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Education and Instruction for Circular Economy: A Review on Drivers and Barriers in Circular Economy Implementation in China

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As a new sustainable alternative to linear economics, the circular economy (CE) is bound to be accompanied by the requirements of the existing production model, science and technology, as well as the public perception of CE. To expose the potential impact of higher education on CE transition, this study systematically reviewed the relevant literature on the drivers and barriers to CE with a mixed analytical method. CiteSpace was used to perform bibliometric analysis and visual presentation of 367 literature accurately retrieved by search formula from two international influential databases, Web of Science and Scopus, and two significant Chinese databases, CNKI and CQVIP. In the results, we identified the number of publications and citations, the annual distribution of publications, annual citation trends, county distribution of publication contribution, the most-cited articles, and the co-citation networks. Moreover, we clarified the main drivers and barriers to CE in China by conducting qualitative content of the keywords related to driver and barrier factors in the literature. The results suggest that higher education has a positive influence on strengthening the main drivers and eliminating the main barriers, which implies that higher education has bright prospects in speeding up the CE transition. To maximize the effect of higher education for CE, we suggested university leaders and lecturers should adopt effective education and instruction measures in improving the performance of education activities for CE, so that the future leaders of various industries in universities could construct CE values and behavior patterns to achieve the replacement of traditional linear economy.

Keywords: bibliometric, circular economy, driver, barrier, higher education

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INTRODUCTION

In the context of global climate deterioration and ecological civilization construction, profound changes are taking place in the mode of economic growth and social lifestyle, as well as the direction of scientific and technological development (Zhang, 2021). CE is a kind of sustainable economic development model which aims at the coordinated development of economy, ecology, and society, directing at improving the resource utilization efficiency and the restoration of ecological environment. To achieve the global sustainable development goals, countries worldwide are energetically exploring the theory research and practice of CE in various industries. As the largest developing country, China has been committed to promoting the large-scale, green and high-quality development of domestic CE industries, such as the construction of the internet sharing economy platform, resource recycling and reusing system, and waste-free cities. In 2020, China took the CE as a crucial point to promote the domestic economic cycle in the Fourteenth Five-Year Plan for National Economic and Social Development (Zhu, 2021). It is undeniable that CE has developed rapidly both in theory and practice recently in China.

CE reflects a new model of productivity development, which is bound to have corresponding requirements on the existing science and technology, the basis of productivity, and people's cognitive level of CE (Sun, 2013). To meet the need of CE implementation, contributions from a variety of stakeholder groups are needed to enable the transition toward CE. There is consensus that education is a dominant intervening measure in changing the knowledge, values, behaviors and lifestyles that needed to achieve sustainable development (Berryman & Sauvé, 2016). As the engine of knowledge and technology, the role of higher education in carrying out education for circular economy has been highlighted in recent years. In particular, the positive influence of educational resources and assets in universities on the transition towards the CE model has been proved (Qu & Shevchenko, 2019). The previous studies on higher education for CE mainly focused on the talent training mode of CE related specialty (Cui et al., 2018), CE education tailored to engineering students (Ormazabal et al., 2018; Andara et al., 2018), CE education in product design perspective (Andrews, 2015; Leube & Walcher, 2017), and CE related curriculum design (Nunes et al., 2018; Kirchherr & Piscicelli, 2019).

However, previous studies on the root cause of higher education and CE transition are relatively few. To expose the potential impact of higher education on CE transition, this study attempts to systematically review the literature on driver and barrier mechanisms of CE and visualize the results of the analysis. Bibliometrics could serve the purpose of achieving this goal by counting the relevant scientific publications and then revealing the history, current status, and trends of the field in the form of tables and statistical images (Mingers & Leydesdorff, 2015). Meanwhile, we aim to classify the main drivers and barriers to CE in China through content analysis, thereby exploring the relationship between higher education and these factors of drivers and barriers. To the best of our knowledge, there is a significant lack of bibliometric research on this topic in the existing literature. The novelty of this study lies in the use of bibliometrics to discuss the

benefits of higher education in accelerating the CE transition from the nature of drivers and barriers. Our findings could show a general map for researchers concerned in this field, and also provide references for the developing countries that committed to the transition of CE.

METHOD

Research design

This study mainly employed a mixed analytical method of bibliometrics and qualitative content analysis to explore the correlation between higher education and the main drivers and barriers in CE implementation, so as to better improve and enhance the practice of higher education and instruction for CE. The international literature is searched from Web of Science (WoS) and Scopus databases, while Chinese literature is retrieved from CNKI and CQVIP databases. Citespace and other data analysis techniques are used to analyze and process the collected data so that the results can be visualized. The content analysis is mainly used to classify the critical variables in literature. Finally, some suggestions are proposed to solve the problems raised in the results.

Research procedure

The procedure of this study is mainly divided into five steps (Figure 1). The first step is to draw up a plan after browsing relevant literature, and preliminarily decide which items need to use bibliometrics and which contents in the literature need to be deeply analyzed by content analysis method. The second step is to carry out a pre-search in the selected database by selecting and determining the search formula in the framework of the research topic. Then, it is necessary to decide to adopt the appropriate software and measurement methods, as well as how to show the results of the analysis. The third step is to formally perform the search and filter the data. The data materials required need to be downloaded and converted to a format that can be used directly. The next step is the data processing phase. The downloaded data should be classified and examined using the selected measurement tool, and the items selected for presentation are processed separately. The final step is the data analysis and result presentation. The results should be presented clearly and concisely in images or tables by adjusting different parameters.

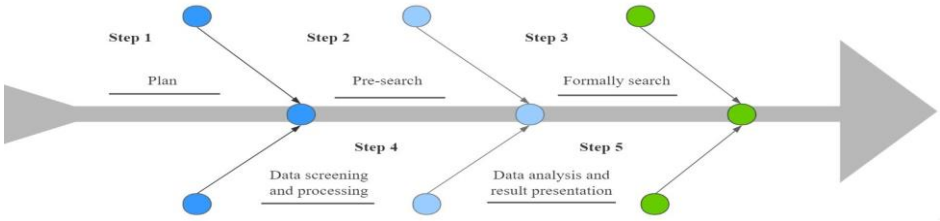

Figure 1
Flow diagram of the research procedure

Data collection methods

Bibliometric data collection requires the clarification, purification, and refinement of the data from selected databases. To improve the reliability of the collected data, WoS and

Scopus are chosen to search the peer-reviewed papers because of their strict standards for content selection and maintenance (Gusenbauer, 2019). The WoS, especially its core collection database, is a high-quality authoritative database universally recognized by scientific researchers and editors operated by Clarivate. Scopus is the world’s largest database of research abstracts and citations operated by Elsevier. In addition, the highly cited Chinese articles are also retrieved via the Chinese database, such as CNKI and QVIP, because this study is focused on the situation of CE issues in China. These two databases are the most commonly used Chinese database in Chinese academic circles, and their core periodicals database indexed articles with strong influence.

