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Investigation of Nexus between Knowledge Learning and Enterprise Green Innovation Based on Meta-Analysis with a Focus on China

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Abstract: Knowledge learning is a vital pre-factor and the driving force of green enterprise innovation; hence, meriting the numerous academic research and accumulated relevant literature. In this paper, the meta-analysis methodology was used to explore the direction and intensity of the influence of knowledge learning on green enterprise innovation, taking 32 independent documents as research samples. Meta-analysis results showed that the search breadth and the search depth of green resources and the green resources absorption and integration have significant positive effects on the green innovation of enterprises, among which green resources absorption and integration were the most important. Further, the research on the moderating effect found that the measurement method of green innovation affected the relationship between knowledge learning and green enterprise innovation; however, the moderating effect of the research object was not pronounced.

Keywords: knowledge learning; green resource search depth; green resource search breadth; green resource absorption and integration; green innovation of enterprises; meta-analysis

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Citation: Zhang, M.; Li, M.; Sun, H.; Oteng Agyeman, F.; ud din Khan, H.S.; Zhang, Z. Investigation of Nexus between Knowledge Learning and Enterprise Green Innovation Based on Meta-Analysis with a Focus on China. *Energies* **2022**, *15*, 1590. https://doi.org/10.3390/en15041590

Academic Editor: Luigi Aldieri

Received: 28 January 2022
Accepted: 17 February 2022
Published: 21 February 2022

1. Introduction

With the rapid development of the economy, the natural environment faces a severe threat, and the contradiction between economic growth and the environment is increasingly becoming eminent [1,2]. Combining the relationship between economic growth and the environment and realizing sustainable economic development has become the focus of world attention [3,4]. This goal can be achieved by ensuring minor resource consumption, minimum negative impact on the environment, and maximum economic benefits [5]. According to the "decoupling theory," green innovation is a crucial measure to consider economic development and environmental protection and to realize strong decoupling between them [6]. Decoupling theory depicts the process of delinking economic growth and carbon dioxide emissions from increasing environmental issues [7,8]. Thus, studies have shown that growth is achieved in the early stages of economic development with growing environmental challenges, pollution, and resource exploitation. With the continuous development trend, the economy becomes less harmful to the environment due to investments in technological and economic efficiency [6]. Green innovation is an innovation guided by the values of sustainable development, centered on saving resources and protecting the environment, and taking the pursuit of sound and rapid development as the starting point and foothold [9,10]. It can "force" producers to improve their technical level, carry out cleaner production to promote energy conservation and emission reduction, and then realize gainful economic development and environmental protection [11–15].

Simultaneously, green innovation can improve resource efficiency and corporate reputation and improve financial performance [16]. In addition, the green innovation capability and development level directly affect the economic development of a country or region and its competitiveness in the international community [17,18]. Therefore, green innovation is of great significance to the sustainable development of society [19]. As early as 2005, the current President of China, Xi Jinping, put forward the scientific judgment that "Lucid waters and lush mountains are invaluable assets". In 2015, "green" was formally put forward as the five development ideas of China for the first time at the Fifth Plenary Session of the 18th CPC Central Committee policies. In 2016, the United Nations officially launched 'the 2030 Agenda for Sustainable Development', calling on all countries to take action to explore the road of green and low-carbon sustainable development and jointly write the blueprint for the future. China's inclusion as a permanent member of the United Nations actively responded to this plan. The report of the 19th National Congress of the Communist Party of China put forward that "building a market-oriented green technology innovation system to enhance green development, promote the construction of ecological civilization, and protecting lucid waters and lush mountains is vital". Thus, promoting green technology innovation as a strategic decision at the national level. Therefore, this study is based on the essence to deeply explore the influencing factors of green innovation and then find out the merit to promote green innovation [12–14].

This study deepens the discussion of the influence of knowledge learning on green enterprise innovation. Knowledge learning is a process of connecting and absorbing specialized information sources for expansion through which knowledge is acquired and applied in a specific field [20–22]. Knowledge learning is classified into external green knowledge search and internal green knowledge absorption and integration [23]. It further suggests that enterprises continuously acquire external new knowledge, new technology, and new ideas through exploratory learning. It then absorbs, integrates, and applies them to the activities of enterprises through utilization learning. Thus, providing new ideas and new directions for green innovation and development of enterprises. Knowledge has the characteristics of concealment. Thus, the sharing of knowledge, skills, and information among enterprises, customers, and suppliers can effectively promote the green innovation behavior of enterprises [24].

First, although most scholars posited that external knowledge search positively affects enterprises' green innovation, the literature review revealed that the existing empirical research had not reached a consistent conclusion. Some research results showed that enterprises' access to external resources positively impacts green innovation [25–28]. However, some scholars, from the perspective of the external network, pointed out that the relationship between the external cooperation network depth of enterprises and the green innovation of enterprises are not in a simple linear relationship but an inverted U relationship [29–31], and a too-high depth knowledge search would also lead enterprises to rely on strong links with external resources, which would lead to increased opportunism risks for enterprises [32,33], and may not be conducive to enterprise innovation [34–36].

Secondly, the intensity of internal absorption and integration of knowledge on green enterprise innovation was also different. Some studies showed that the green innovation of enterprises with a high capacity to absorb and integrate external knowledge was significantly higher than that of enterprises with low ability, and the correlation coefficient between the ability to absorb external integration and enterprise innovation was greater than 0.5 [27,37]. However, the correlation obtained by some other studies was much weaker [38,39]. Different studies showed differences in the intensity of external knowledge search and internal knowledge absorption and integration on green enterprise innovation. Each study adopted other research methods based on various research objects, making the conclusions not universal.

Therefore, it is both practically and theoretically important to synthesize the existing literature and examine the effect of knowledge learning on the green innovation of enterprises. There is no general conclusion to identify the factors that influence the current relationships. It is important to conduct a meta-analytical investigation of the prior literature to synthesize the effects of green resource search breadth, green resource search depth, and green resource absorption and integration on green innovation of enterprises. Simultaneously, this study provides up-to-date findings on which factor is more important to enterprises' green innovation.

Based on the different results of previous research, the relative importance of these three factors for enterprises' green innovation and the potential role of the definition of green innovation and research objects through the application of meta-analysis for analysis has several merits. Firstly, this investigation provides an overview of the previous literature on the relationship between knowledge learning and green innovation and puts forward the corresponding assumptions. Secondly, a meta-analysis is conducted to examine these three factors' respective and relative effects on enterprises' green innovation. Thirdly, the study also examines two moderators to draw their moderative effects on the relationship between green resource search breadth, green resource search depth, and green resource absorption and integration on green innovation. Finally, based on the meta-analytical findings, this study provides countermeasures and suggestions for further theory development and managerial practices in enterprises' green innovation management. Meta-analysis is an empirical research method that systematically collects the statistical indicators of the same kind of research in the past, integrates and analyzes them, and finally draws a more accurate and general conclusion [40]. It simply counts the average effect value of the relationship between two variables and explores the moderating effect of situational factors on the relationship between research variables. The moderating effects of two potential variables were also analyzed: the definition of green innovation and the research object.

