 292       | 0.21| F.G. Kaiser| 166       | 0.05|
| P.W. Schultz| 221      | 0.35| A. Kollmuss| 162       | 0.01|
| R.E. Dunlap| 215       | 0.05| S.H. Schwartz| 159      | 0.19|
| S. Bamberg | 196       | 0.04| J. Thogersen| 137       | 0.09|
The author who ranked second is Ajzen, who focused on attitudes and behavioral relationships [41]. The frequency is 292 times, with a centrality of 0.21. The planning behavior theory proposed by Ajzen is a comprehensive interpretation of the complex activities of human behavior from a psychological perspective and is widely used in the field of environmental behavior research. There are also other authors with prominent contributions. For example, Schultz mainly studied environmental psychology, norms, etc., and his research was cited 221 times [42]. Bamberg proposed the multi-factor integration model [25]. Kaiser focused on attitude behavioral consistency, environmental psychology, and environmental sociology and constructed a model of environmental attitudes and values influencing ecological behavior [21]. Finally, Steg et al. reviewed the factors influencing environmental behavior through the literature review and designs interventions to reduce negative environmental behavior [43].

Another prominent node author is Dunlap, who proposed the new environmental paradigm theory [8]. Dunlap revised the new environmental paradigm scale to measure environmental concerns, which made up for the shortcomings of the original one, and renamed it the new ecological paradigm scale. He provided methodological guidance for environmental behavior research by designing scales that measure environmental concerns. In general, the above scholars have jointly promoted the progress of environmental behavior research.

### 4.4. Analysis of Journals

The number of articles on environmental behavior in the top 20 cited journals is displayed in Table 4. It should be pointed out that in this analysis, most of these journals are on the environment field, and one, Human Behaviors, is correlated to the fields of psychology and sociology. The top-cited journal was the Journal of Environment Psychology, and it is a key node in the network with a frequency of 535. It is followed by Environment Behavior (531) and Sustainability (378). It is observed that journals with high impact factors may have higher quotation frequencies. In addition, top academic journals publishing original research across a wide range of scientific fields are included, such as Science (362) and Nature (246). Comparing the frequency of citation, psychology journals such as the Journal of Personality and Social Psychology (339), the Journal of Applied Social Psychology (319), and Psychological Bulletin (290) had a higher frequency than journals on sociology and management. Others with a high frequency were the Journal of Environment Education (284) and Organizational Behavior and Human Decision Processes (229). The most prolific journals on environmental behavior research do not necessarily have a bigger impact and are not cited more frequently. However, journals with higher effective factors may have higher co-citation frequency.

| Frequency | BC  | Journal                                      | Frequency | BC  | Journal                                      |
|-----------|-----|----------------------------------------------|-----------|-----|----------------------------------------------|
| 535       | 0.18| Journal of Environment Psychology             | 246       | 0.06| Nature                                       |
| 531       | 0.05| Environment and Behavior                      | 229       | 0.01| Organizational Behavior and Human Decision Processes |
| 378       | 0.12| Sustainability                                | 223       | 0.06| American Psychologist                       |
| 362       | 0.18| Science                                      | 197       | 0.01| Environment Science Technology               |
| 339       | 0.23| Journal of Personality and Social Psychology  | 196       | 0.02| PLoS ONE                                    |
| 319       | 0.02| Journal of Applied Social Psychology          | 172       | 0.01| Ecological Economics                        |
| 290       | 0.2 | Psychological Bulletin                        | 165       | 0.02| Journal of Cleaner Production               |
| 284       | 0.07| Journal of Environment Education              | 162       | 0.05| Journal of Business Research                 |
| 255       | 0.01| Proceedings of the National Academy of Sciences| 141       | 0.01| Journal of Consumer Research                |
| 251       | 0.02| Environmental Education Research               | 141       | 0   | Journal of Environment Management           |
4.5. Analysis of References