To be sure that the newest data is included in this study, we decided to retrieve the publication in CNKI and CQVIP from 2005 to 2021. The year 2005 was chosen as the starting point because the pre-search revealed that the first article relevant to the research topic was published in 2005. Similarly, the timespan we searched in WoS and Scopus ranged from 2011 to 2021 because the pre-search results show no result on the topic prior to 2011. The data retrieval time of this study is October 10, 2021.

With the guidance of pre-search, we finally chose “circular economy, driv*, bar*” in the title as the search criteria. As a result, 104 valid search records were obtained in WoS core collection, and 111 records in Scopus. As for the Chinese literature, we have obtained 68 valid records in CNKI core periodicals database and 84 records in CQVIP respectively after deleting invalid ones. The specific precise search criteria and results can be seen in Table 1.

Table 1
Specific precise search criteria and results in different databases

Databases	WoS (core collection)	Scopus	CNKI (core periodicals databases)	CQVIP (core periodicals databases)
Search formula	TI="circular economy" AND TI=(driv* OR bar*) AND DT=(Article OR Review)	TITLE (circular economy* AND (driv* OR bar*)) AND DOCTYPE (ar OR re)	TI='circular economy'*('driver' +'barrier')	T=circular economy AND (driver OR barrier)
Timespan	2011-2021	2011-2021	2005-2021	2005-2021
Data of retrieval	October 10, 2021	October 10, 2021	October 10, 2021	October 10, 2021
Results	104	111	68	84

Data analysis methods

The data analysis instruments used in this study are mainly CiteSpace and Excel, which are used to analyze data, make tables, and draw knowledge diagrams after the search results are exported to RefWorks and Excel formats respectively. Citespace 5.7 R1 (64-bit) designed by Chen (2004) is a popular bibliometrics tool to visualize the network of relationships between various properties of the literature (Gao et al., 2020). Citespace is mainly used to make co-occurrence matrixes, while Excel is used for filtering and counting data, as well as creating tables, histograms, and Venn diagram that shows the number and proportion of literature in all databases.

FINDINGS

Databases distribution

Selecting comprehensive databases can provide a larger sample for the study to increase the reliability of the results. Four databases are mainly chosen for retrieval in this study, and the number of the obtained articles and overlaps are shown in Figure 2. According to preset search criteria, we obtained 215 articles in total from the WoS core collection and Scopus, 98 of which were repeated in both databases. There are only a small number of articles appearing in the unique database, 6 for WoS and 13 for Scopus. Similarly, there are 67 articles duplicated in the total of 152 relevant articles retrieved from CNKI and CQVIP. The large proportion of duplication also demonstrates the reliability of our database selection.

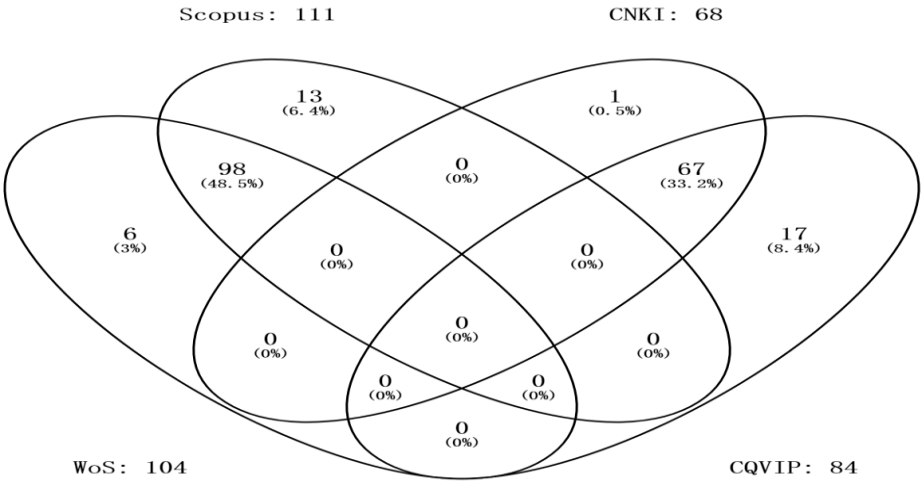

Figure 2
Database distribution of relevant articles

Publication and citation status

Through a statistical analysis of the publication years, we identified the year when the topic-related publications were first published and the year with the largest number of publications (Figure 3).

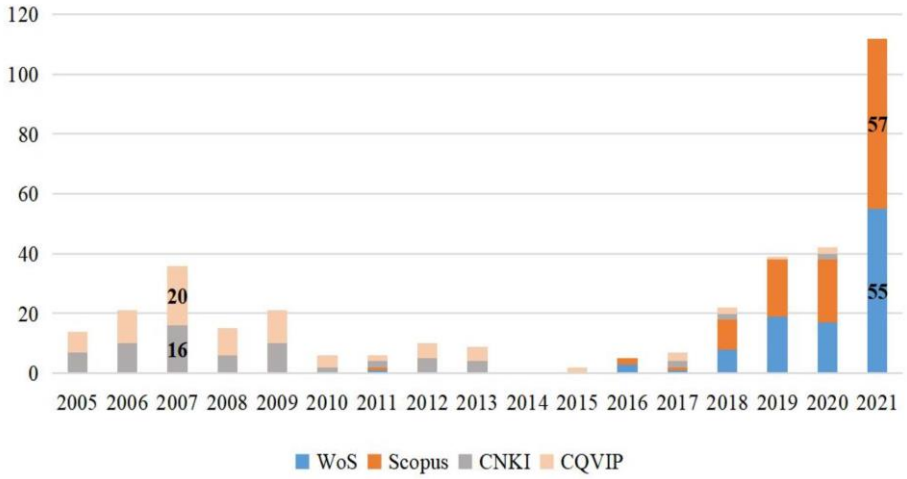

Figure 3
Number of publications in different databases

In both Wos and Scopus, the first publication consistent with the topic appeared in 2011. However, no publications appeared between 2012 and 2015. It was not until 2016 that new articles appeared again, and presumably continued to increase in the following years. The number of publications reached the peak in 2021 (112 articles), indicating that this topic is attracting more researchers' attention. On the contrary, the annual number of articles on this topic shows an opposite trend in the CNKI and CQVIP. The first publication on the topic appeared in 2005. The number of publications has declined each year since peaking at 36 in 2007. No related articles have been published so far in 2021. In fact, this phenomenon is mainly related to the Chinese government policy on CE. In 2005, China issued regulations to clarify the goal and ambition of realizing the CE goals, marking the comprehensive start of China's CE implementation. Since then, the research on the issues related to CE began to rise, but the enthusiasm gradually decreased again with the passage of time.