Specifically, this study contributes to the existing body of knowledge by deepening the discussion on the influence of knowledge learning on green enterprise innovation. Additionally, this study broadens the scope of research by analyzing the influence of green resource search breadth, green resource search depth, and green resource absorption and integration on the green innovation of enterprises in China. This study provides an in-depth analysis of the selected variables by analyzing the publication bias heterogenous test effects and applying the "failure safety factor N" test to evaluate the publication bias more accurately. Thus, this study is the pioneer in investigating knowledge learning and green enterprise innovation through the moderation effect of meta-analysis methodology.

The principal objective of this study seeks to explore the direction and intensity of the influence of knowledge learning on green enterprise innovation employing 32 independent empirical literature documents as research samples. Further, this study aims to broaden the knowledge on effective resource consumption while projecting the merits of ensuring minimum negative impact on the environment to achieve maximum economic benefits.

This current study is structured as follows: Section 1 of this study provides the introduction, Section 2 outlines the literature review and research hypothesis development, Section 3 provides the methodology, Section 4 outlines the results and analysis, and Section 5 provides the research conclusions and suggestions.

2. Literature Review and Research Hypothesis Development

Knowledge learning can help enterprises consciously formulate strategies to adapt to the dynamic changes of the environment, build competitive ability and enhance the competitive advantage of enterprises [41]. Knowledge learning also influences enterprises' essential innovation performance and evolution of technological trajectory [42]. The extension of knowledge learning to the environmental field is environmental knowledge learning, which includes the whole process of acquisition, absorption, and utilization of ecological resources [43–45]. Knowledge learning can help enterprises acquire technologies for producing environment-friendly products to cope with complex environmental problems [46]. It could positively influence the green innovation behavior of enterprises [47]. In this study, knowledge learning has been categorized into two main parts, i.e., resource searching and green resources absorption and integration.

2.1. The Relationship between Green Resource Searching and Green Innovation

Green resources emit a relatively minimal quantity of pollution and serve as the essential driving force to promote the efficiency of natural resources [48]. Green resource searching comprised search breadth of green resource and search depth of green resource. The search breadth of green resources refers to the wide channels, large quantity, and diverse fields for enterprises to search and acquire external knowledge. The search depth of green resources means that enterprises excavate and reuse the knowledge searched and received from outside, support each other with groups from which they get knowledge, and maintain long-term cooperation.

Firstly, enterprises need to implement green innovation based on comprehensive knowledge in technology, market, and environment [49,50]. However, no enterprise can create all the required knowledge for innovation only by internal resources. Even large enterprises with a strong technical force can do nothing without collaboration [51,52]. Therefore, searching for external knowledge and acquiring more critical resources that enterprises lack in their development is the key to better adapting to external environment shocks. It is also crucial for enterprises to develop green innovation and enhance competitiveness [26]. Conversely, the industry 2.0 and 4.0 eras allowed enterprises to acquire lots of external knowledge [53,54]. Through the open search strategy, diversified, heterogeneous, and complementary new resources can be obtained in this era from the market, suppliers, customers, universities, research institutes, and even competitors. It may not include only new knowledge and technologies needed for innovation activities but also information encompassing market status and demand, competitors' behaviors, and customer preferences [23,55–59]. These may assist enterprises in acquiring more advanced knowledge, increasing their reserves of new knowledge, and promoting enterprises' green innovation.

Secondly, increasing the extraction and utilization of external knowledge by enterprises will help to strengthen the search path of enterprises and the trust with the subject or knowledge sources [60]. Thus, enterprises need to use new and complex technologies when sharing knowledge with other organizations [61]. Enterprises need to improve search efficiency and reduce search costs [62]. However, over-reliance on a deep knowledge search would lead enterprises to rely on strong links from external resources, which would lead to increased opportunism risks [32,33] and may not be conducive to enterprise innovation [36].

The empirical investigation of [28,63] pointed out that the stronger the breadth and depth of external knowledge search, the higher the openness of its search activities, the richer the knowledge acquired by enterprises, and the more conducive to the development of innovation activities. Based on the classification of innovation, [64] found that the deep knowledge search had a significant positive effect on the progressive innovation of enterprises, and the broad knowledge search positively affected the breakthrough innovation of enterprises. Nevertheless, other scholars have given different conclusions [34] that a deep knowledge search is beneficial to green innovation of enterprises, but the influence is not significant.

Some scholars have pointed out that the breadth and depth of knowledge search have a nonlinear relationship with green innovation of enterprises. It was concluded by [65] that the relationship between the breadth of external knowledge sources and the tendency of ecological innovation was influenced by coordination difficulties and limited rationality, showing an inverted U-shaped relationship. Some researchers analyzed the connection from the network angle and indicated that a network is essential for enterprises to obtain external knowledge resources [66]. Enterprises located in the critical position of social network can get to know more external network members and access more resources, which is beneficial for enterprises to acquire technology, talents, and raw materials for green products needed by the market and to improve the enterprises' innovation ability [27,67–72].

Notwithstanding, [31,69] considered that the enterprise's social network that makes it obtain resources has a non-linear influence on green innovation, and there is a threshold. If the threshold is exceeded, the former will have a negative impact on the latter; thus, the embedding of external network relations and green innovation has an inverted U-shaped relationship. After analyzing different types of innovation, [73] pointed out the inverted U-shaped relationship between collaboration breadth and aggressive innovation performance and between collaboration depth and progressive innovation performance.

Based on the previously analyzed studies, this current study tries to identify the relationship between external knowledge search and green enterprise innovation and the relationship intensity. This study put forward the following assumption based on previous empirical research results.

Hypothesis 1 (H1a). *The search breadth of green resources positively affects the green innovation of enterprises.*

Hypothesis 1 (H1b). *The search depth of green resources positively affects the green innovation of enterprises.*

2.2. The Relationship between Green Resources Absorption and Integration and Green Innovation

The capability to absorb and integrate green resources is key to the green innovation of enterprises [74]. It serves as a great potential to identify the value of new information, understand the learned knowledge, apply it, and predict the future development direction of knowledge and technology in the later practice of enterprises [75–78]. Further, with the expansion of enterprises' potential to acquire external knowledge, it is anticipated that the pool of the enterprises' knowledge will continue to broaden. Thus, if the knowledge is not adequately absorbed and integrated, it will lead to a lot of disorder and redundancy in a state of knowledge without bringing high-impact inventions [79]. Enterprise knowledge redundancy may imbalance the enterprise's green utilization innovation and green exploration innovation, which invariably impacts green balance development. The internal absorptive knowledge capacity enhancement can promote the mutual integration of internal and external valuable knowledge and increase enterprises' stock of effective knowledge [80].