The key authors and articles contributing to environmental behavior research can be identified by an analysis of references. The most-cited articles can be regarded as landmarks due to their ground-breaking contributions [44]. The top 20 cited papers and their frequency are shown in Table 5. As observed, Steg and Vlek was the most cited reference, who observed that environmental quality depends on human behavior patterns and reviewed the contribution and potential of environmental psychology in understanding and promoting pro-environmental behavior [1]. The second-most-cited article was Bamberg and Möser, the goal of whom was replication and extension of Hines Results [25]. It confirmed that personal moral norm is a predictor of pro-environmental behavioral intention besides attitude and behavioral control. Gifford and Nilsson is another influential work on psychosocial determinants of pro-environmental behavior, the paper outlining personal and social factors that influence pro-environmental behavior [45]. Whitmarsh and O’Neill focused on effective and socially acceptable ways to adopt pro-environmental behaviors [46]. Steg et al. proposed an integrated theoretical framework for understanding behavior change that identifies two routes to encourage pro-environmental behavior and analyzes the influence of environmental knowledge on positive environmental behavior among university students from countries with different levels of economic development as well [47]. Differences were found between students from emerging and developed countries, which suggests that external factors (culture, environmental structures, and services in each country) might play a relevant role in university students’ behavior toward the environment [48]. The above result suggests that scholars are increasingly focusing on quantitative research in the construction of the theoretical framework and methodology to analyze environmental behavior.

| Frequency | Authors | Reference |
|-----------|---------|-----------|
| 81        | L. Steg and C. Vlek | Encouraging pro-environmental behavior: An integrative review and research agenda |
| 55        | S. Bamberg and G. Möser | Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behavior |
| 46        | L. Whitmarsh and S. O’Neill | Green identity, green living? The role of pro-environmental self-identity in determining consistency across diverse pro-environmental behaviors |
| 36        | R. Gifford and A. Nilsson | Personal and social factors that influence pro-environmental concern and behavior: A review |
| 35        | L. Steg et al. | An integrated framework for encouraging pro-environmental behavior: the role of values, situational factors and goals |
| 25        | A. Zsoka et al. | Greening due to environmental education? Environmental knowledge, attitudes, consumer behavior and everyday pro-environmental activities of Hungarian high school and university students |
| 25        | R. Gifford | The dragons of inaction: Psychological barriers that limit climate change mitigation and adaptation |
| 23        | D. Nigbur et al. | Attitudes, norms, identity and environmental behavior: Using an expanded theory of planned behavior to predict participation in a kerbside recycling programme |
| 22        | E. van der Werff et al. | The value of environmental self-identity: The relationship between biospheric values, environmental self-identity and environmental preferences, intentions and behavior |
| 22        | C.A. Klockner | A comprehensive model of the psychology of environmental behavior—A meta-analysis |
| 22        | H. Han | Travelers’ pro-environmental behavior in a green lodging context: Converging value-belief-norm theory and the theory of planned behavior |
Table 5. Cont.

| Frequency | Authors               | Reference                                                                                           |
|-----------|-----------------------|-----------------------------------------------------------------------------------------------------|
| 20        | E.A. Halpenny         | Pro-environmental behaviors and park visitors: The effect of place attachment                        |
| 20        | A.D. Leeuw et al.     | Using the theory of planned behavior to identify key beliefs underlying pro-environmental behavior in high-school students: Implications for educational interventions |
| 19        | K.S. Fielding et al.  | Theory of planned behavior, identity and intentions to engage in environmental activism              |
| 19        | H.B. Truelove et al.  | Positive and negative spillover of pro-environmental behavior: An integrative review and theoretical framework |
| 18        | A.F. Hayes and K.J. Preacher | Statistical mediation analysis with a multicategorical independent variable                           |
| 18        | J.L. Robertson and J. Barling | Greening organizations through leaders’ influence on employees’ pro-environmental behaviors          |
| 17        | J. De Groot and L. Steg | Value Orientations to Explain Beliefs Related to Environmental Significant Behavior: How to Measure Egoistic, Altruistic, and Biospheric Value Orientations |
| 17        | R.E. Dunlap et al.    | Measuring Endorsement of the New Ecological Paradigm: A Revised NEP Scale                            |
| 15        | S. Oreg and T. Katz-Gerro | Predicting Pro-environmental behavior Cross-Nationally: Values, the Theory of Planned Behavior, and Value-Belief-Norm Theory |

4.6. Analysis of Keywords

Keywords analysis is used to reveal the trend in environmental behavior research and then identify the current research hotspots and future orientation [44]. In this study, author keywords were used as statistical objects for keyword analysis. The keywords analysis in our study adopted author keywords as statistical objects. VOSviewer, which is more suitable for the analysis at an aggregate level, was used to analyze the keyword cluster in this section [49]. The co-occurrence network of high-frequency keywords is shown in Figure 3, and a summary of the keyword cluster is given in Table 6. This visualization view arranges keywords in correspondence to the time of their publication or their peak time. According to the major keywords, the main topics can be divided into four aspects: the concept of environmental behavior, factors affecting environmental behavior, the dimension division of environmental behavior, and the construction of a sustainable environmental behavior model. The four aspects are in accord with previous quantitative observations of main themes in environmental behavior research.