It is imperative to summarize the number of citations that reflect the importance of the article to a certain extent. As shown in Figure 4, there were fewer publications in 2011 and 2016 in both WoS and Scopus, but the number of citations was high. The number of annual citations peaked in 2018, reflecting the emergence of significant literature in 2018. In the meantime, it is also needed to note that articles of the last three years would take a longer time to get a stable number of citations. In CNKI and CQVIP, the peak of citation number appeared in 2006, which reflects that the literature in 2006 was more influential to researchers.

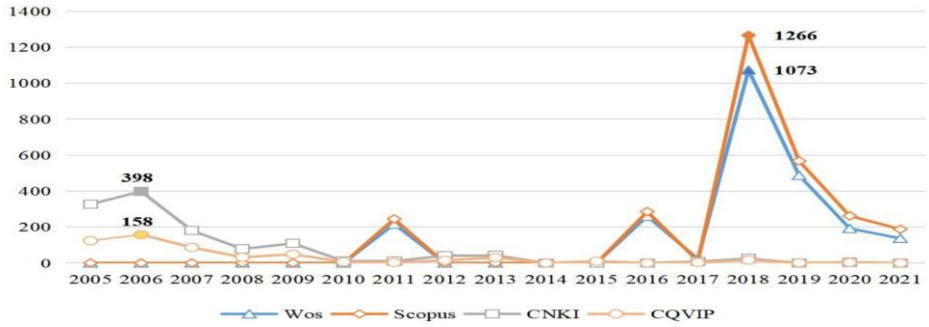

Figure 4
Trends in the number of citations in different databases

Country distribution

In terms of country distribution, the authors of articles in CNKI and CQVIP are all from China. Therefore, we conducted statistical data on the articles retrieved from WoS and Scopus to learn which countries in the world have made more contributions to the study on this topic (Figure 5). The parameter we used in Citespace is available in the upper left corner of the figure. To show the results more clearly, we adjusted the location of the country nodes. The larger country nodes signify the more articles contributed by the country. The outer ring of nodes represents the value of centrality, which is an indicator reflecting the importance degree of literature.

Figure 5
Top 10 countries in publication contributions

We put together the list of the top 10 countries by publication numbers (see Table 2). England, India, Italy, China, and Finland are the top five countries by the publication volume. Also, the centrality of England ranked first. China ranks fourth in the number of publications and second by the value of centrality. It is worth noting that Chinese scholars first published an article on the topic in WoS and Scopus in 2019, while the

first article in Chinese databases appeared in 2005. To some extent, this reflects Chinese scholars have shifted the direction of publication to international journals.

Table 2
Top 10 countries in publication numbers

Country	Count	Rank (Count)	Centrality	Rank (Centrality)	Year
England	31	1	0.56	1	2016
India	16	2	0.13	4	2019
Italy	13	3	0.13	5	2011
China	9	4	0.24	2	2019
Finland	8	5	0.10	9	2018
Netherlands	8	6	0.08	13	2016
Brazil	8	7	0.02	23	2019
France	7	8	0.07	15	2019
Australia	6	9	0.12	6	2011
United States	6	10	0.12	7	2019

Articles and co-citation network

Based on the data collected from WoS and Scopus, the articles ranked by the total number of citations and the related information are shown in Table 3. In general, the citation rankings of the articles in WoS and Scopus are different. Fortunately, we found that the top nine most-cited articles in the two databases were consistent, so we enumerated the information of these nine articles. The final ranking is based on the sum of the number of citations in both WoS and Scopus. There are two studies on China's CE issues in the listed articles.

Table 3
Top 9 most-cited articles in WoS and Scopus

No	Title	Author(s)	Times Cited (Total)
1	Barriers to the Circular Economy: Evidence From the European Union (EU)	Kirchherr J., et al., 2018	554
2	Progress toward a circular economy in China: The drivers (and inhibitors) of eco-industrial initiative	Mathews J.A. & Tan H., 2011	461
3	Implementation of circular economy business models by small and medium-sized enterprises (SMEs): Barriers and enablers	Rizos V., et al., 2016	452
4	A systematic review on drivers, barriers, and practices towards circular economy: a supply chain perspective	Govindan K., & Hasanagic M., 2018	434
5	Lost in Transition? Drivers and Barriers in the Eco-innovation Road to the Circular Economy	de Jesus A.& Mendonça S., 2018	397
6	Exploring institutional drivers and barriers of the circular economy: A cross-regional comparison of China, the US, and Europe	Ranta V., et al., 2018	247
7	Drivers to sustainable manufacturing practices and circular economy: A perspective of leather industries in Bangladesh	Moktadir M.A., et al., 2018	241
8	Prioritizing barriers to adopt circular economy in construction and demolition waste management	Mahpour A., 2018	183
9	Towards a more circular economy: exploring the awareness, practices, and barriers from a focal firm perspective	Masi D., et al., 2018	159

To learn the weight of literature and the co-citation network, we presented the co-citation network diagram of literature made through Citespace (Figure 6). The parameters we used can be seen in the figure. To improve the readability, we set the

threshold of "k" to 20. The cited frequency of articles determines the size of nodes and their labels. The larger nodes mean more times that the article is cited. The larger the outer ring of the node is, the higher the centrality is, which also means the closer co-citation relationship between the article and the others.

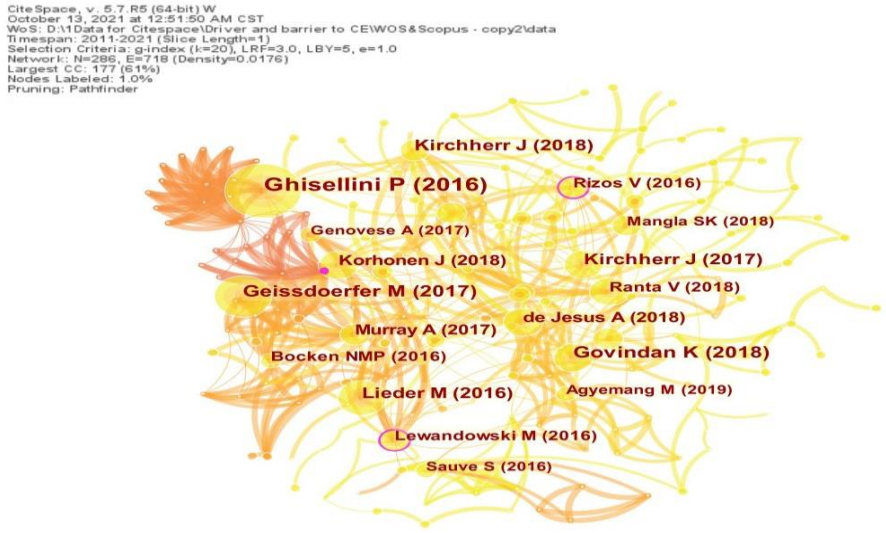

Figure 6
Co-citation network

Detailed information about co-citation networks can be seen in Table 4. The network has a total of 322 nodes and 4742 links. There was a break period from 2012 to 2015. The nodes and links in 2021 made up the most significant proportion of the total, indicating that the research on the topic has received more and more attention recently.