Therefore, enterprises need resources with relevant attributes to achieve excellent performance and integrate heterogeneous resources while managing diversified resources [81]. Additionally, environmental knowledge is an essential prerequisite for formulating a green integration strategy [82]. Effective knowledge can promote the deep development of existing knowledge and technology scope and the cognitive understanding of new knowledge. Thus, more novel and valuable theories and ideas can be implemented [83,84]. Therefore, the absorptive capacity determines whether the effective knowledge of enterprises can be fully transformed and utilized to influence green innovation. With a strong absorptive and integrated capacity, enterprises can absorb and utilize proprietary technologies and swiftly adapt to the rapidly changing market environment [85–87].

There were many empirical investigations about the relationship between absorptive capacity and green enterprise innovation. One of it showed that absorptive capacity plays a significant role in regulating organizational learning and green enterprise innovation was analyzed by [39]. When an enterprise has a high absorptive capacity, internalizing and applying external knowledge will be greater. The learning enthusiasm of employees will be correspondingly improved, thus effectively promoting green enterprise innovation. It was pointed out by [88–90] that the dynamics in green enterprises' capabilities are the ability of enterprises to effectively develop, integrate, reorganize, and utilize internal and external green resources. Thus, it facilitates the process of green innovation, and, making timely adjustments and changes under the uncertain external environment, are helping to improve the enterprise's green innovation capability [91]. The stronger the potential of green innovation, the more favorable it is for enterprises to avoid the heavy dependence on the research and development (R&D) path and swiftly integrate, optimize, and utilize internal and external resources. Simultaneously, it is necessary to share and coordinate the internal resources of enterprises among different departments, thus promoting the development of green innovation. It was found by [84] that knowledge sources largely influence the success of enterprises' green innovation process; nevertheless, the most important thing is the combination degree of internal and external knowledge in each stage of the green innovation process. It was indicated by [92] that enterprises can apply the newly accepted knowledge of green environmental protection to their daily operation and management through learning. It must often train employees to strengthen their capability of knowledge absorption through meetings and discussions, which is conducive to the green innovation of enterprises. It was noted by [93] that the depth of knowledge integration ability positively regulated the relationship between enterprise green technology relevance and green innovation. Based on the above discussion, the following assumption was put forward.

Hypothesis 2 (H2). *The ability of Green Resources Absorption & Integration positively affects the green innovation of enterprises.*

2.3. Regulatory Effect

2.3.1. The Regulatory Role and the Definition of Green Innovation

Green innovation is considered a multi-dimensional structure, and different measurement methods may be adopted in various investigations [94,95]. Researchers have classified green innovation according to different classification standards [94,96–98]. According to innovation contents, green innovation was divided into green product innovation, green process innovation, green management innovation, and green marketing innovation terminal technology; however, the former two are primarily investigated [52,94–98]. According to innovation intensity, green innovation was mainly grouped into progressive green innovation and breakthrough green innovation. Furthermore, based on the dualistic organization theory, green innovation was divided into green utilization and exploration. Thus, studies continue to adopt innovation in many fields including innovation on environmental pollution in assessing economic growth [99].

Further, different studies have analyzed green innovation from various perspectives, including green product innovation, green process innovation, green management innovation, and other multi-dimensional comprehensive green innovation, exploratory green innovation, gradual green innovation, etc. Different measurement methods of green innovation could impact the relationship between associated variables [34]. Table 1 describes and summarizes the related definitions. Based on the above literature discussion, this current study put forward the following assumption.

Hypothesis 3 (H3). *The definition of green innovation affects the relationship between green resource search, green resource absorption and integration, and green innovation.*

Table 1. Summary of the Main Variable and Definitions.

Variables		Explanations
Knowledge learning	Green resource search	The search breadth of green resources refers to the breadth of enterprises' searching and acquiring external knowledge, which is mainly reflected in the number of external knowledge channels used, the breadth of external knowledge fields searched, and the number of levels or types of external knowledge searched [16,28,100].
		The search depth of green resources refers to the enterprise's mining and reuse of the externally searched and acquired knowledge, mainly manifested in the frequency and persistence of cooperation and communication with knowledge sources [16,28,100].
	Green resource absorption & integration	The ability to absorb and integrate green resources is mainly based on the external resources obtained, enterprises identifying the value of new information, understanding and learning knowledge, and the ability to apply resources in the later practice of enterprises [89,101].
Comprehensive green innovation		Comprehensive green innovation is an innovation activity that avoids or reduces the damage to the environment by introducing new or improved ideas, products, processes, technologies, and systems into economic activities, taking economic benefits, environmental benefits, and social benefits into consideration [102]. Different classification standards also include green product innovation, green process innovation, and green marketing innovation.
Green product innovation		Green product innovation seeks to modify or change products through nontoxic biodegradable materials or compounds within the production process to minimize the disposal influence on the environment and improve energy efficiency [103,104].
Green process innovation		Green process innovation mainly refers to the activities of enterprises to reduce toxic and harmful emissions, reduce the consumption of water, electricity, coal, and other energy sources, and treat wastes or emissions through process improvement and technology application in the manufacturing process [102].
Green marketing innovation		Green marketing innovation assumes that the lifecycle of a product, from materials acquisition, production, sale, and consumption to the disposal of waste, has a minimal influence on the environment. Green marketing comprises advertising the reduced emissions connected with a product's manufacturing process or the consumption of post-consumer recycled substances for a product's packaging [105].
Breakthrough green innovation		Breakthrough green innovation refers to completely breaking away from the existing knowledge, technology, and other foundations, creating something challenging to be imitated and surpassed in a short period. Its achievements can create differentiated competitive advantages for enterprises and promote green innovation to obtain long-term benefits [106].
Progressive green innovation		Progressive green innovation is a kind of green innovation that enterprises continuously improve existing green technologies, which can enhance enterprises' performance in a short time and can also be predicted based on financial data [107]. It is characterized by fast innovation development, low risk, and low cost.