The first is the concept of environmental behavior. Given the trend of globalization of environmental problems, the corresponding measurement of specific environmental behavior will be diversified. Some scholars define environmental behavior with environmental attitude, including perception [50], intention [51,52], emotion [53], and attitude [54,55]. As a core psychological variable in environmental behavior, it plays an important role in explaining environmental behavior in its unique way. Accurate measurement of environmental attitude becomes a prerequisite in analyzing behavior. In most research patterns, environmental attitude or environmental concern is usually considered as a key variable that aims to reveal the sophisticated intrinsic process and psychological mechanism of environmental behavior [56].

The second is factors affecting environmental behavior. Keywords can be classified into two types, namely, personal factors and contextual factors. The former includes environmental attitude, environmental concern, value, environmental belief, environmental knowledge, norms, perception, and behavioral intention, while the latter includes environmental policy and also other external driving factors. In particular, attitude has the largest node. Environmental attitude is even thought to be the decisive factor affecting environmental behavior. It adheres to the general law that psychological attitude determines...
environmental behavior. With the increase of related studies, value also becomes a leading inherent variable of behavior. As pointed out by Stern, ecological and altruistic values have a significant positive influence on private behavior [3]. Earlier environmental knowledge is thought to be influential in environmental behavior [57,58], and for this reason, environmental knowledge, concern, behavior, and attitudes become the earliest linear model in the field. As found in further research, increasing environmental knowledge does not bring about changes in environmental behavior. Kollmuss and Agyeman concluded that some internal factors, such as gender, age, residence, social classes, and educational background, are all defined as major factors affecting environmental behavior [19]. Furthermore, other factors, such as belief, intention, emotion, awareness, and a sense of responsibility [59], coexist. It is acknowledged that the existing research on clarifying environmental behaviors of different groups has policy implications and theoretical significance.

The third is dimension divisions of environmental behavior, including consumption behavior, recovery behavior, and energy conservation behavior. It implies that the research on environmental behavior needs to be refined and that different environmental behaviors have different influential factors. Some scholars have classified environmental behavior as civic behavior [60], financial behavior [36], legal behavior [36], and persuasive behavior [61] for their own research. Big progress has been made in the research of consumption behavior, recycling behavior, and energy-saving behavior [62,63]. The above studies involve various types of environmental behaviors and factors affecting them.

Figure 3. Co-occurrence network of high-frequency keywords.
Table 6. Summary of the keyword cluster.

| Keywords                        | Cluster | Total Link Strength | Frequency |
|--------------------------------|---------|---------------------|-----------|
| sustainability                  | 3       | 79                  | 48        |
| climate change                  | 1       | 66                  | 43        |
| environmental attitudes         | 2       | 48                  | 33        |
| environmental education         | 5       | 63                  | 32        |
| theory of planned behavior      | 3       | 44                  | 32        |
| behavior change                 | 5       | 48                  | 28        |
| values                          | 1       | 47                  | 25        |
| environmental knowledge         | 3       | 51                  | 24        |
| recycling                       | 6       | 49                  | 22        |
| sustainable development         | 1       | 49                  | 20        |
| place attachment                | 5       | 48                  | 17        |
| environmental concern           | 5       | 47                  | 17        |
| social norms                    | 6       | 51                  | 16        |
| environmental policy            | 1       | 51                  | 16        |
| intervention                    | 4       | 51                  | 15        |
| environmental management        | 1       | 51                  | 14        |
| behavior                        | 6       | 51                  | 13        |
| education                       | 3       | 51                  | 12        |
| environmental values            | 1       | 51                  | 12        |
| environmental attitude          | 1       | 51                  | 11        |
| environmental sustainability    | 3       | 51                  | 11        |
| soil                            | 2       | 51                  | 10        |
| sustainable consumption         | 4       | 51                  | 10        |
| trust                           | 1       | 51                  | 10        |
| conservation                    | 6       | 51                  | 9         |
| consumer behavior               | 4       | 51                  | 9         |
| environmental awareness         | 1       | 51                  | 9         |
| sediment                        | 2       | 51                  | 9         |