Table 4
Information of the co-citation networks

Year	Criteria (g-index)	Nodes	Exposed Links	Total links
2011	2	21	63	210
2012-2015	0	0	0	0
2016	3	22	66	101
2017	2	21	63	102
2018	5	41	123	400
2019	7	57	171	820
2020	8	58	174	791
2021	15	102	306	2318
Total	--	322	966	4742

Main Drivers of CE Model

It is well-known that the development of everything needs to be driven by power, so clarifying the driving mechanism of CE and understanding the drivers of CE are essential to promote the implementation of the CE model continually. The research on the drivers of CE in China mainly focuses on three directions.

Driver Generation Sources of CE

Many researchers have brought forward their views from the perspective of government, enterprises, and the public or the perspective of government and market. Li D. (2008) justified that the internal drivers of CE include the economic benefit target pursued by enterprises and the social benefit target pursued by governments, enterprises, and residents, while the external drivers include policy support, legal guarantee, technological support, and market competition. Based on the analysis of the government's behaviour pattern, Li & Li (2011) highlighted that the government's appropriate guidance is the dominant driver in CE implementation. Ranta et al. (2018) conducted a cross-regional comparison among China, the US, and Europe, and discussed the drivers and barriers in the specific and general institutional environments in regulatory, normative, and cultural-cognitive aspects in China. According to Zhou H. (2012), CE awareness, environmental protection laws and standards, technological application and support, policy guidance and incentives, and social recycling system are the drivers for CE implementation in China. Guo et al. (2016) argued that promoting and strengthening public awareness and knowledge of CE through publicity and education can effectively promote residents' CE practice in their daily life. As for the enterprises, the economic benefits are the fundamental driver to implement the CE model (Liu & Xia, 2015). In the context of industry 4.0 and circular economy, technological progress and structural ecologicalization are the main drivers of sustainable economic growth in China (Zhou et al., 2020).

Dynamic Mechanism Construction of CE

According to Xiao & Peng (2008), the internal drivers of regional CE include five forces which are profit, technology, scale economy, social responsibility, and new opportunities, while the external binding force consists of five forces, such as government macro strategy, green concept, resource constraint, national policies and regulations, and appeal from the public. Based on the analysis of the Marxist view of interests, Duan (2012) argued that the fundamental driver of CE is the economic interest-driven mechanism, and the construction of CE dynamic mechanism should centre on the interest mechanism to combine property rights incentives, price incentives, fiscal policy incentives, and administrative incentives. In the view of Zhang (2018), the internal driving mechanism of CE in enterprises is the production system and management system in line with the 3R principles of CE, while the external driving mechanism is government guidance and incentive, government preference and compensation, law improvement and implementation, scientific and technological innovation, and public participation and supervision. Liu (2014) proposed that the participation of government, enterprises, and the public in CE practice should be strengthened to activate the internal drivers of CE, while the policy environment should be improved through institutional innovation to provide an excellent external mechanism guarantee for CE implementation. Moreover, the construction of the scientific and technological driving mechanism of CE is the pivotal problem to be solved urgently in CE implementation (Liu, 2015).

Drivers in Different Industries and Fields

According to Matus et al. (2012), the main drivers of CE innovation in the green chemistry and green engineering sector in China are energy efficiency policy, strict enforcement of pollution regulations, and national attention to CE concepts. Mathews & Tan (2016) argued that the drivers of Eco-industrial initiative should be considered from both top-down and bottom-up, with the former referring to institutional arrangements and the latter to individual behaviors, such as taking Eco-industrial initiatives and embracing the CE concepts, yet a bottom-up approach is arguably more critical (Desrochers, 2008). In the field of industry, the driving source of CE mainly includes the internal drivers, that is, the market factors, including economic benefit, CE responsibility consciousness of enterprise, and the construction of industrial park and industry cluster base, and the external drivers, which refers to the government factors, including the government regulation mechanism and policy system (Ai & Xi, 2010). Additionally, there is the leading force of scientific and technological progress and innovation and the elevating power of the CE industry (Xi & Ai, 2011). The driving mechanism for promoting the circular agricultural industrial chain includes the internal source dynamic mechanism with price mechanism and competition mechanism as the core, and the external power mechanism focusing on policy system, technological innovation, market construction, and talent cultivation (Zhou et al., 2012). The endogenous drivers of CE innovation in resource-based cities include interest demand, technology demand, scale economy demand, and social responsibility demand, while the exogenous drivers include resource scarcity constraint, policy and regulation guidance, urban and external competition, and public opinion supervision (Zhou Y., 2012).

Based on the literature analysis, we constructed the keyword cloud map by summarizing the keywords related to the driver factor in the literature (Figure 7). The size of the keyword font represents the frequency of occurrence, that is, the keywords with larger font appeared more frequently in literature. Through inductive analysis of these 33 keywords summarized in the figure, we found that researchers generally believe government policy support, public participation, economic benefits, the awareness and knowledge of CE and technological support are typically recognized as the main drivers of CE in China. Relevant literature sources for the main drivers are summarized in Table 5.

Figure 7
Cloud map of keywords that related to drivers

Table 5
Main drivers in the transition towards CE model in China

Main drivers	Literature sources
Government policy support	Li D. (2008), Li & Li (2011), Ranta et al. (2018), Zhou H. (2012), Xiao & Peng (2008), Duan (2012), Zhang (2018), Liu (2014), Matus et al. (2012), Mathews & Tan (2016), Ai & Xi (2010), Zhou et al. (2012), Zhou Y. (2012)
Public participation	Zhou H. (2012), Xiao & Peng (2008), Zhang (2018), Liu (2014), Mathews & Tan (2016), Zhou Y. (2012)
Economic benefits	Xiao & Peng (2008), Duan (2012), Ai & Xi (2010), Zhou et al. (2012), Zhou Y. (2012), Liu (2015), Liu & Xia (2015)
Awareness and knowledge	Ranta et al. (2018), Zhou H. (2012), Guo et al. (2016), Xiao & Peng (2008), Matus (2012), Mathews & Tan (2016), Ai & Xi (2010)
Technological support	Li D. (2008), Zhou H. (2012), Xiao & Peng (2008), Zhang (2018), Liu (2015), Xi & Ai (2011), Zhou et al. (2012), Zhou Y. (2012), Zhou et al. (2020)

Main Barriers to CE Model

The drivers of CE are these factors that enable and encourage the transition to a CE, while the barriers to CE are the bottlenecks that obstruct transitions towards a CE (de Jesus & Mendonça, 2018). Researchers have already done a significant amount of study and analysis on the barriers in the implementation process of CE. By summarizing the 30 keywords related to the barrier factor in the literature, we constructed the keyword cloud map to present these keywords and the frequency of occurrence (Figure 8). The keywords with larger font appeared more frequently in literature. The results obtained through inductive analysis of these keywords are similar to Kirchlerr's classification of barriers to CE (Kirchherr et al., 2018), that is, cultural barriers, market barriers, regulatory barriers, and technical barriers are the main barriers that often struggle to mitigate China's process of CE implementation at present. Relevant literature sources for the main barriers are summarized in Table 6.