2.3.2. The Regulatory Role of the Research Object

Many researchers have employed different research objects, including resource-based manufacturing and manufacturing enterprises with severe pollution green-oriented enterprises [99]. There is a significant discrepancy between resource-based and manufacturing enterprises regarding provided products, invested resources, customer demand, environmental factors, organizational structure, etc. Compared with the latter, the former is more dependent on resource endowment. It invests less intelligence and organizational resources; therefore, the motivation of resource-based enterprises to obtain heterogeneous and diverse resources through external networks will be weak. Besides, the external networks of intelligent manufacturing and green-oriented enterprises were more complex [31] and often invested high human, material, and financial resources in carrying out green innovation [12,13]. Compared with resource-based enterprises, knowledge learning in manufacturing has a more significant impact on green innovation. In analyzing the general manufacturing sector, the adoption of knowledge learning by intelligent manufacturing and green-oriented enterprises has a more substantial effect on green innovation. Based on the above discussion, the following assumption is put forward.

Hypothesis 4 (H4). *The research object can regulate the relationship between knowledge learning and green innovation.*

3. Research Methods

3.1. Literature Search and Select

This current study is based on the influence of knowledge learning on Chinese enterprises' green innovation and provides suggestions that are feasible for the Chinese enterprises' green innovation development. The following steps were used to search and screen documents to avoid omitting documents as much as possible and ensure complete data collection. (1) Searching documents in China National Knowledge Infrastructure (CNKI) database by theme. The search terms were set as green innovation, green management innovation, green process innovation, green energy innovation, green technology innovation, terminal technology innovation, and low-carbon technology innovation. All the literature related to green innovation were the research objects, and the period was from January 1994 to July 2021, mainly including academic dissertations and journal papers. (2) According to the title and abstract of the paper, preliminary screening was carried out to obtain empirical research related to green innovation, and the full texts of these papers were downloaded. (3) Through browsing the full text for secondary screening, the papers containing both knowledge learning and green innovation and the correlation coefficient between them were selected. (4) After collecting the data, a second comparison was made to avoid wrong data collection. Figure 1 indicates the flow chart of document retrieval and screening processes.

To ensure the effectiveness of meta-analysis application and to consider the research topic, the documents included in the final meta-analysis must meet the following conditions: (1) It must simultaneously contain any two of the three variables of external knowledge search, internal knowledge absorption and integration, and green innovation. (2) The research object must be related to enterprises. (3) It must be an empirical study and include sample size, correlation coefficient, or other indicators that can be converted into a correlation coefficient. (4) Each study must provide independent data sets. Studies with the same sample size were selected and categorized based on sufficient details. After screening, there were 32 documents suitable for the analysis and 45 independent data sets encoded into meta-analysis. Because some papers were classified under green innovation, the data sets were larger than the documents. The variables K(k) were used in this study to denote the number of studies obtained from the database and the final samples selected and screened.

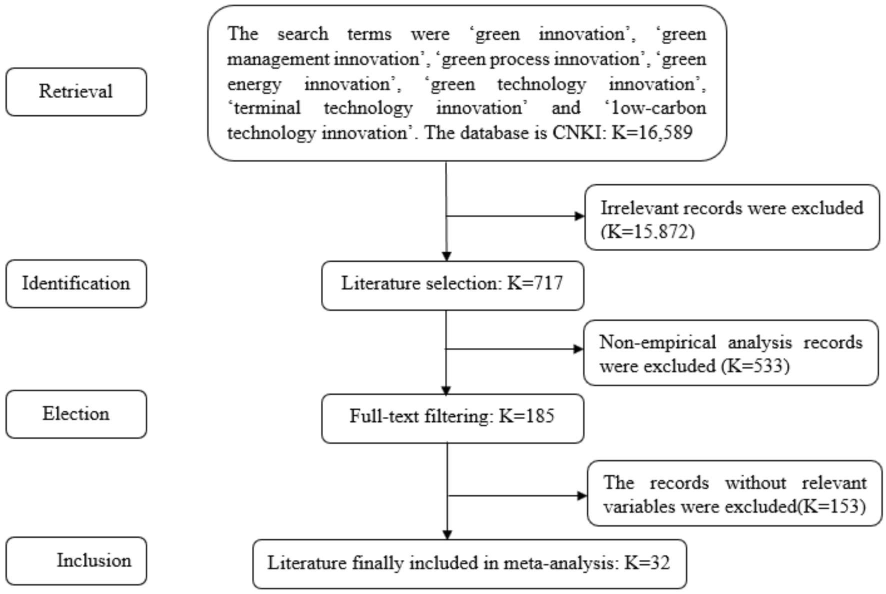

Figure 1. Flow Chart of Document Retrieval and Screening.

3.2. Coding Process

Due to various researchers' different expressions of related concepts, there was some uncertainty in the classification of variables, which made the document coding work subjective to some extent. Simultaneously, there was the possibility of errors caused by a heavy workload. Therefore, to increase the reliability of document coding, two coders were employed in the coding process of this study, and the document coding work was completed according to the following steps: (1) Two coders independently completed data coding; (2) After the first coding, a discussion was made on the inconsistent information until the opinions were consistent, to avoid personal subjective judgment; (3) Comparing the coding results by sampling, and reviewing the original text to check and discuss the questionable results again; (4) 79 effect values were obtained from 45 independent samples in 32 works of literature, and the data were rechecked to complete the final coding. In addition to the basic information of the study, including the authors' name, publication year, degree thesis and school, or journal name, the encoded data also included different dimensions of variables such as green product innovation, green process innovation, etc. and the related statistics comprising of sample size, correlation coefficient, and Cronbach alpha and possible regulatory variables containing the industry in which the enterprise is located, literature type, research time point, etc. The regulatory variables of this paper were mainly the definition of green innovation, including comprehensive green innovation, green product innovation, green process innovation, green marketing innovation, breakthrough green innovation, and progressive green innovation, and the research objects are resource-based enterprises, manufacturing enterprises, and intelligent or green manufacturing enterprises.

3.3. Meta-Analysis

The meta-analysis, first named by American educationist Glass in 1976 [108], is a method of reanalyzing data based on several empirical research results of the same problem to obtain a more general conclusion. In this study, the measurement error was corrected by the reliability correction of the correlation coefficient. The heterogeneity test determined the model selection, followed by the publication bias analysis. It was carried out according to the "failure safety factor N". Finally, the Comprehensive Meta-analysis 2.0 software was employed to analyze the data effectively. The specific process was as follows.

(1) Reliability Correction of Correlation Coefficient

Firstly, to correct the deviation of correlation coefficient in different empirical studies, this study adopted the approach of [109] to evaluate the reliability of each original correlation coefficient of all samples.

$$R = \frac{r_{xy}}{\sqrt{\alpha_x \alpha_y}} \quad (1)$$

where R denotes the reliability of the correlation coefficient of the samples, r_{xy} is the correlation coefficient of each pair of observed variables in all samples, that is, the effect value; α_x and α_y are the Cronbach's α value of the corresponding explanatory variable and the dependent variable, that is, the reliability value.