The last is the construction of a sustainable environmental behavior model. The concept and model of psychology to explain and predict individual environmental behavior are widely applied in the field of environmental research, and numerous empirical studies have been performed. Many theories have been put forward to explain the formation mechanism of environmental behavior, including multi-factor integration theory [64], the environmentally responsible behavior model [65], and the environmental attainment model [66]. Verifying the factors influencing environmental behavior helps to understand the structural factors of environmental behavior, predict individual environmental behavior, and implement a positive environmental behavior. The key role of environmental-behavior-related theories and models in this field is a hot research topic and will be so in the future as well.

4.7. Analysis of Research Trends

Bursts refer to terms that appear many times in a short period or with a high frequency of usage. The trends in the research field can be judged according to the frequency change of a burst. According to the hotspot analysis and the bursts shown in Table 7, this paper presents five types of environmental behavior research.

The first type of research is environmental behavior based on the background of sustainable development. In the context of global environmental change, the papers focus on individual risk factors, such as attitude, values, behaviors, and policy preferences [67,68]. The promotion of environmental behavior has become an important way to realize sustainable development, and research on environmental behaviors related to sustainable development ideas is also expanding, such as sustainable consumption behavior [69,70], education [26,66], and energy sources and environmental policies [71,72].
The second is the environmental behavior indicator. Recent research has shown that prosociality behavior, consumption behavior, green behavior, ecological behavior, and pro-environmental behavior can be useful alternative indicators of environmental behavior. From 2007 to 2011, many studies began performing environmental behavior research from an ethological perspective [67,68]. For instance, Chao suggested that environment behavior intention is determined by the attitude toward the behavior [65]. The stronger the environmental attitude, the more is the possibility that environmental behavior might occur. Recent studies have found that increased pro-environmental behaviors co-occur with more desirable, safe, and valuable environment behavior [75]. Research shows that people who exhibit a greater degree of prosociality are more likely to engage in environmental protection [19]. People who identify as prosocial assign themselves higher levels of personal responsibility for pro-environmental behavior [76], and sustainable or pro-environmental behaviors are more likely to be successfully implemented when actors are cooperative and exhibit prosociality [77]. In addition, Brosdahl pointed that consumption behavior has a great effect on the environment [78]; future studies could partially overcome the environmental problems, at least in terms of the behavioral component, by monitoring unecological consumption behavior. Therefore, it is a research direction to study more specific pro-environment behaviors from different perspectives.

The third is the influence on environmental behavior factors. The bursts of pro-environmental behavior, environmental knowledge, and environmental commitment indicate that research on environmental behavior factors for effects and anticipating environmental behavior through intrinsic variables is still the key content of the field. The determinants include the internal factors (such as standards, beliefs, values, responsibility, sensitivity, intention, perception); structural factors (such as environmental policies, interpersonal influences, economics, law, technology), and their internal logic relations. These are beneficial to understand the mechanism of environmental behavior formation, then providing references to the innovation of environmental management, modes, methods, and other aspects. It is important to study the factors influencing individual environ-
mental behavior to improve the behavior pattern [79]. In-depth research on the factors of environmental behavior is the trend of future research.

The fourth is the construction of an environmental behavior theory model. Based on a large number of empirical studies, many studies have been conducted on the theoretical frameworks from the original linear model to the multi-factor model or from applying the existing behavioral theories to innovating others in the field of environmental behavior research [80,81]. By constructing theory models, we can create a universal rule from the limited data. The anticipation of behavior needs the support and verification of theoretical models. In the future, it will be important to innovate scientific theoretical models and integrate the existing theoretical models.

The fifth is the application of environmental behavior. The purpose of environmental behavior theory research is to apply the factors, measurement tools, and mechanism of environmental behavior to environmental decision-making, management policy, education policy formulation, and inspection [82,83]. It attempts to change the environmental behavior of individuals and thus provide direction for future practice.