Figure 8
Cloud map of keywords that related to barriers

Table 6
Main barriers in the transition towards CE model in China

Main barriers	Literature sources
Cultural barriers	Zhang et al. (2019), Deng et al. (2013), Guo et al. (2016), Wang (2016), Liu et al. (2021), Xia and Ruan (2020), Ranta et al. (2018)
Market barriers	Matus et al. (2012), Kang (2016), Li (2018), Yin & Liu (2012), Wang (2016), Zhang et al. (2019), Xia and Ruan (2020)
Regulatory barriers	Zhang et al. (2019), Matus et al. (2012), Liu (2014), Jiang & Chen (2017), Yang (2017), Deng et al. (2013), Liu et al. (2021), Ranta et al. (2018)
Technological barriers	Matus et al. (2012), Xu et al. (2012), Xu et al. (2016), Xu et al. (2017), Yuan (2013), Andrews (2015), Xia and Ruan (2020)

Cultural Barriers

Cultural barriers mainly refer to the deficiency in CE awareness and knowledge of the public. Although the concept of CE and green development has been introduced into China for many years, there is still a massive gap between the requirements of CE implementation and people's genuine understanding of CE values. Zhou et al. (2018) combined the available data to calculate the urban domestic waste recycling utilization roughly, and the results showed that the recycling rate of urban domestic waste in China from 2006 to 2015 fluctuated between 12.1% and 17.0%, which is lower than the average level of global domestic waste recycling. Through the investigation and analysis of the status quo of waste classification collection in 600 pilot communities in Beijing, it is found that the current accuracy rate of waste classification and delivery were not high, 4.5% and 31.2% respectively, and the awareness rate is an essential factor affecting these accuracy rates. Also, it is concluded that the publicity of classification knowledge should be strengthened most by sorting out the residents' suggestions on community waste classification (Deng et al., 2013). According to the survey results of residents in the Midong district of Urumqi in 2013, the residents have a limited understanding of the CE, and only 41% of respondents understand the CE concept and 58.5% of them believe that waster can be recycled. Residents are still faced with the uncertainty of responsibility and a lack of knowledge of garbage classification (Guo et al., 2016). Another survey found that 52.7% of respondents are not familiar with the specific connotation of environment-friendly products, so that they are not sure whether they are environmentally friendly (Wang, 2016). Zhang et al. (2019) conducted interviews with experienced practitioners in China and identified that insufficiency of environmental education and culture of environmental protection is the sifnificant causal barriers to smart waste management, which is consistent with the findings of later research (Liu et al., 2021; Xia & Ruan, 2020). Due to these cultural barriers, many people's behaviors contrary to CE principles are still relatively common, delaying the advancement of CE.

Market Barriers

Market barriers mainly embody the production and consumption of pro-circular green products. The construction of resource-saving and environment-friendly consumer behavior should be based on the rational supply of green products and the protection of consumers' adequate consumption. As the CE model is oriented to the whole process of a product life cycle, the implementation of green design, green materials, green

technology, green packaging, and green consumption in the production and consumption market of green products is an vital part of the CE model (Wang, 2018). However, on the one hand, due to the lack of CE concept, many enterprises are often deterred by the large number of costs required for the CE implementation (Kang, 2016). On the other hand, the price of green products in China is too high, which is the main barrier to adequate consumption of green products (Li, 2018). For ordinary consumers, saving energy means saving money. In fact, the price of energy-saving products is often much higher than the price of regular products because of technology patents and the use of special materials. Green environmental protection products fail to become the first choice due to price issues when people plan to buy commodities. Take energy-saving lamps as an example, the price of energy-saving lamps is often several times or even more than ten times that of ordinary incandescent lamps. Many consumers report that the reason why they are not willing to buy energy-saving lamps is that the price of energy-saving lamps is high (Yin & Liu, 2012). Through the survey of community residents in Jiaozuo city, it is found that 50% of respondents report that the price of environmentally friendly products is higher so that the consumption proportion of environment-friendly products in the total household expenditure is still less than 20% (Wang, 2016). Also, there are still many unreasonable consumption behaviors in China, which leads to a large amount of waste of resources, such as excessive packaging of goods and excessive decoration of housing (Yin & Liu, 2012). In any case, the unreasonable operation of the green product market is an essential barrier to CE in China.

Regulatory Barrier

Regulatory barrier mainly reflects in the insufficient bottom-up supervision of the public, which should be coordinated with the top-down supervision of the government. In the market-oriented economy, the producer pursues profit maximization, so CE implementation in enterprises is easily restricted by production cost, technology, and economic benefit. In response to this, the Chinese government has successively issued a series of laws and regulations, as well as financial and taxation policies, to constrain the traditional linear model on the one hand and help the enterprises find the ideal balance between social benefits and social benefits to make them spontaneously change production patterns into CE model on the other. However, the implementation effect is not superior (Liu, 2014). The reason lies in the lack of timeliness and convenience in the top-down supervision of the government. Although the public's bottom-up supervision is characterized by efficiency and convenience, it fails to exert its role effectively due to many reasons, such as the lack of CE awareness and cognition of the public. The long-term lax supervision leads to the CE model cannot be successfully implemented in many enterprises, and some enterprises continue the extensive development model, the efficiency of resource utilization is not high, and the problem of excessive emission of pollutants still exists in different degrees (Jiang & Chen, 2017), even some industrial enterprises sought government subsidies in the name of CE, and actually did not implement the CE model (Yang, 2017). In addition, in the construction of domestic waste sorting and recycling system, strengthening the supervision of correct waste classification is generally considered an effective way to promote the system (Deng et

al., 2013). The lack of regulatory enforcement and accountability were highlighted as the key barriers to the sustainable food sector in China (Liu et al., 2021).