Many researchers report that the values of some variables were missing in individual studies where the reliability is affected. This recent study contributes to the body of knowledge and literature by employing the weighted mean of reliability of non-missing variables to fix all missing variable problems. The specific calculation is shown in Formula (2), and the objective reliability was replaced by 1.

$$\overline{\alpha} = \frac{\sum_{i=1}^{k} n_i \alpha_i}{\sum_{i=1}^{k} n_i} \quad (2)$$

Additionally, n_i is the corresponding sample size of each similar study, and α_i denotes the Cronbach's α value of an observed variable studied.

(2) Model Selection

Meta-analysis mainly adopts the fixed effect model or the random effect model, and the difference between them primarily lies in the different weight components. The former assumes that there is only one true effect value behind all samples in the meta-analysis. The difference in the effect values is considered to be a sampling error. The latter projects that the true effect value of each sample is not the same and the difference is caused by different true effects and sampling errors. This current study projects that using two different models for analysis would make the significance of the average effect value, interval estimation value, and moderating variable in the meta-analysis results differently. Therefore, to avoid the situation that the model would be replaced because the results were inconsistent with the assumptions, it was necessary to determine which model to choose from the theoretical and practical analysis level before the effect analysis.

Conversely, 32 independent research documents were finally selected as samples in this paper. The research objects of the chosen samples were different, comprising of manufacturing enterprises and resource-based enterprises. There were also distinct characteristics of addresses and levels of the same type of enterprises. Therefore, the effect quantity obtained by meta-analysis could not be limited to all the objects in a certain study. On the other hand, the analysis of regulatory variables was involved. Therefore, theoretically, the random effect model is projected to be more suitable for this meta-analysis than the fixed effect model. Further, the heterogeneity test would be used to verify the choice of the model from the practical level.

(3) Publication Bias

When published research cannot represent the overall objective in related fields, it would be considered that there has been a "publication bias" [110]; when this occurs, it will lead to the final effect value being higher than the true value. In this paper, firstly, the funnel chart was used to analyze "publication bias" to intuitively determine whether there was a publication bias in the samples selected in this paper. Afterward, "failure safety factor N" and Egger's test method were used to evaluate the publication bias of all samples in meta-analysis. "Failure safety factor N" posits that it is necessary to add some unpublished studies so that the final correlation coefficient or its significant level is lower than a specific critical value, that was, 5k + 10 (k is the sample size of meta-analysis); otherwise, there would be publication bias [111].

4. Result Analysis

4.1. Heterogeneity Test

Heterogeneity tests were conducted on the search breadth of green resource, the search depth of green resource, and green resource absorption and integration. From the test results of heterogeneity effect quantity in Table 2, the Q test of the three variables was significant ($p < 0.001$), which indicated the heterogeneity of sample effect values in meta-analysis. In addition, heterogeneity was judged according to the I^2 value. The I^2 values of the three variables were 96.300, 94.926, and 96.687, respectively, which indicated that 96.300%, 94.926%, and 96.687% of the observed variations in the study of the relationship between the three variables and green enterprise innovation were caused by their real differences among them. τ^2 represents the true effect quantity variance, and all three variables indicated some variation in the true effect quantity. Therefore, according to the heterogeneity test results, it was reasonable to choose a random effect model for meta-analysis in this paper.

Table 2. Test Results of the Heterogeneity of Effect Quantity.

Explanatory Variable	Q	df	p	I^2	τ^2
Green resource search breadth	1000.004	37	<0.001	96.300	0.643
Green resource search depth	197.081	10	<0.001	94.926	0.066
Green resource absorption and integration	754.631	25	<0.001	96.687	0.110

4.2. Publication Bias Assessment

Firstly, the issue of "publication bias" was visually checked by a funnel chart. From the funnel chart, the effect values of the assessed literature, which explains the relationship between the search breadth of green resource, the search depth of green resource, and green enterprise innovation, were relatively evenly distributed on both sides of the total effect as indicated in Figures 2 and 3. Their interconnection showed no publication bias between these two variables' relationships. However, the effect values of the assessed literature based on the relationship between the search breadth of green resource, the search depth of green resource, and green enterprise innovation, were not evenly distributed on both sides of the total effect (see Figure 4), which indicated that the investigation on these variables might have publication bias.

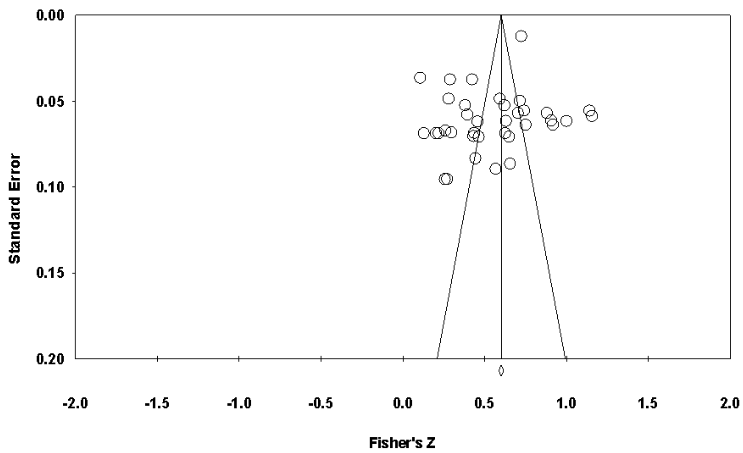

Figure 2. Funnel Diagram of Research on the Search Breadth of Green Resources.

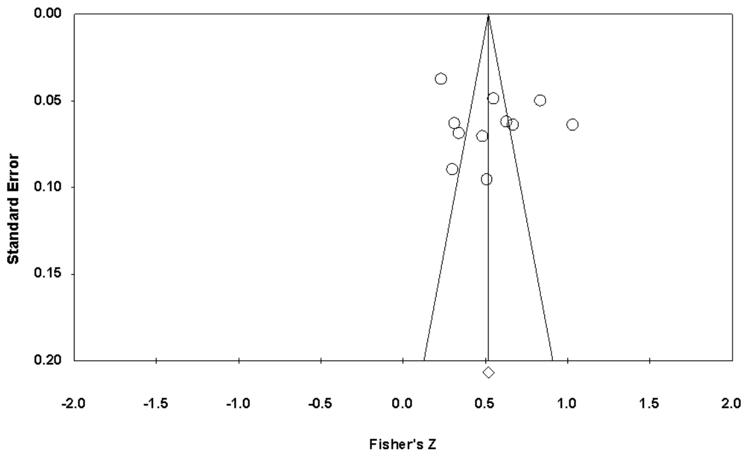

Figure 3. Funnel Diagram of Research on the Search Depth of Green Resources.