5. Conclusions

This paper provided the development history of environmental behavior and discussed the core scholars and their studies. A number of conclusions can be drawn from the results. First, the 818 papers from 2002 to 2020 reveal the increasing trends, identify significant points, and provide a systematic overview of environmental behavior. Environmental behavior has been involved in multidisciplinary research, especially in the last four years. Second, it is obvious that the study on environmental behavior has been dominated by the United States, China, Japan, Australia, and other European countries, and the United States plays a central role in the cooperative linkage between countries, a role that has been established gradually since 2002. According to the loose structure and the few close relationships, the institution co-citation network indicates the relatively low maturity of the research community. Third, the most cited authors are reasonably consistent with being the most productive authors, while the relationship between cited journals and high-yield journals is weak. It is interesting that many psychology journals are more influential than several environmental journals, indicating the multidisciplinary nature of environmental change and behavior research. Fourth, the research hotspots can be classified into the following categories: the concept of environmental behavior, the factors influencing environmental behavior, the dimension division of environmental behavior, and the construction of a sustainable environmental behavior model. Finally, these studies abstract from five trends on environmental behavior: the background of sustainable development, innovation of the environmental behavior indicator, in-depth research on the influencing factors of environmental behavior, construction of the environmental behavior theory model, and the application of environmental behavior.

Although academic research in this area has made progress, many substantial gaps need to be filled. First, institution collaboration networks and cooperative studies are rare. Second, the environmental behavior model is proposed under different research backgrounds and different discipline angles, leading to ambiguous concepts in research. Third, variable measurement methods are not unified. Common scales are related to environmental behavior, including environmental attitude, environmental concern, and environmental perception, most of which lack continuous empirical testing and are not representative. Many studies, particularly those that ignore the gap between real behavior and data, need further verification. Fourth, there is no in-depth analysis of the formation mechanism of environmental behavior. Previous studies have focused on factors relating to cultural backgrounds, such as value and norm, but ignored the influence of variables of complex sociocultural backgrounds and individual backgrounds and their relations, especially policy effects within different contexts of environmental behavior and influence of the periods before and after environmental policy formulation on individual environmental behavior.
On the basis of combining previous research on environmental behavior to expand the breadth and scope of this research, further research could be considered as follows: firstly, based on the researches from various institutions, universities, research institutes, and laboratories, we should design a reasonable and persuasive research framework and verify it in combination with large-sample data survey. Secondly, environmental behavior and related concepts should be defined, particularly on the basis of psychology attitude variables, and be structurally and operationally summarized and classified. Thirdly, the research on environmental behavior as per different cultural backgrounds, economic conditions, and different regions should be strengthened. Due to the huge differences in individual behaviors, characteristics, influences, and behavior formation, an in-depth analysis of the mechanism of environment behavior formation has become necessary. Fourth, some scholars have established a series of environment behavior theological studies. We should conduct detailed research on the relationship between theory conditions and types of environmental behavior. Fifth, the research should strengthen longitudinal surveys on the same interviewee group or the same region. Research methods such as the propulsion experiment method, the observation method and longitudinal survey, and isotropy analysis should be introduced to make the results verifiable.

Some inherent limitations of the contents and methods of this study are listed as follows: firstly, researchers usually tend to cite their own works and many high-quality papers, which may impact the number of citations of top journals. Future research may consider removing self-citations. Secondly, many scholars study this subject in Chinese, so an in-depth analysis through CNKI and a comparison between their studies can be performed in the future. Thirdly, the visualized knowledge map of the environment behavior research can be analyzed further by combining different knowledge fields and visualization technology. For example, the UCINET tool can be used to examine various properties of collaborative networks. To expand our research results, the literature review technique can be applied to environment behavior research.

Author Contributions: Conceptualization, P.T. and Z.S.; methodology, P.T.; software, P.T.; validation, P.T. and Z.S.; formal analysis, P.T.; investigation, Z.S.; resources, C.Z.; data curation, Z.S.; writing—original draft preparation, P.T.; writing—review and editing, Z.S.; visualization, P.T.; supervision, C.Z.; project administration, C.Z.; funding acquisition, C.Z. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Major National Social Science Fund of China, Grant Number 16ZDA081.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data sharing not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

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