Technology Barriers

Technology barriers mainly manifest in the disability to deliver high-quality re-manufactured products. As an advanced form of resource regeneration, re-manufacturing is the extension of green manufacturing for the whole life cycle and an important measure to realize the transition to CE model and efficient use of resources (Xu et al., 2012). At present, the development of green re-manufacturing faces technological barriers such as non-destructive dismantling technology, environmentally friendly cleaning materials, damage detection and life assessment technology, quality control and intelligent technology, which is challenging to meet the diversified needs of re-manufactured products (Xu et al., 2016). Compared with the manufacture of new products, re-manufacturing can save 60% energy, 70% of materials, air pollutant emissions reduced by more than 80%, and has an obvious price advantage. Still, the re-manufactured products are not well recognized by all sectors of the society, especially the users, because of the long-term formed consumption concept of loving the new and loathing the old, and the sales channels and markets for re-manufactured products have not been fully established (Xu et al., 2017). Moreover, in terms of waste recycling, the current types of waste recycling in China are mainly concentrated in a few easy-to-handle and easily sold materials like scrap metal, beverage bottles, newspapers, books, and product packaging, and the technological level of processing the waste like batteries and plastics is relatively backward, resulting in the market has not yet been able to produce actual demand for some recycled products (Yuan, 2013). Additionally, the technological barrier is also reflected in the lack of recyclable design in the process of research and development of products, even some enterprises always deliberately set some barriers in product design to prevent the recycling of products for ensuring their own interests. For instance, Apple company uses custom accessories designed to complicate products, and even prohibits battery and other parts from being replaced. Further examples of unsustainable products include branded printer cartridges designed to prevent both refilling and the use of all ink (Andrews, 2015).

DISCUSSION

This study conducted a comprehensive review of the literature on drivers and barriers to CE through data analysis and visual presentation of bibliometrics, thereby acquainting researchers with the current status and possible future research trends of this field. Subsequently, this study threw light on the main drivers and barriers to CE in China by conducting a qualitative content analysis of the relevant keywords in the literature. Among the main drivers we have identified, China stands out in terms of government policy support. The Chinese government has already issued numerous laws and regulations and devised a series of ambitious plans for achieving the CE target in China's government development plan, which provided sufficient policy support for the CE implementation. As for the other drivers of CE, it requires efforts from other enablers, such as higher educational institutions, other than the government, enterprises, and the public. Colleges and universities have the advantage of education and scientific

research, as well as the responsibility of serving the society, which could and should improve the public awareness and behaviors of CE, including providing technological support, cultivating professionals, popularizing CE knowledge, and publicizing CE concept.

In terms of the main barriers, they interact and influence each other, which could be considered as nested. Cultural barriers could be most commonly recognized as the main barriers in the transition to the CE model. Still, this statement needs to be confirmed by further empirical research on various stakeholders. Anyway, it is evident that to eliminate cultural barriers in CE transition need to popularize the CE awareness to the public and carry out the CE education. To eliminate the market barriers need to develop consumers' cognitive and pro-circular behaviors. To eliminate regulatory barriers need to improve the willingness and ability of the public to participate in the supervision of CE implementation. Also, to eliminate technological barriers need to strengthen the innovation of CE technology research. Anyway, these paths are closely related to the universities with educational and scientific research assets, which could promote or streamline a CE, as well as remove or weaken the barriers that most frequently derail a CE.

Higher education has a positive influence on strengthening the drives and eliminating the barriers, that is, higher education has bright prospects in the process of speeding up the CE transition. Leaders and lecturers of higher education institutions need to take the initiative to integrate CE concepts into their education and instruction process. On the one hand, the implementation of professional education and general education related to CE in colleges and universities should be carried out synchronously. Professional education can train professional practitioners and experts in the CE field, while general education that aimed at popularizing the CE values has a broader target audience, including all students, the industries in which they will work, and the communities where they will live in the future (Qu & Shevchenko, 2020). In China, CE-related specialties in universities are emerging and still in the initial stage of development. Higher education institution leaders should actively implement the national strategy of strengthening human resources of CE and enhance the construction of CE-related specialties and the innovation of talent training mode to actively cultivate qualified applied talents in line with the needs of society and the market (Abidin, 2021). Besides, CE transition involves all fields of society, so making CE general education courses included in the general education schedule of all majors is of great significance to the personal growth of college students and social development. University leaders should realize the importance of general education of CE and strengthen the overall arrangement of CE general education courses.

On the other hand, transformative learning and education are effective means for higher education to promote the CE transition. According to Bateson's hierarchy of learning theory, learning should consist of three levels from low to high, namely embracing learning, meta-learning, and epistemic learning (Blake et al., 2013). Compared with the first level that mainly imparts knowledge through transmissive pedagogy, the high-level learning that could completely reconstruct the learners' paradigm is more beneficial for

learners to internalize the CE awareness and values into their world view and then stimulate the spontaneous occurrence of pro-circular behaviors. The effects of transformative learning in the field of adult education (Sokol & Shaughnessy, 2018) and education for sustainable development (Burns, 2018) have been proven and confirmed. Lecturers should combine theoretical teaching and practice to explore effective ways for realizing transformative learning and education, so that students can construct CE values and behavior patterns that will completely change the inherent thinking and operation mode of traditional linear economy.

Moreover, lecturers could explore adopting effective educational approaches and tools in CE teaching practice. Appropriate teaching methods can have a positive impact on learners' attitudes and motivation (Sugano & Mamolo, 2021). All of the extant literature on education for CE is grounded on various learning and teaching theories. Pedagogical principles of constructive alignment and problem-based learning have been applied to CE curriculum design. For example, Kirchherr and Piscicelli (2019) developed seven exercises for ECE that include a drill game, buzzword bingo, a teardown lab, an eco-industrial park simulation, policy instruments, a circular party and circular futures. Whalen et al. (2018) advocate for experiential learning by using a serious game that supports holistic and transdisciplinary thinking for a CE. Also, participatory teaching and interactive teaching are adopted as core design principles for CE introductory courses (Kopnina, 2018).

CONCLUSIONS

This study aims to expose the potential impact of higher education as a stakeholder on CE transition. To achieve the goals, Citespace is used to carry out a bibliometric analysis of the relevant literature on the drivers and barriers to CE, and then comprehensively summarizes and classifies the main types of drivers and barriers in China. On that basis, we attempt to clarify the root correlation between higher education and these main types of drivers and barriers, and put forward operational suggestions for higher education institutions in fostering the CE transition.

We present the quantitative data and visualizations on the literature of drivers and barriers to CE. As this study ultimately focuses on the issues of education for CE in China, we select the two most influential databases in the world, Wos and Scopus, and also include two commonly used Chinese databases, CNKI and CQVIP. The scope of this study is mainly 367 publications retrieved from the four databases, among which 98 publications were duplicated in Wos and Scopus and another 67 publications were duplicated in CNKI and CQVIP. Affected by the issued time of China's CE policy, the first relevant publication in Chinese databases appeared in 2005, and the number of publications peaked in 2007. The relevant publication in Wos and Scopus first appeared in 2011, and the number of publications peaked in 2021, although 2021 has not yet ended.