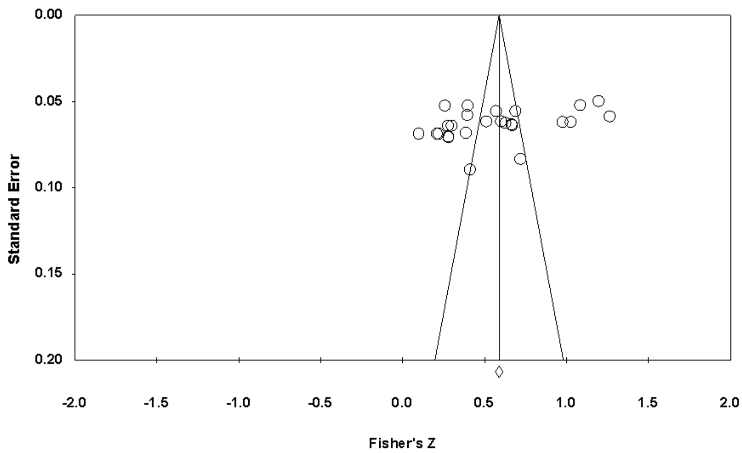

Figure 4. Funnel Diagram of Green Resource Absorption and Integration.

Because the funnel chart was only an intuitive preliminary check of publication bias according to the chart, it is subjective to some extent. The "failure safety factor N" test was carried out to evaluate publication bias more accurately. Additionally, the funnel plot of standardized error by Fisher Z transformation demonstrated the significance of the differences between the correlations coefficient of the variables and the effect size estimate standard errors in Figures 2–4 [112–114].

Secondly, according to [115], a test on the Failsafe N test described as "failure safety factor N" was necessary for meta-analysis to incorporate many related research documents as adopted in this study (>2400) to make the three total effects of this study's variables insignificant as shown in Table 3. The results further showed no serious publication bias regarding the relationship of the three sets of variables investigated in this current study.

Table 3. Publication Bias Test Results.

Explanatory Variable	Failure Safety Factor
Search breadth of green resources	3339
Search depth of green resources	2403
Green resource absorption and integration	5046

4.3. Effect Analysis

4.3.1. Main Effect Analysis

Table 4 shows the analysis result of the main effect through the random effect model. The main effect describes an independent variable's effect on a dependent variable averaged across the levels of any other independent variables [116,117]. That is, according to the random effect model results, the influence of the three explanatory variables, namely, green resource search breadth, green resource search depth, and green resource absorption and integration on the green innovation of enterprises demonstrated that the correlation coefficient, the lower limit and upper limit of 95% confidence interval, *Z* value and a *p*-value of the three variables had a significant relationship.

Table 4. Analysis Results of the Random Effect Model of the Main Effect.

Explanatory Variable	*k*	*N*	*r*	*LL*	*UL*	*Z*	*p*
Search breadth of green resources	38	17,847	0.498	0.433	0.558	12.902	<0.001
Search depth of green resources	14	4492	0.489	0.361	0.599	6.667	<0.001
Green resource absorption and integration	27	7360	0.507	0.404	0.597	8.427	<0.001

Note: *k* represents the number of studies, *N* represents the total sample size, *LL* and *UL* represent the lower and upper limit of 95% confidence interval of *r*.

The correlation coefficient between the search breadth of green resources and enterprises' green innovation value obtained in this study was 0.498. The corresponding *p*-value was less than 0.001, indicating that their relationship was moderately correlated [118]. The lower limit and upper limit of 95% confidence interval were 0.433 and 0.558, respectively, which showed that the coefficient can reflect the relationship between the variables accurately and truly to a certain extent, so the assumption of H1a had been verified.

The correlation coefficient between the search depth of green resources and enterprises' green innovation was 0.489. The corresponding *p*-value was less than 0.001, indicating that the relationship between the variables was moderately correlated. The lower limit and upper limit of 95% confidence interval were 0.361 and 0.599, respectively, which showed that the coefficient could accurately and genuinely reflect the relationship between them to a certain extent, so the assumption of H1b had been verified.

The correlation coefficient between green resource absorption and integration and green innovation was 0.507, and the corresponding *p*-value was less than 0.001, showing a significant correlation between the variables. The lower limit and upper limit of 95% confidence interval were 0.404 and 0.597, respectively, which showed that the coefficient could reflect the relationship between them accurately and truly to a certain extent, so the assumption of H2 had been verified.

In general, the green resources absorption and integration had the most significant influence on the innovation ability of enterprises.

4.3.2. Regulatory Effect Test

(1) The Regulatory Role of the Definition of Green Innovation

The differences in the influence of different definitions of green enterprise innovation on the relationship between three explanatory variables and green innovation were analyzed in this study. Table 5 presents the obtained results.

Firstly, the influence of the search breadth of green resources on six different enterprise green innovations was significantly positive, but there were apparent differences in their significance level. (1) According to the innovation content, the correlation coefficients between the search breadth of green resources and comprehensive green innovation, green product innovation, green process innovation, and green marketing innovation were 0.546, 0.518, 0.455, and 0.460, respectively. The *p*-values were all less than 0.001, which indicates that the search breadth of green resources has a significant positive correlation with these four types of green innovation, but there were some differences in correlation. The breadth of green resource search had the most significant impact on comprehensive green innovation and green product search. (2) For the innovation intensity, the correlation coefficients between the search breadth of green resources and breakthrough green innovation, progressive green innovation were 0.565 and 0.438, respectively, the *p*-values were 0.076 and 0.058, which showed that the search breadth of green resources had a more significant influence on the breakthrough green innovation.

Table 5. Analysis Results of the Moderating Effect of Green Innovation Definition.

Explanatory Variable	Category	*k*	*r*	*LL*	*UL*	*Z*	*p*
Search breadth of green resources	Comprehensive green innovation	15	0.546	0.448	0.631	9.194	<0.001
	Green product innovation	6	0.518	0.358	0.649	5.642	<0.001
	Green process innovation	7	0.455	0.251	0.620	4.101	<0.001
	Green marketing innovation	3	0.460	0.278	0.611	4.593	<0.001
	Breakthrough green innovation	2	0.565	−0.067	0.873	1.774	0.076
	Progressive green innovation	2	0.438	−0.016	0.742	1.894	0.058
Search depth of green resources	Comprehensive green innovation	7	0.492	0.327	0.627	5.310	<0.001
	Green product innovation	2	0.341	0.084	0.555	2.570	0.010
	Green marketing innovation	1	0.499	0.424	0.567	11.270	<0.001
	Progressive green innovation	1	0.682	0.626	0.731	16.740	<0.001
Resource absorption & integration ability	Comprehensive green innovation	12	0.566	0.427	0.680	6.770	<0.001
	Green product innovation	4	0.395	0.302	0.480	7.722	<0.001
	Green process innovation	4	0.347	0.136	0.527	3.153	0.002
	Green marketing innovation	2	0.687	0.354	0.865	3.493	<0.001
	Breakthrough green innovation	1	0.470	0.371	0.559	8.288	<0.001
	Progressive green innovation	2	0.570	−0.404	0.938	1.179	0.238

Note: Green innovation was defined by the number of patents in three records, which were not studied in this Table.

Secondly, there was relatively little research on the relationship between the search depth of green resources and green enterprise innovation, so there was a lack of research literature about green process innovation and breakthrough green innovation. At the same time, there was only one piece of literature on progressive green innovation, which could not be compared and analyzed according to the innovation intensity. Therefore, the relationship between the search depth of green resources and progressive green innovation was not examined. The correlation coefficients between search depth of green resource and comprehensive green innovation, green product innovation, green marketing innovation were 0.492, 0.341, and 0.499, respectively. The p values were all less than or equal to 0.01, which indicates that green resource search depth had a significant positive impact on all three. It had the strongest correlation with green marketing innovation.

Finally, green resources absorption and integration positively impacted the six types of enterprises' green innovation. The impacts were all significant except the gradual green innovation. (1) According to the innovation content, the correlation coefficients of green resource absorption and integration with green innovation, green product innovation, green process innovation, green marketing innovation were 0.566, 0.395, 0.347, and 0.687 accordingly. The p-values were less than 0.001, indicating green resource absorption and integration significance to influence these four green innovations. Notwithstanding, the correlation coefficient with green marketing innovation was the largest. (2) According to the innovation intensity, the correlation coefficients of green resources absorption and integration ability with breaking green innovation and progressive green innovation were 0.470 and 0.570 ($p < 0.001$ and 0.238 respectively), which meant that the correlation between green resources absorption and integration and progressive green innovation was stronger, but the significance was less than that of breaking green innovation.

To sum up, due to different definitions of green innovation, there were apparent differences in the correlation and significance between the three explanatory variables and other types of green innovation. Therefore, the H3 hypothesis was been verified.

(2) The Regulatory Role of the Research Object.

Through literature observation, it was found that there were significant differences in research objects selected by different studies, including resource-based enterprises, manufacturing industry, and green-oriented enterprises in the manufacturing industry. Therefore, an industry type was another variable that might affect the relationship between knowledge learning and green enterprise innovation. Some enterprises had a strong ability to acquire external knowledge and industry collaboration [29,52], which further affected green enterprise innovation. The research samples were coded into manufacturing enterprises, resource-based enterprises, and green-oriented enterprises in this study. Most of the meta-analysis samples were from manufacturing companies, and knowledge learning was classified into resource search breadth, resource search depth, and resource absorption and integration. The amount of data about resource-based enterprises would have been too small. Overall, this present study only explored the role of different enterprises in regulating knowledge learning and green enterprise. It can be seen from Table 6 that the correlation coefficients between knowledge learning and green innovation in the three different types of enterprises were 0.494, 0.541, and 0.473. The p-values were all less than 0.001, which indicates that knowledge learning had a significant positive impact on green innovation in the three types of enterprises. Further, the green innovation of resource-based enterprises was most significantly influenced by knowledge learning, which was inconsistent with the original assumption, so the assumption H4 was not verified.

Table 6. Analysis Results of the Regulatory Effect of Research Objects.

Explanatory Variable	Category	k	r	LL	UL	Z	p
Knowledge learning	Manufacturing enterprise	57	0.494	0.434	0.550	13.742	<0.001
	Resource-based enterprise	3	0.541	0.415	0.647	7.220	<0.001
	Green oriented enterprise	16	0.473	0.358	0.575	7.207	<0.001

Note: There were only two studies on the construction industry and one on the mixed enterprises of agriculture, manufacturing, and service industry, neither of which had been classified.

5. Discussion and Conclusions

5.1. Discussion

Green innovation is a kind of innovation with high technical cost and complexity [119], which needs more green knowledge than traditional innovations. In implementing green innovation into practice, firms should learn to attain green resources and improve green innovation [120]. Some quantitative empirical studies show that involving a large number of external knowledge sources in innovation is a promising alternative for large companies [121]; it plays an important role in enterprises' green innovation.

(1) The influence of green resource search on green innovation. This study reveals that external green resource search breadth and depth are positively related to green innovation propensity and process, which agrees with the results of prior research which was in the context of the Spanish food and beverage manufacturing industry over the period 2008–2014 [122]; but there are some other research findings with similar research objects that demonstrate an inverted U-shaped relationship between the breadth of firm's knowledge network and its eco-innovations in a random sample of 279 food firms in Spain [123]. Notwithstanding, most studies have shown that green resource search breadth and depth positively affect enterprise innovation, and there is no inflection point of the opposite effect [124]. This indicates that enterprises can acquire more quantity, diversity, and heterogeneity of green resources to enrich the foundation of green innovation enterprises by broadening external channels. Simultaneously, strengthening the contact and cooperation with the outside, digging deep into knowledge and information, finding valuable resources, and reducing resource acquisition costs can help enterprises quickly grasp the market development direction and customers' green demand. These would enable enterprises to implement effective green innovation.

(2) The influence of green resource absorption and integration on green innovation demonstrates that green resource absorption and integration had a more significant impact on green enterprise innovation. Thus, the search for green resources is an essential foundation for the green innovation of enterprises [125], and the failure of individuals

and industries to absorb, integrate and make effective use will create resource redundancy. Thus, green resource absorption and integration leads to much green knowledge and helps reduce market risk in business fluctuations [84]. Green absorptive and integrative capacity can positively affect green innovation, consistent with prior research [126]. The statistical test results of this study demonstrated a significant positive correlation between green resource absorption and integration and green innovation. The findings indicate that increasing green resources' absorption and integration capability can help enterprises internalize the green resources through the new knowledge, information, and technologies obtained from the external search. Thus, providing a stable material basis for enterprises' green innovation. Concurrently, the findings further denote that enhancing green resources' absorption and integration ability can generate positive two-way impetus with enterprise employees' continuous learning and progress, provide continuous intellectual support for green enterprise innovation, and then lay a solid foundation for green enterprise innovation.