The country contribution analysis of the literature in Wos and Scopus shows that England, India, Italy, China, and Finland are the five countries with the most publications. The number of publications in China ranks fourth place, while the

centrality reaches second place, reflecting the high degree of importance of these publications. In terms of the article distribution, we list the top nine articles according to the total number of articles cited, in which there are two articles about China's CE issues. Additionally, there were 322 nodes and 4742 links in the co-citation network. The number of nodes and links in 2021 accounts for the most significant proportion of the total, implying that the research on the drivers and barriers to CE has recently attracted more and more scholars' attention.

By analyzing the keywords related to driver and barrier factors in the extant literature, this study proposes that the main drivers of CE are government policy support, public participation, economic benefits, CE awareness and knowledge, and CE technological support. Moreover, we put forward that the main barriers to the transition of a CE model are cultural barriers, market barriers, regulatory barriers, and technological barriers. Higher education can exert an enormous influence on strengthening the drivers and removing barriers to CE through education and instruction. University leaders should carry out the professional education and general education related to CE synchronously. In addition to the cultivation of professional practitioners and experts in the CE field, the popularization of CE concepts to all students should also be paid attention to producing hidden education to their future work fields and living communities. For lecturers in universities, effective ways should be explored to realize transformative learning and education, so that learners can construct CE values and behavior patterns that can completely change the inherent thinking and operation mode of the linear economy. Also, lecturers could try to adopt effective educational approaches and tools in CE teaching practice to improve the performance of education activities for CE.

We acknowledge that there are still some deficiencies in this study. Due to the limitations of the applicability of Citespace, this study focused on the literature in WoS and Scopus for visual statistical analysis. In fact, the influence and popularity of articles in Chinese core periodicals databases have been increasing in recent years. In addition, we found a large number of relevant literature published in 2021 through the pre-search. To include the cutting-edge findings, the end time of the retrieved timespan was set as 2021. However, since our data of retrieval is October 10, 2021, there will be new publications in the last two months of 2021, which will affect the repeatability of the results in the future. Besides, this study did not yet specifically analyze the weight of the variables of driver and barrier and the correlation degree between these variables and high education, which could become a concern in future research.

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REFERENCES

Abidin, M. (2021). Stakeholders evaluation on educational quality of higher education. *International Journal of Instruction, 14*(3), 287-308. https://doi.org/10.29333/iji.2021.14317a

Ai L., & Xi Y. (2010). Research on the power mechanism of circular economy in industrial development. *Energy and Environment, 5*, 76-79.

Andara A., Belver R., Salvador M., & Nicolás R. (2018). Roadmapping towards sustainability proficiency in engineering education. *International Journal of Sustainability in Higher Education, 19* (2), 413-438.

Andrews D. (2015). The circular economy, design thinking and education for sustainability. *Local Economy, 30*(3), 305–315.

Berryman, T., & Sauvé, L., (2016). Ruling relationships in sustainable development and education for sustainable development. *J. Environ. Educ, 47*, 104-117. https://doi.org/10.1080/00958964.2015.1092934.

Blake, J., Sterling, S., & Goodson, I., (2013). Transformative learning for a sustainable future: An exploration of pedagogies for change at an alternative college. *Sustainability, 5*(12), 5347-5372. http://dx.doi.org/10.3390/su5125347

Burns, H. (2018). Thematic Analysis: Transformative Sustainability Education. *Journal of Transformative Education, 4*, 277-279.

Chen, C. (2004). Searching for intellectual turning points: Progressive knowledge domain visualization. *Proceedings of the National Academy of Sciences, 101(Supplement 1)*, 5303 – 5310. https://doi.org/10.1073/pnas.0307513100

Cui, X., Di, Y., Zhou, C., Liu, X., Nan, N., & Xu, S. (2018). Research of applied talents training mode of resource recycling science and engineering specialty in the perspective of circular economy. *Recyclable Resources and Circular Economy*, *11*(1), 12-15.

De Jesus A., & Mendonça S. (2018). Lost in transition? Drivers and barriers in the Eco-innovation road to the circular economy. *Ecological Economics, 145*, 75-89.

Deng J., Xu W., & Zhou C. (2013). Investigation on the effectiveness of classified collection of household garbage in Beijing and its long-term management mechanism. *Environmental Science*, *34*(1), 395-400.

Desrochers P. (2008). Did the invisible hand need a regulatory glove to develop a green thumb? Some historical perspective on market incentives, win-win innovations and the porter hypothesis. *Environmental and Resource Economics, 41*(4), 519-539.

Duan X. (2012). Economic benefit driving mechanism: The fundamental driving force of circular economy development--Analysis based on Marxist concept of interest. *Modern Finance and Economics (Journal of Tianjin University of Finance and Economics), 32*(9), 3-10+50.

Gao, H., Ding, X.-H., & Wu, S. (2020). Exploring the domain of open innovation: Bibliometric and content analyses. *Journal of Cleaner Production, 275,* 122580. https://doi.org/10.1016/j.jclepro.2020.122580

Guo B., Geng Y., Sterr T., Zhu Q., & Liu Y. (2016). Investigating public awareness on circular economy in western China: A case of Urumqi Midong. *Journal of Cleaner Production, 142*(4), 2177-2186.

Gusenbauer, M. (2019). Google Scholar to overshadow them all? Comparing the sizes of 12 academic search engines and bibliographic databases. *Scientometrics, 118*(1), 177-214. https://doi.org/10.1007/s11192-018-2958-5

Jiang R., & Chen H. (2017). Business strategy and implementation model innovation of enterprise environmental protection issues. *Operation and Management, 9,* 36-38.

Kang S. (2016). Research on enterprise cost management strategy based on circular economy. *Modern Business, 5,* 97-98.

Kirchherr J., & Piscicelli L. (2019). Towards an education for the CE (ECE): Five teaching principles and a case study. *Resources, Conservation & Recycling, 150,* 104406.

Kirchherr J., Piscicelli L., Bour R., Kostense-Smit E., Muller J., Huibrechtse-Truijens A., & Hekkert M. (2018). Barriers to the circular economy: Evidence from the European Union (EU). *Ecological Economics, 150,* 264-272.

Kopnina, H., (2018). Circular economy and Cradle to Cradle in educational practice. *J. Integr. Environ. Sci. 15,* 123–138. https://doi.org/10.1080/1943815X.2018.1471724.

Leube M., & Walcher D. (2017). Designing for the next CE: an appeal to renew the curricula of design schools. *The Design Journal, 20* (1), 492-501.

Li D. (2008). Development of circular economy should solve the problem of dynamic mechanism. *Theoretical Perspective, 10,* 60-61.

Li D. (2018). Development path of recycling economy of new materials. *New Materials Industry, 3,* 8-15.

Li X., & Li Y. (2011). Driving Forces on China's circular economy: From government's perspectives. *Energy Procedia, 5,* 297-301.

Liu Q. (2014). The policy characteristics and perfection ideas of developing circular economy in China: A perspective of ecological civilization. *Ecological Economy, 30*(4), 27-34.

Liu Q. (2015). The dynamic mechanism of science and technology under circular economy. *Business, 28,* 263-264.

Liu S., & Xiao X. (2015). Research on the driving mechanism of economic interests in circular economy development of enterprises. *Finance and Banking, 3,* 70-74.

Liu, Y., Wood, L.C., Venkatesh, V.G., Zhang, A. & Farooque, M. (2021). Barriers to sustainable food consumption and production in China: A fuzzy DEMATEL analysis from a circular economy perspective. *Sustainable Production & Consumption, 28,* 1114-1129. https://doi.org/10.1016/j.spc.2021.07.028

Mathews J.A., & Tan H. (2016). Lessons from China. *Nature, 531*(7595), 440-442.

Matus K.J.M., Xiao X., & Zimmerman J.B. (2012). Green chemistry and green engineering in China: Drivers, policies and barriers to innovation. *Journal of Cleaner Production, 32,* 193-203.

Mingers, J., & Leydesdorff, L. (2015). A review of theory and practice in scientometrics. *European Journal of Operational Research*, *246*(1), 1-19. https://doi.org/10.1016/j.ejor.2015.04.002

Nunes B., Pollard S., Burgess P., Ellis G., Rios I., & Charnley F. (2018). University contributions to the CE: professing the hidden curriculum. *Sustainability, 10* (8), 2719.

Ormazabal, M., Jaca, C., Prieto-Sandoval, V., & Lleó, Á., (2018). Increasing engineering students ' involvement in circular economy practices. *Memoria Investigaciones en Ingeniería, 16*, 99-107.

Qu D., & Shevchenko T. (2020). University curriculum education activities towards circular economy implementation. *International Journal of Scientific & Technology Research, 9*(5), 200-206.

Qu, D., & Shevchenko, T. (2019). Universities as a driving force for circular economy implementation in China. *Bulletin of Sumy National Agrarian University, 1* (79), 14-20. http://dx.doi.org/10.32845/bsnau.2019.1.3

Ranta V., Aarikka-Stenroos L., Ritala P., & Mäkinen S.J. (2018). Exploring institutional drivers and barriers of the circular economy: A cross-regional comparison of China, the US, and Europe. *Resources, Conservation and Recycling, 135*, 70-82.

Sokol, R.G., & Shaughnessy, A.F. (2018). Making the most of continuing medical education: evidence of transformative learning during a course in evidence-based medicine and decision making. *Journal of Continuing Education in the Health Professions, 38*(2), 102-109. http://dx.doi.org/10.1097/CEH.0000000000000199

Sugano, S. G. C., & Mamolo, L. A. (2021). The effects of teaching methodologies on students ' attitude and motivation: A meta-analysis. *International Journal of Instruction, 14*(3), 827-846. https://doi.org/10.29333/iji.2021.14348a

Sun W. (2013). Development obstacle and countermeasure of circular economy in the horizon of historical materialism. *Explore, 2*, 90-94.

Wang L. (2016). Analysis of environmentally friendly products consumption attitudes and influence factors--Based on a survey of community residents in Jiaozuo city. *Journal of Arid Land Resources and Environment, 30*(2), 7-12.

Wang Q. (2018). Thoughts on green circular economy and green design. *Comprehensive Utilization of Resources in China, 36*(1), 179-181.

Whalen, K.A., Berlin, C., Ekberg, J., Barletta, I., & Hammersberg, P. (2018). All they do is win': lessons learned from use of a serious game for Circular Economy education. *Resour. Conserv. Recycl, 135*, 335–345.

Xi Y., & Ai L. (2011). Dynamic analysis and structural optimization of circular economy in industrial development. *Development Research, 6*, 105-108.

Xia X., & Ruan J. (2020). Analyzing barriers for developing a sustainable circular economy in agriculture in China using grey-DEMATEL approach. *Sustainability, 12*(16), 6358. https://doi.org/10.3390/su12166358

Xiao H., & Peng J. (2008). Dynamic mechanism of regional circular economy development. *Statistics and Decision-making, 13,* 130-131.

Xu B., Li E., Zheng H., Sang F., & Shi P. (2017). China re-manufacturing industry and its development strategy. *China Engineering Science, 19*(3), 61-65.

Xu B., Shi P., & Liu B. (2012). Research on process management of re-manufacturing industrialization. *China Surface Engineering, 25*(6), 107-111.

Xu B., Zhu S., & Shi P. (2016). Innovative development of green re-manufacturing technology. *Welding Technology, 45*(5), 11-14.

Yang P. (2017). The realistic predicaments and route choice of industrial circular economy in China. *Reformation and Strategy, 33*(12), 84-89.

Yin X., & Liu M. (2012). Accelerating the construction of resource-saving and environment-friendly consumption model. *Consumer Economic, 28*(1), 12-14.

Yuan L. (2013). Technological innovation mechanism and policy research of circular economy from the perspective of value chain. *Journal of Macroeconomic, 9,* 71-76.

Zhang A., Venkatesh V.G., Liu Y., Wan M., Qu T., & Huisingh D. (2019). Barriers to smart waste management for a circular economy in China. *Journal of Cleaner Production, 240,* 1-12.

Zhang Z. (2021). Evolution paths of green economy modes and their trend of hypercycle economy. *China Population. Resources and Environment, 31*(1), 78-89.

Zhang X. (2018). On the overall benefit concept of enterprise development and the driving mechanism of ecological enterprise. *Ningxia Social Science, 1,* 104-109.

Zhou C., Lv B., Shi L., Chen Z., & Liu Y. (2018). Assessment of municipal solid waste recycling rate and its statistic data collecting strategy in China. *Chinese Journal of Environmental Management, 10*(3), 70-76.

Zhou H. (2012). Driving force and prospect of circular economy. *Renewable Resources and Circular Economy, 5*(5), 4-8.

Zhou X., Song M., & Cui L. (2020) Driving force for China’s economic development under industry 4.0 and circular economy: Technological innovation or structural change?, Journal of Cleaner Production, *Journal of Cleaner Production, 271,* 122680. https://doi.org/10.1016/j.jclepro.2020.122680.

Zhou Y. (2012). Research on innovative driving force mechanism of recycling economy in resource-based cities. *Management Modernization, 2,* 15-17.

Zhou Y., Yin C., & Zhang J. (2012). Research on the operation rule and power mechanism of circular agriculture industry chain. *Ecological Economy, 2,* 36-40+51.

Zhu T. (2021). The development of circular economy under the new development pattern. *People’s Forum · Academic Frontiers, 5*, 46-51.