(3) The adjustment function of the different definitions of green innovation revealed four crucial findings:

Firstly, from the perspective of innovation content: (1) The search breadth of green resources had the strongest correlation with comprehensive green innovation, which may be due to the fact that when comprehensive green innovation is defined, the respondents will be affected by different items, and the obtained green innovation value will be relatively high. Secondly, there is a significant correlation between the search breadth of green resources and green product search, which showed that diversified external resources could help enterprises be more innovative in product design and material selection stages. (2) The search depth of green resources and the green absorption and integration had the strongest correlation with green marketing innovation, which indicates that enterprises can grasp consumers' preferences by strengthening cooperation and communication with the outside partners. Moreover, by absorbing and integrating green resources, enterprises can promote innovation achievements and increase the profits of new products. Conversely, in terms of green product and process innovation, green innovation would have been influenced by enterprises' capability and social responsibility, so the influence effect was relatively small.

Secondly, from the perspective of innovation intensity: (1) The search breadth of green resource had a higher correlation with exploratory analysis of green innovation, which indicated that the search breadth of external resources could help enterprises to explore new resources, provide direction for continuously exploring current innovational ideas and help in the exploratory analysis of innovation. (2) The green resources absorption and integration had a stronger correlation with progressive green innovation, but it was not significant, which indicated that enterprises constantly make use of the obtained external resources to carry out progressive innovation and provide them with sufficient resources. However, enterprises' absorption and integration ability was relatively weak, and the positive impact on green innovation is not significant enough.

(4) Further, the regulatory role of the research object based on the moderating effect of the meta-analysis revealed that knowledge learning had a positive impact on different types of enterprises' green innovation, and there was a significant correlation with resource-based enterprises' green innovation. The possible reason was that the economic activities of resource-based enterprises were more dependent on natural resources. With the development of the economy and society, natural resources are becoming scarce. It had become an essential concern of resource-based enterprises to maximize limited natural resources by learning external knowledge and understanding new technologies.

5.2. Conclusions

This study employed 32 pieces of empirical literature to investigate the relationship between knowledge learning and green enterprise innovation in China through meta-analysis methodology. This study initially analyzed the main effects of green search breadth, green search depth, and green resources absorption and integration on green innovation. Afterward, the moderating effects of green innovation definition and research objects on the three-pair relationship were explored. The results of this current study revealed that knowledge learning could significantly and positively influence green enterprise, and green innovation definitions and the sample research objects had moderating effects.

5.3. Countermeasures and Suggestions

(1) Enterprises must pay attention to the accumulating external resources and promote breaking green innovation. Thus, with the development of social connections and global integration, the external network members of enterprises are gradually extending to government departments, supply chain partners, management consulting institutions, universities and research institutes, competitors, customers, and other enterprises. It may also include relevant organizations and individuals in the international community. By enhancing the capability of enterprises to search, and absorb more green resources, it would be cumbersome for the competitors to imitate. Hence, it is helpful to provide human, material, and financial support for enterprises' green innovation. Additionally, enterprises can collaborate with other external organizations by participating in various related conferences held at home and abroad. The collaborations will help demonstrate enterprises' healthy competitiveness to attract other participants to expand the external network to members. On the other hand, with the advent of the era of big data, enterprises can learn and master big data analysis methods to actively understand the dynamic development of the market and dig out hidden information to predict the future trend of the market.

(2) Improving the capability of resource absorption and integration and promoting progressive innovation. In the era of massive data, identifying how to quickly perceive, acquire and absorb useful information and integrate, utilize and transform the searched external resources into the core competitiveness of enterprises has become the top priority of green innovation. This study projects that enterprises can carry out brainstorming activities such as holding meetings or making suggestions to assist managers with strategic ideas to motivate employees to make meaningful suggestions for the company's development. Simultaneously, enterprises should pay much attention to employee training, set up special funds, and adopt the path of opening up or broadening employees' horizons. This approach will stimulate employees' new ideas and creativity, continuously improve the learning potential of managers and employees, strengthen the cultivation of their comprehensive skills, and provide sufficient workforce support for enterprises to absorb and integrate external resources.

(3) Resource-based enterprises need to pay more attention to knowledge learning. Limited by the constrained resources, resource-based enterprises are even more necessary to acquire and absorb external information to reduce over-dependence on specific resources and produce a new path for energy development. A green innovation alliance for resource-based enterprises led by leading industries, universities, research institutes, and other parties should be established. Further, the industries could form a high-quality green innovation working mechanism and provide a cooperation platform for SMEs to obtain green resources. Simultaneously, the contract spirit should be cultivated and strengthened to avoid free-riding behavior.

(4) Enterprises should engage in effective collaborations and focus on the whole process of green innovation. Thus, the enterprises should strengthen the series of processes involved in the enterprises' green innovation cycle, including product design and marketing, due to the inherent economic impact of new products. Enterprises should apply the acquired and absorbed technologies to actual production and actively improve processes and technologies through collaborative efforts. Additionally, industries should effectively save energy, reduce emissions, produce easily degradable and recyclable products, and create avenues for recycling available waste. This study suggests that enterprises must go beyond the traditional notion of taking economic profit as the sole goal and support environmental protection. Therefore, managers of the enterprises should strengthen the cultivation of environmental education awareness to promote green innovation culture.

5.4. Limitations and Future Study

In this current study, the results indicated a positive relationship between knowledge learning and green enterprise innovation. The green resources absorption and integration had the most significant influence on green enterprise innovation. In contrast, different definitions of green innovation and different research objects had moderating effects on the relationship between knowledge learning and green innovation. However, the constraint of this paper was that the meta-analysis conducted is only based on Chinese literature collected from the CNKI database. The study did not consider foreign literature for the analysis; therefore, the authors of this study project to conduct another relevant study that combines domestic and foreign countries' research data sources to obtain dynamic results. The authors aim to increase the sample size and the scope of the research in future research.

Author Contributions: Conceptualization and Software: M.Z.; Formal analysis and Supervision: M.L.; Methodology: H.S.; Writing and Reviewing: F.O.A.; Data Curation: H.S.u.d.K.; Interpretation of data: Z.Z. All authors have read and agreed to the published version of the manuscript.

Funding: This work is supported by the National Natural Science Foundation of China [grant number 72174076 and 71974081], and Jiangsu Postgraduate Scientific Research Innovation Project [grant number B1810012/SJKY19_2520].

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data used for this study is available and will be supplied upon request.

Acknowledgments: The manuscript authors acknowledge the immense support granted by the Social Science Funding Project of Jiangsu Province, the Key Research Base of Universities in Jiangsu Province for Philosophy and Social Science "Research Center for Green Development and Environmental Governance.

Conflicts of Interest: The authors of the manuscript declare no competing interest.

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